Staff Papers Series

P84-27 SEPTEMBER 1984

MANAGEMENT OF FARM BUSINESS AND FINANCIAL RISK

by

Richard N. Weldon
Jerry L. Thompson
Vernon R. Eidman
Maryline R. Gois
Gregory A. Bauer

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

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* Funding for this research was provided by the Minnesota Governor's Council on Rural Development and the Agricultural Experiment Station. The work was completed under Minnesota Agricultural Experiment Station Project Mn 14-039: An Economic Analysis of Risk Management Strategies for Agricultural Production Firms.

** The authors were Research Assistant, Assistant Professor, Professor, Research Assistant and Research Assistant, respectively, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, Minnesota at the time the research was conducted.

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Management of Farm Business and Financial Risk

INTRODUCTION

Risk implies not knowing what will happen at some future point in time. Exposure to risk means accepting a position now that will yield a future uncertain outcome - an outcome that may be good or bad. Historically, risk and exposure to risk have been an integral part of farming and many of the technological advances that have been made were motivated by the desire to reduce risk and increase returns. New crop varieties, pesticides and irrigation are examples of technologies that have reduced risk and increased income. The purpose of this paper is to examine some of the major sources of risk on Minnesota farms and analyze various strategies for dealing with this risk.

Traditionally, risk at the farm level has been thought of as resulting primarily from, 1) production risk due to the biological and climatic nature of the industry and 2) price risk due to unexpected adjustments in both product and input prices. Recent changes in capital markets resulting in unexpected changes in interest rate levels and credit limits have led to a third, relatively unexplored type of risk, financial risk, that interacts significantly with the business risk (production and price). To examine the interactions of these in more detail it is helpful to look at the accounting measure of net farm income:

Net Farm
Income (Pretax) = (Quantity of Production x Price of Product) minus
(Quantity of Variable Inputs 1/ x Price of inputs) minus

1/ Variable inputs are those whose usage level varies in proportion to the level of output produced. Examples are seed, fertilizer, and feed.

(Fixed Operating Expenses [2/]) minus

(Interest Rate on Debt x Average Amount of Outstanding Debt During the Year)

Net farm income is the return to the operator's labor, management and equity capital (including the equity in real estate) for a period such as one year. The risk in net farm income for a future period, such as the next year, depends on the three types of risk - production, price and financial. The influence of weather and pests can result in high or low production for the farmer. Factors that shift supply and demand for both outputs and inputs give rise to price risk on the farm. The last 10 to 15 years have shown a dramatic increase in the price risk at the individual farm level. One has only to look at the results of the "Russian wheat purchases," presidential grain trade embargos, and fertilizer supply shortages to begin to appreciate the price risk facing Minnesota farmers. The combined effect of production and price risk influence the value of the first two lines of the net farm income equation above.

The effect of these two risk items is also reflected in an earnings measure generally referred to as the contribution margin which reflects only the first two lines of the net farm income equation listed above. That is, contribution margin equals gross sales (i.e. Quantity of Production x Price of Product) minus total variable cost of production (i.e. Quantity of Variable Inputs x Price of Variable Inputs). To examine just production and price risk it is feasible to examine the impact of these risk factors on the contribution

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[2/] Fixed operating expenses are those whose level does not vary with output level. Examples are real estate taxes, insurance, depreciation and accounting expense.

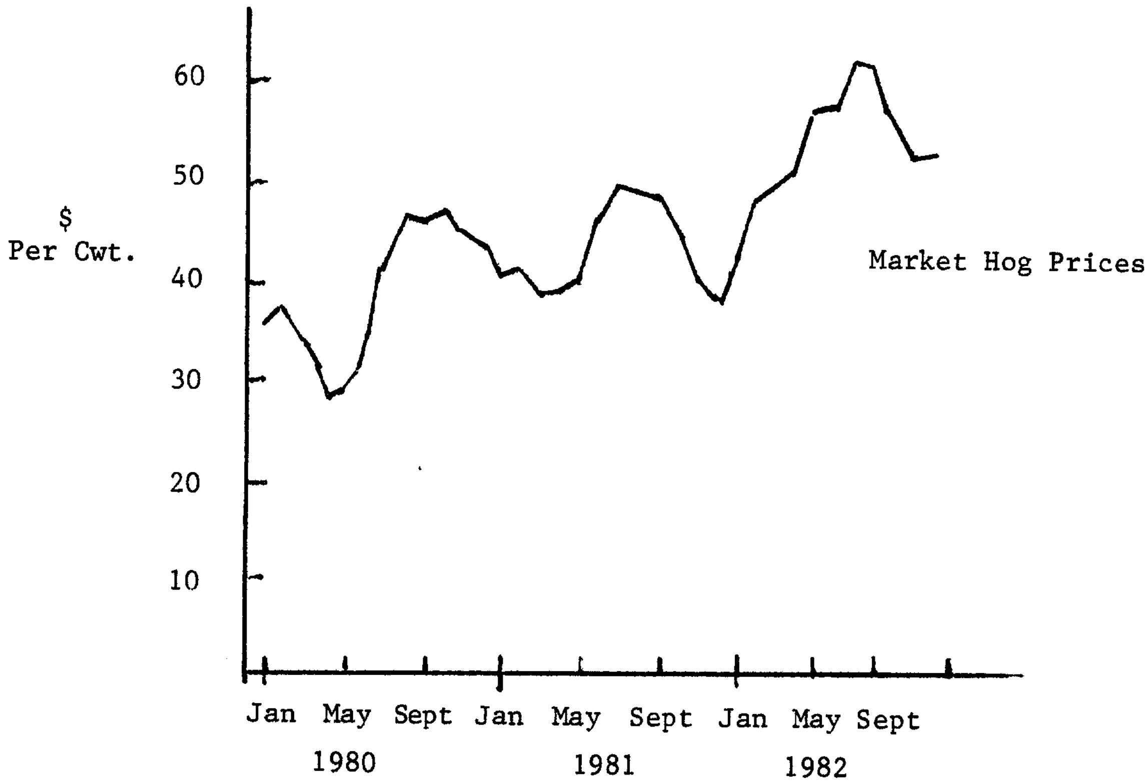
margin measure. High and volatile interest rates impact the fourth term of the net farm income equation. Furthermore, the uncertainty of interest rates, loan limits and security requirements may impact on the farm's ability to acquire and profitably utilize a wide variety of inputs which, in turn, may affect the quantity of outputs produced by that farm unit. Thus, financial risk may result in additional production uncertainty as well.

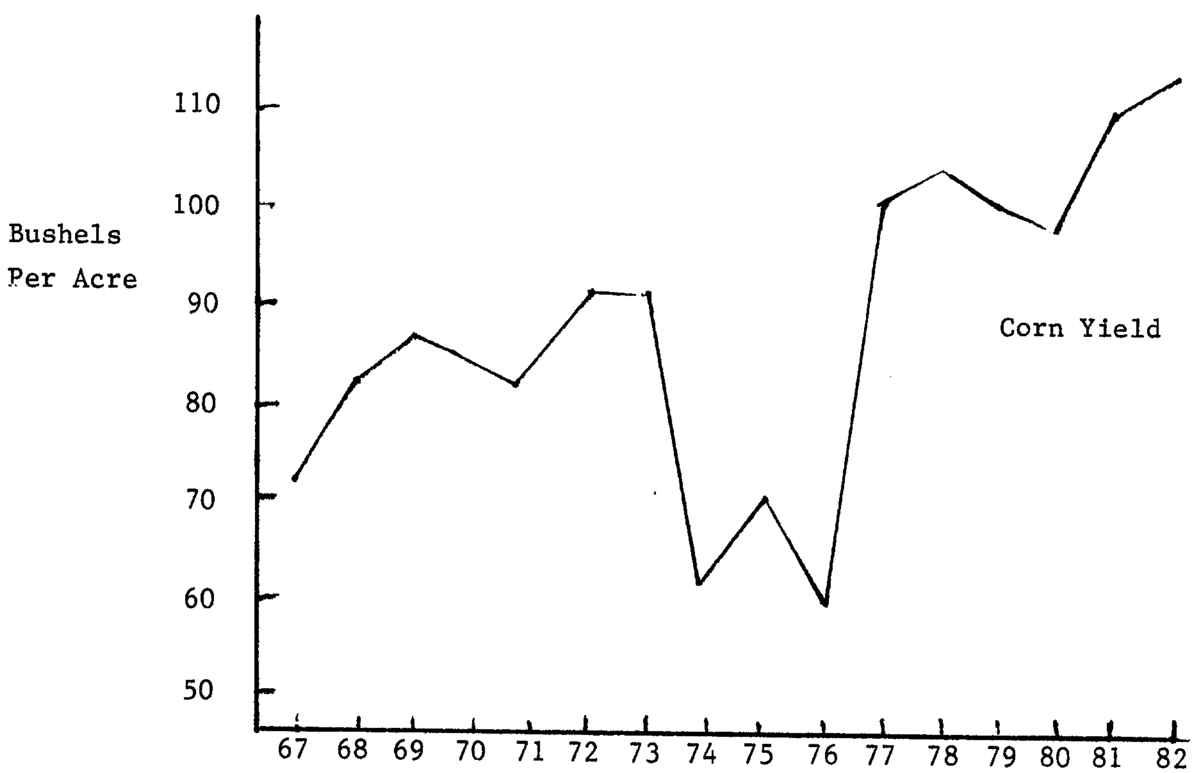
Risk on Minnesota Farms

The degree of risk associated with Minnesota farms is large. Figure 1 reflects the magnitude of the price variability for swine. Shown are the average monthly prices for 1980, 1981, and 1982. Hog prices ranged from a low of $28.50 per 100 pounds in April 1980 to $62.00 in August 1982. The May 1980 price was $28.70 per 100 pounds, while in August, just 3 months later, the price had increased to $46.60. Furthermore, the variability of monthly average prices is less than the fluctuation in daily prices. Averaging over the days in a month necessarily averages out the extreme highs and lows. For example the $28.50 price in May of 1980 obviously includes some daily and individual prices below $28.50 and, likewise, a monthly price of $62.00 includes prices in excess of $62.00 realized by individual farmers. Similar variability is found in the prices of other agricultural commodities and agricultural inputs. While farmers can often predict the general direction of price movements, their inability to predict the input prices they will pay and the product prices they will receive represents a major source of risk.

Average state corn yields are also shown in Figure 1. Yields since 1967 have ranged from a low of 59 bushels per acre in 1976 to a high of 113 bushels in 1982. These are average values over all farms and, again, understate the yield variability that actually exists on an individual farm. For example, the average 1982 state yield of 113 bushels per acre includes an average yield

Figure 1: Minnesota Monthly Hog Prices, 1980-1982 and Minnesota Yearly Corn for Grain Yield 1967-1982.





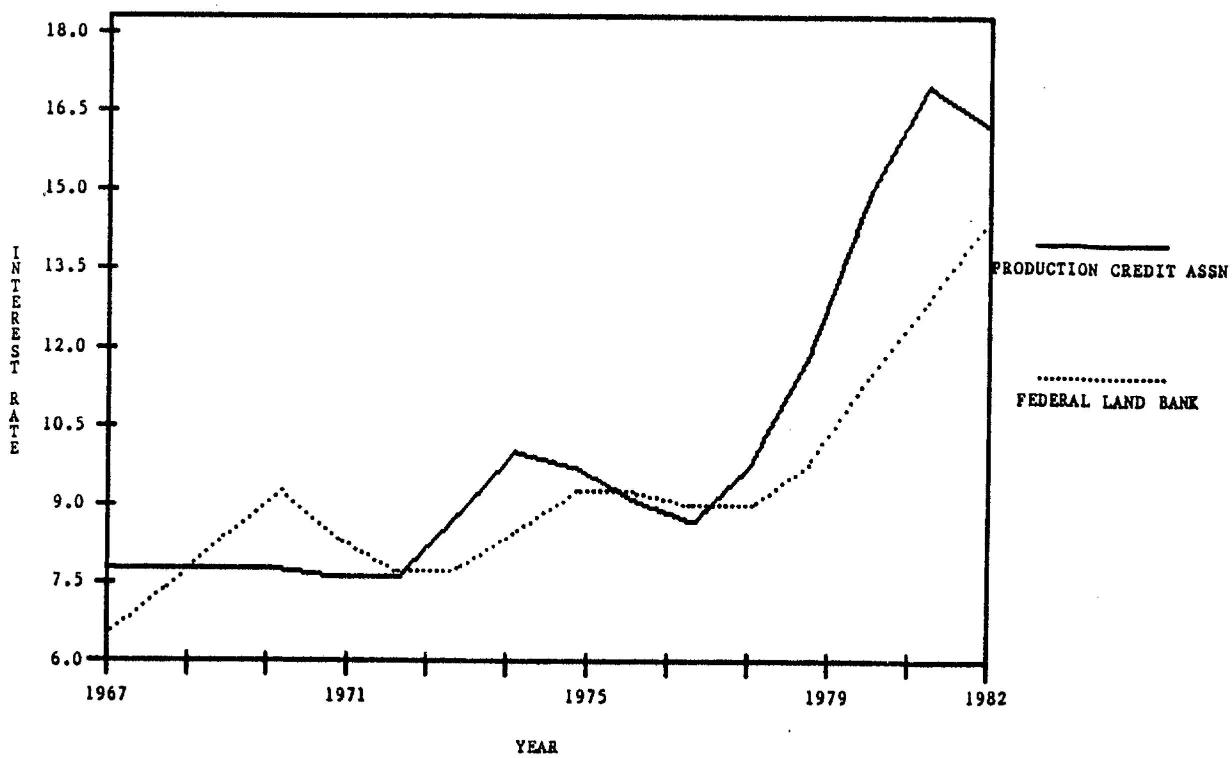
of 84 bushels per acre (and less on some farms) from 128,900 acres in Ottertail County in West Central Minnesota and 132 bushels per acre (and more on some individual farms) on 100,900 acres in Nicollet County in the South Central part of the state. Farm to farm variability is, in general, much greater than the variability of county averages. Isolated weather conditions such as hail can lead to a large range in crop yields in one location.

In addition to production and price risk, a farmer using substantial amounts of borrowed funds faces the risk that interest rates will move unexpectedly upward and increase interest expenses. For some farmers, particularly those using relatively small amounts of debt, the risk of adverse interest rate movements may be insignificant compared to the other risks they face. A highly leveraged farmer with variable rate loans, however, may be concerned about, and exposed to large potential interest rate movements that pose potentially disastrous consequences for the farm unit.

The major agricultural credit sources available to farmers generally are the Farm Credit System agencies and local commercial banks. The Farm Credit System (FCS) agencies include the Production Credit Associations (PCA), which are a source of short and intermediate term credit, and the Federal Land Bank Associations (FLBA), which are a source of long term real estate credit.

Figure 2 shows the Farm Credit System's average annual effective interest rates. These rates show some fluctuations through 1978. After 1978, however, both rates climb sharply with the FLBA's rate lagging behind. FLBA's rate adjustment lag results from use of average cost of funds based pricing and the use of longer term, fixed rate fund sources, which turn over (for renewal) more slowly and prevent the average cost of the funds from rising (or falling) quickly. Thus a farmer with a variable rate loan with FCS realized a drastic increase in interest expense after 1978, though the increase was less for FLBA

Figure 2: Farm Credit System Interest Rates - Yearly Averages



loans than for PCA loans. Farm borrowers obtaining funds from commercial banks on a variable rate basis would have faced similar or even greater rate escalations. Present economic conditions suggest that future interest rates will continue to be quite volatile.

Ultimately the risk of price, yield, and interest rate variability are translated into variability of net farm income. Table 1 provides some insight into the variability of returns for 2 major Minnesota farm enterprises over the last six years. Based on average values for Southwest Minnesota Farm Management Association farms, returns (over costs as listed) ranged from -$18.41 per acre in 1982 to $94.54 per acre in 1980 for corn and from $3.51 per cwt. for farrow-to-finish hog enterprises in 1979 to $22.96 in 1982. Again it must be pointed out that the use of averages greatly reduces (and understates) the variability of the values experienced by individual producers. For example when the average returns on corn were -$18.41 in 1982 the thirty-seven low return farms in the sample (of 185 farms) had returns that averaged -$65.50 per acre. Similarly when average returns for corn were $94.54 in 1980, the thirty-six high return farms (of the 179 farms in total) had average returns of $173.58 per acre.

Analyzing Risk Management

Two of the more frequently used economic models, static optimization and dynamic simulation, will be employed to analyze risk at the farm level in this paper. The static optimization model used in this analysis maximizes expected income subject to constraints on land, labor, capital use and the level of risk. Solving the static model for each of several alternative levels of acceptable risk, yields useful information about how the level of acceptable risk affects the best allocation of scarce resources with the framework of a one year planning horizon. Dynamic simulation on the other hand provides

Table 1: Returns Over Listed Costs - Southwestern Minnesota Farm Management Association

	Corn for Grain Per Acre	Complete Hogs Per Cwt.
1977	$15.67	$12.11
1978	10.89	20.45
1979	-.09	3.51
1980	94.54	4.05
1981	15.74	4.58
1982	-18.41	22.96

Source: Southwestern Minnesota Farm Management Association Annual Report. Various issues.

insights into the multi-year problem. The nature of simulation analysis is to trace the effect of a representative farm following a particular risk management strategy through time on key variables, i.e. it links the financial results (net income, debt levels and asset levels) of one period to those of the next based on the production, price and interest rate levels experienced. This base situation (for one strategy) is then compared to similar simulations for other strategies. The comparison provides insights into the effect that a change in strategy will have on the financial success of the representative farm.

This paper has three objectives. The first objective is to estimate the magnitude of production, commodity price and financial risk affecting the behavior and survival of a common type of Minnesota farm. In addition to measuring production risk for the major enterprises, this involves identifying pricing strategies and measuring the uncertainty associated with each strategy for this type of farm. It also requires measuring the interest rate risk for alternative sources of debt financing. The second objective is to identify, and evaluate alternative production and pricing strategies which farmers can use in risk management programs to maximize expected levels of returns for given levels of risk. Work under this objective will identify the combination of production and pricing strategies that have the greatest promise in risk management programs on the type of farm analyzed. These strategies will be selected for alternative levels of risk to provide results for farmers with a wide range of attitudes towards risk. The third objective is to evaluate the impact of alternative financial strategies for one set of production and pricing strategies. This will indicate the contribution financial risk makes to the firm's total risk. While it might be desirable to duplicate the effort for the production and pricing strategies selected at each of several risk levels in objective 2, this more comprehensive analysis would require more resources than were available for the study.

Risk and Decision Making

Historical data clearly indicate that yields and prices on Minnesota farms have varied greatly. Some sources of variability, such as commodity price changes resulting from the effect of weather on world supplies, are outside of the control of an individual farmer. On the other hand the farmer can typically contract commodities for future delivery, an action which may reduce price risk. An individual farmer may also be able to employ production systems which reduce yield variability. For example, irrigation can reduce the risk of low yields on soils with low available water holding capacity. While neither contracting nor irrigation can eliminate the risk altogether, they can be thought of as strategies to manage risk. This concept of choosing strategies to manage risk is basic to the decision making of Minnesota farmers.

An economic model of the firm to evaluate risk management strategies can be thought of in the following framework:

a) The decision maker defines the relevant technical (production) relationships that exist between the inputs and outputs that are being considered.

b) The decision maker specifies the potential production and price outcomes and subjectively assigns a likelihood (or probability) of each outcome occurring.

c) Then the decision maker considers both the subjectively assigned probabilities and his/her willingness to accept risk in choosing strategies that maximize the decision maker's expected utility.

Maximization of expected utility or satisfaction implies that the decision maker will chose that risky course of action that maximize(s) his/her expected utility. Stating it another way, the decision maker will chose among the risky alternatives in such a way that the satisfaction derived is as large as possible. The utility (or satisfaction) associated with a given decision may be affected by both monetary and nonmonetary characteristics of the outcome. For the purposes of this study, however, it is assumed that net income or net profit is the single factor that determines the utility of the decision maker. It follows then that the shape of the probability distribution of profits (the probability associated with each level of profit) must be considered in evaluating risky alternatives. One simple way to characterize the shape of the profit distribution is with its mean and variance. For certain distributions, notably the normal distribution, the shape is completely characterized by these two parameters, and the associated utility of normally distributed profits also is determined by the mean and variance. The mean is the expected or average value of profits and variance, as the name implies, is a measure of how the potential incomes vary around the average or expected value. The variance is a numerical estimation of the variability or dispersion of the risky alternatives. The larger the variance the greater the variability of potential outcomes and for normal distributions the larger the risk. 3/

An example may help clarify the concepts of the expected or average value

3/ A larger variance does not necessarily imply greater risk for all distributions. For example, when comparing two distributions of outcomes for which one distribution has a high degree of positive skewness (which results when the distribution has some large but unlikely positive return levels), larger variance of the positively skewed distribution need not imply larger risk.

and variance of the risky outcome. Assume a farmer is considering planting 500 acres to soybeans. Based on knowledge of historic weather conditions, he/she feels the range in growing conditions (which are infinite in number) can be adequately represented by the five possibilities in Table 2. The

Table 2: Potential Profit Levels and Associated Probabilities for Raising Soybeans

Planting & Harvesting Conditions	Profit/Ac. ($Income_i$)	Probability of these conditions & profit (P_i)
Wet Spring and Wet Fall	$20.00	10%
Wet Spring and Normal Fall	22.50	20%
Normal Spring and Normal Fall	25.00	40%
Normal Spring and Dry Fall	30.00	20%
Dry Spring and Dry Fall	40.00	10%

farmer estimates the profit per acre for each of these five weather conditions given the current production and marketing strategy employed and lists his/her feeling concerning the likelihood (probability) that the alternative weather conditions will occur.

The most likely outcome or the expected profit [denoted E (Income)] is defined by:

$$E\ (\text{Income}) = \sum_{i=1}^{5} (P_i \times \text{Income}_i) = .10 \times \$20 + .20 \times \$22.50 + .40 \times \$25.00 + .20 \times \$30 + .10 \times \$40$$

$$= \$26.5$$

The measure of dispersion or the variance of profit [denoted Var (Income)] is defined by:

$$\text{Var (Income)} = \sum_{i=1}^{5} P_i\ (\text{Income}_i - 26.5)^2 = .1\ (20.00-26.50)^2 + .2\ (22.50-26.50)^2 + .4\ (25.00-26.50)^2 + .2\ (30.00-26.50)^2 + .1\ (40.00-26.50)^2$$

$= \$29.0$

Since variance is measured in units squared (in this case dollars squared) it is often more convenient to use the standard deviation [denoted σ (Income)] which is defined as:

σ(Income) = $\sqrt{[\text{Var (Income)}]}$, the square root of the variance.

= 5.39, which is dispersion of profit measured in dollars. These estimates of expected return and variability of return can then be compared to those associated with other production and marketing strategies.

The expected utility hypothesis recognizes that the individual's attitude to risk is important in making decisions. Some individuals may select strategies having the highest expected returns regardless of the variability, while others may be more conservative and sacrifice some expected income if they can reduce the risk (particularly the risk of low returns). Thus the decision model used can accommodate both those decision makers that are profit maximizers and those that are commonly referred to as risk averters.

Risk in the Whole Farm Setting

The previous discussion of decision making under risk indicates the preferred course of action is determined considering both the distribution of (range and likelihood of alternative) outcomes for each action and the individual's risk preferences. It follows, then, that any two decision makers considering the same set of risky actions (strategies) may select different alternatives because of the difference in their attitude toward risk. For example, two farmers may consider whether to contract the sale of hogs on feed or sell on the cash market. Both farmers may agree the expected sale price on the cash market is higher, but one may choose to price the hogs in advance with the contract to avoid the price risk, while the other prefers the more risky cash market because of the possibility of receiving a higher price. The role of risk preferences in selecting the preferred action and the difficulty of estimating risk preferences makes it difficult (if not impossible) to prescribe the best risky management action for an individual decision maker. However, it is possible to eliminate many of the potential decision actions/strategies and define what is referred to as an efficient set of alternatives. If utility is a function of mean and variance or, its square root, the standard deviation, then the efficient set is defined in terms of mean income and variance (or standard deviation) of income. Each course of action has associated with it some expected income and some variance of income. In a whole farm setting this efficient set consists of all feasible farm plans that promise the highest expected return for a given level of variance (or standard deviation) of returns, or viewed another way, the efficient set is composed of those alternatives which promise the lowest variance (or standard deviation) for a given level of expected returns.

An example may help clarify this concept. Consider the previous example of the farmer considering soybean production on a section of land that promises an expected profit of $26.50 per acre with a standard deviation of $5.39. Assume he is considering planting corn as an alternative to soybeans. Table 3 gives the profit per acre for each of the five planting and harvesting conditions. In this example the profit level is lower for corn than soybeans for the most unfavorable weather conditions, the same for the three medium weather conditions and greater for corn than soybeans for the most favorable weather conditions. The result is an expected profit from raising corn of $26.50 per acre, the same as soybeans, but a greater standard deviation, $9.43 per acre, for corn compared to soybeans. Thus growing soybeans is a more efficient course of action than growing corn in this example because the two

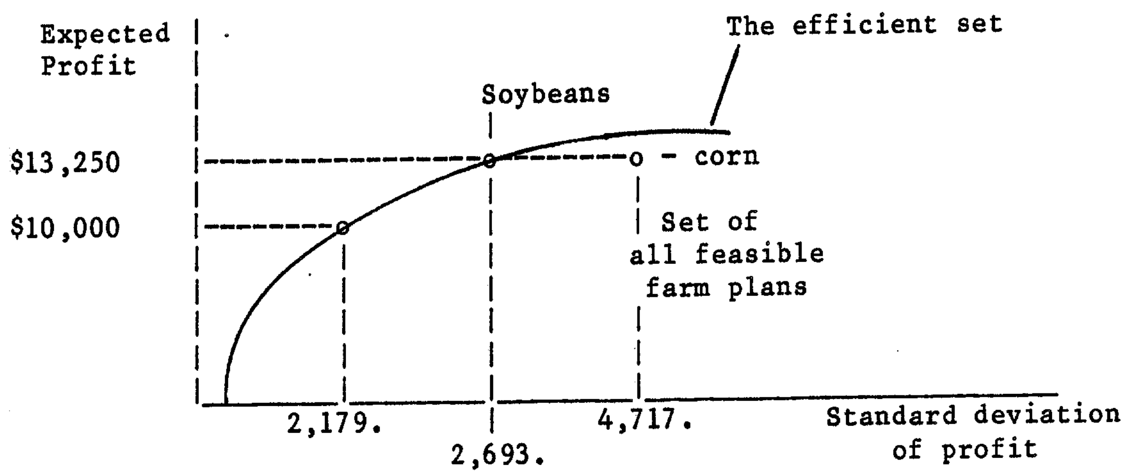
Table 3: Potential Profit Levels and Associated Probabilities of Raising Corn

Planting & Harvesting Conditions	Profit	Probability of these conditions and profit
Wet Spring and Wet Fall	$10.00	10%
Wet Spring and Normal Fall	22.50	20%
Normal Spring and Normal Fall	25.00	40%
Normal Spring and Dry Fall	30.00	20%
Dry Spring and Dry Fall	50.00	10%

crops have the same expected return but growing soybeans has the smaller standard deviation of returns. The relationship of raising corn or soybeans on 500 acres is shown in Figure 3. Notice that the expected return for each crop on 500 acres is simply 500 times the per acre returns, and the standard deviation of returns is also 500 times the per acre value. However, the variance is $(500)^2$ times the variance per acre in each case. Now suppose a third crop, wheat, has an expected return of \$20.00 per acre and a standard deviation of returns of \$4.36 per acre. Some risk averse farmers may prefer wheat to soybeans, that is, they may prefer giving up the higher expected income to obtain the lower variance (risk). If these are the only three alternatives to be considered, the efficient set is composed of the actions grow wheat and grow soybeans. Growing corn is not an efficient action - as noted above.

A more realistic evaluation of cropping alternatives would consider producing various combinations of the three crops on the available land. The expected value and variance for each combination on the 500 acres could be calculated and plotted on the graph shown in Figure 3. For example, the expected income and variance for planting 250 acres to wheat and 250 acres to soybeans could be calculated and compared to the three alternatives already shown. It should be noted that the expected return would simply be the expected return from 250 acres of wheat plus the expected return from 250 acres of soybeans, or \$11,625. The variance (or its square root - the standard deviation), however, is typically less for a combination of enterprises than a simple linear combination of variances would imply because of what are sometimes called "offsetting or diversification effects" in

Figure 3: Efficient Boundary Set



laymen's terms. 4/ The methodology used must consider the effect of enterprise combinations on risk in defining the efficiency frontier. However, no effort is made here to include combinations of the enterprises for the example in Figure 3.

The various enterprises in a farm generally compete for some of the farmer's limited resources (land, labor and capital), but they may be supplementary in the use of others. For example, corn and soybeans compete for the use of land in a given year, but the differences in planting and harvesting periods are such that the two enterprises may not require labor and machinery simultaneously. Thus the two enterprises are somewhat supplementary for the use of labor and machinery. Furthermore, producing the two crops in rotation results in somewhat higher yields per acre for both crops than is achieved from growing either crop continuously. Hence, an economic model of

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4/ More correctly, the variance of a combination of soybeans and wheat is given by: $(A_s)^2$ (Var_s) + $2(A_s)$ (A_w) r_{sw} σ_s σ_w + $(A_w)^2$ (Var_w) where: A_s and A_w are acres of wheat and soybeans, respectively, r_{sw} is the correlation of net returns per acre of wheat and soybeans, the Var_s and Var_w refers to variance per acre for soybeans and wheat, and σ_s and σ_w refer to the standard deviation per acre for soybeans and wheat. The standard deviation for the combination would again be calculated by simply taking the square root of the variance for the combination. The correlation is positive when the net return from the two crops tend to be high (and both also tend to be low) in the same production period. They are said to be negatively correlated if one tends to be high when the other is low. Net return for two crops produced during the same period typically have positively correlated net returns because the same weather and economic conditions typically cause yield and price levels for both crops to move in the same direction. Suppose the correlation of net returns is .8 for wheat and soybeans. In this case the variance for 250 acres of soybeans and 250 acres of wheat is $(250)^2$ (29) + 2(.8) (250) (250) (5.38) (4.47) + $(250)^2$ (20) = $5,467,360.

the farm to evaluate risk management strategies must consider the effect of resource use on enterprise mix, the resulting expected profitability and the associated risk. The mathematical programming model used in this study accomplishes this by choosing the combination of enterprises with the lowest variance of profit for a specified level of profit. By solving this for alternative levels of profit ranging from zero to the maximum possible returns for the farm considered, the decision maker is able to define the efficient set of farm plans (in terms of mean return and variance) as shown in Figure 3.

The final step in the decision making process is to select that one plan that maximizes the decision maker's utility based on the individual's feelings toward expected return and variance of return. Decision makers may make this selection in a very subjective manner. There can be little doubt, however, that they do consider both expected return and variance of return (proportional to the risk involved with the action) in selecting courses of action. Thus economic models must consider this if they are to reflect the reality of the decision making process.

ANALYSIS OF PRODUCTION AND PRICE RISK

Method of Analysis

The method of analysis follows directly from the previous discussion of risk in the whole farm setting. A mathematical programming model is employed to estimate a set of farm plans under various risk situations (again, that set of plans that provides the least risk for various levels of expected returns). The analysis focuses on the combination of crop and livestock activities and pricing strategies included in the efficient farm plan at each level of expected income. The analysis will proceed along the following lines:

1. Define the type of farm to study and specify the resources available on the representative farm. Various types of farm operations

exist in Minnesota; these vary in size, location, resources available and enterprises employed. A representative farm in one geographic area must be chosen and the land, labor, building, machinery and other capital resources must be specified.

2. Define the crop and livestock production alternatives and pricing (marketing) strategies for the representative farm.
3. Estimate the resource requirements and expected returns for each production and pricing alternative.
4. Estimate the risk associated with each production and pricing strategy.
5. Generate the efficient (boundary) set of farm plans.

The following discussion details the above steps.

Characteristics of the Representative Farm

A corn, soybean and hog operation was chosen as the representative farm type because it offers a multitude of risk management opportunities and because it is a very common type of farm in Minnesota. Southwestern Minnesota is chosen as the area of study because corn and soybeans are the predominant crops grown in that part of the state. Farrow-to-finish swine are a predominant livestock enterprise on farms in that area of Minnesota.

No two corn, soybean, and hog operations are exactly alike nor are they managed in exactly the same manner, making it impossible to create a single simulation that is identical to all cash-grain hog operations. It was decided to identify an actual farm business that is both well managed and at least the size of an average farm in the study area. A well managed farm is one which operates using the husbandry practices for producing crop and livestock that are typical for "good managers" in the area. It is felt that an analysis of risk management for a representative farm meeting these criteria will provide insights that can be used in managing commercial family farms of this type. The challenge then is to obtain time series data on well managed corn, soybean and hog farms in Southwestern Minnesota that can be used to estimate the production relationships and risk for this model.

Among the most accurate time series data available on individual farm yields, production costs, price paid and prices received for Southwestern Minnesota are the farm accounts kept by the Southwestern Minnesota Farm Management Association members. The Department of Agricultural and Applied Economics and the Agricultural Extension Service of the University of Minnesota cooperate in maintaining the farm management service. Each farmer member keeps records on their expenses, production levels and returns on each farm enterprise. The account books are summarized annually by the Association to provide an analysis of individual enterprises and the whole farm business.

The 1981 Annual Report summarized the records of 172 farms. The average farm in the Association had 536 total acres and 448 tillable acres. This is somewhat larger than the average farm size of 303 acres for all farms in the nine counties containing the Association farms (Minnesota Agricultural Statistics, 1981).

A careful examination of the Association data indicated that only a few farms had completed the record for each of the years 1967-1982 and had produced corn, soybeans and hogs over the desired period. Each of the farms within this group with farrow-to-finish swine enterprises had made significant changes in the frequency of farrowing and/or facilities used for swine production. It is important to obtain data on the same farrow-to-finish system over the 15 years since the data are used to estimate risk. Thus it was necessary to draw on the records of two farms to provide the time series data for this study. The land, labor, machinery and financial resources are based on a farm business in Cottonwood County. The production data on the two crops are also based on this farm. However, the record data used to develop the coefficients for the swine enterprise are taken from a second farm in southern Minnesota.

A few comparisons of the physical production data underscore the importance of using individual farm data instead of averages across farms to estimate risk. The farm's crop yields and the Cottonwood county yields for 1967-1982 are reported in Table 4. The farm's yield was greater than the county average in most years (each year except 1978 for soybeans and 1979 for both corn and soybeans) as expected, reflecting better than average management. Furthermore, the range of yields on the farm was greater than the range in county average yields, as expected. The criterion selected to measure the production variability in a swine enterprise is the feed-gain ratio, that is, the total pounds of concentrates fed per hundred weight of gain. The feed-gain ratio for the farm is compared to the average for all farms with farrow-to-finish enterprises in the Southwestern Minnesota Farm Management Association in Table 5. The model farm has a lower (i.e. more efficient) feed-gain ratio than the average for all years except 1972, 1979, and 1980. This indicates that the model farm performs better on average than the average of Southwestern Minnesota Association farms, but the production is more variable on the model farm than the average of all Association farms, as expected. The final two columns of Table 5 list the number of pounds of pork produced by an average Association farm and the model farm. These data show that the size of the farm selected is representative of the average farm size in the Southwestern Association and the costs should also be representative.

The resources available (land, machinery, buildings, labor) and the production practices (land preparation for crops, feeding of hogs, etc.)

Table 4: Cottonwood County Average Yields and Actual Yields of the Model Farm for Corn and Soybeans (1967-1980)

Year	Actual Corn Yield - Cottonwood County Farm	Cottonwood County Average Corn Yield	Actual Soybean Yield - Cottonwood County Farm	Cottonwood County Average Soybean Yield
	bu/ac	bu/ac	bu/ac	bu/ac
1967	107.9	83.0	32.5	22.0
1968	121.0	89.0	33.2	21.0
1969	120.9	97.0	38.0	28.0
1970	104.7	93.0	36.5	28.0
1971	101.3	87.0	30.8	24.0
1972	123.5	110.0	40.0	32.0
1973	90.0	89.0	34.1	27.0
1974	80.0	63.6	30.0	21.0
1975	71.4	64.9	40.0	26.6
1976	80.0	64.0	30.0	24.5
1977	115.2	107.7	42.2	39.4
1978	121.3	109.2	37.4	38.8
1979	64.5	103.0	12.7	31.0
1980	121.2	109.0	40.0	36.0

Source: Minnesota Agricultural Statistics, 1967-1980 (Minnesota Department of Agriculture); Individual Farm Records for 1967-1980

Table 5: Comparison of Feed Gain Ratio and Size of the Model Farm with the Averages of All Farms in Southwestern Minnesota Farm Management Association

Year	Actual Feed To Gain Ratio For Model Farm Lbs./Cwt Gain	Southwestern Assc. Average Feed Gain Ratio Lbs./Cwt. Gain	Pounds Produced Per Year On Model Farm	Pounds Produced Per Year On Average Southwesten Assc. Farm	Number Of Farms On Which Southwestern Assc. Average Is Based
1967	381.0	441.0	211,970	73,324	106*
1968	401.0	427.0	223,326	80,202	102*
1969	369.0	454.0	179,588	78,457	98*
1970	385.0	430.0	172,728	79,174	101*
1971	373.0	445.0	221,716	83,030	102*
1972	493.0	447.0	183,850	88,793	105*
1973	429.0	454.0	255,236	109,593	89*
1974	407.0	420.0	326,793	116,202	91*
1975	381.0	447.0	298,618	122,467	78*
1976	395.0	401.0	303,974	143,168	65*
1977	411.1	437.6	275,205	145,474	79
1978	403.4	429.8	313,907	160,415	67
1979	423.3	415.5	260,457	183,397	53
1980	447.6	419.6	254,305	180,296	53

* Average of all hog farms

Source: Southwestern Minnesota Farm Management Association, Annual Reports for the years 1967 - 1980.

considered are actual data from the Cottonwood County representative farm. Yield data employed reflect these factors and the actual weather conditions experienced. The farm has 760 acres of tillable land. The model was constrained to raise a minimum of 130 hogs from each of four farrowings, the number required to trade one futures contract for each farrowing. A total confinement housing system for hogs is assumed on the model farm. Buildings for machinery and grain storage and common farm machinery (chisel plow, moldboard plow, cultivator, planter, fertilizer spreader, etc.) are available on the farm.

The amount of time that field conditions are suitable for tillage, planting, cultivating and harvest is a major source of risk on crop farms in southern Minnesota. The model considers the amount of field time available for each of 17 periods identified in the work by Boisvert and Jensen (1973). They computed the number of field days for several counties of Southwestern Minnesota on the basis of moisture content of the soil, weather data, and a 14-hour work day. Cottonwood County is adjacent to the study area and these data are judged relevant given the location of the representative farm.

Labor requirements per acre of land preparation and land harvested were from Benson, et al. (1981). Labor requirements for the hog enterprise were derived from the study by Greene and Eidman (1979) of a four-litter confinement farrow-to-finish production system.

The variable costs of production for both crops and livestock are actual data from the farmers records for the years 1967-1980. They include seed, fertilizer, pesticides, fuel, lubrication, repairs and variable storage costs for crops. Feed costs, veterinary expenses, and building and equipment repairs are included among the operating costs for hogs. The returns for each activity were computed by subtracting the variable costs from the sales value (price times level of production) to arrive at a contribution margin. 5/ In contrast, net farm income equals this amount minus the firm's fixed costs including depreciation, interest on nonoperating credit, insurance expense, rent expense, property tax and accounting expenses.

Production Strategies

Production risk (variation in physical yields) is one source of variability of net farm income. This risk is linked primarily to the weather uncertainty and the timeliness of cropping activities as well as outbreaks of disease and pests. Production strategies generally involve the timing and use of farm assets to reduce production risk. Production strategies for the representative farm emphasize the management of tillage and harvesting activities to minimize yield variability in crop production.

Boisvert and Jensen (1973) incorporated information concerning both the time available for fieldwork and the yield losses associated with "untimely" crop production into a farm planning model. They applied their study to a corn-soybean farm in southern Minnesota. They suggested that risk averse farmers plan their production in such a way that any "bottlenecks" in field operation performances are least likely to occur at planting time. The scheduling of critical field operations is quite sensitive to relative planting capacity and the availability of seasonal hired labor. The study of Baker and McCarl (1982) reinforce the results of Boisvert and Jensen on the importance of timing as a production strategy for minimizing income risk. They argued that risk is overstated by models with limited time

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5/ The contribution margin is defined as sales value minus variable production expense. It is a measure of the amount of returns available to cover all fixed expenses and (when the contribution margin exceeds fixed expenses) to provide a net profit.

disaggregation.

This study considers field days available in an effort to incorporate the effect of timeliness on corn and soybean yields. Land preparation and harvest activities are included as a separate activity for each crop. For each system, an activity is generated for each operation in each production period for that operation. Sequencing constraints preserve the ordering of harvest, preparation operations and planting when associated operations overlap. The model then chooses the best strategies for crop production and crop mix.

Marketing Strategies

Marketing strategies refer to those actions taken by a producer to establish the price of a given quantity of output. Farmers have several methods available for the pricing of their commodities. They offer varying levels of risk, flexibility and constraint. Included among these various pricing strategies are: cash transactions at time of sale, hedging on the futures market, and forward contracting.

Cash transactions at the time of sale involve pricing the product on the cash market at the time the product is sold. This could occur for crops at harvest or any time thereafter that the farmer decides to market the crop. Farmers following this method of pricing hogs accept the cash market price on the day the hogs are marketed. In this study, hogs are marketed at about 230 lbs. and are graded as U.S. 1-2. This strategy is referred to as cash sale at harvest in the case of the corn and soybean and cash sale of slaughter hogs in the case of the swine production.

Hedging on the futures market is the process of shifting risk of price changes to a speculator through the use of a futures contract. For a crop farmer to hedge means to sell a grain futures contract in anticipation of harvesting the commodity (and/or as a storage hedge if the grain is then placed in storage). A hog farmer on the other hand sells a hog futures contract to set a sale price for hogs that are not ready for market and may not as yet be farrowed. The farmer may have a partial hedge on only a portion of expected production or hedge all of expected production. Hedging in excess of levels of expected output means the farmer is speculating to make income from price movements. Rarely is a futures contract fulfilled in that the commodity is actually delivered but rather an offsetting futures contract is purchased to cancel the farmers earlier sale of a contract. This referred to as lifting the hedge. Any gain (or loss) resulting from differences in the sale versus purchase price of the contract will offset losses (or gains) that arise from changes in the cash market price during the hedge period.

The difference between the cash price and the price of a futures contract at a particular point in time is called the basis. The magnitude of the basis is determined by quality differences, location differences (reflecting transportation costs), cost of storage for storable commodities such as grain, and a risk premium when inventories are excessive. The basis will fluctuate over time but in general will tend to narrow as the contract date nears, and if there are no location or quality differences the basis is zero at the contract date. However, frequently the cash sale of the commodity occurs prior to the contract date and the basis of the offsetting futures contract can reflect factors other than quality, storage and location differences. These other factors are present and expected market conditions.

Changes in basis, i.e. changes in the difference between cash and futures price means that hedging does not completely eliminate price risk unless these changes are completely expected (for example, those which reflect storage costs). At the time of the cash sale the actual price received for the commodity will be the futures price plus the basis at the time of the actual sale. For example, a corn farmer sells a December corn futures (corn futures contracts are traded which mature in the months of December, March, May, July and September) in July for \$3.00 per bushel. Suppose that the basis is -\$.35 at this point in time reflecting a local cash market of \$2.65 per bushel (basis can be defined as cash price minus futures price). In late October the corn is harvested and sold at the local county elevator for \$2.60 per bushel, with December futures now priced at \$2.97 and so the basis at that time is -\$.37. The actual price received then is \$2.63 (\$3.00 - \$.37 which also is equal to 2.60 + (3.00 - 2.97) - the cash market price plus the profit on the hedging transaction). A smaller (less negative) basis would mean a higher actual price. If in October the December futures price and the cash price were \$2.97 and \$2.72, respectively, then the -\$.25 basis would mean an actual, net price received of \$2.75 (\$3.00 - \$.25). Generally, hedging future commodity sales tends to reduce losses due to unfavorable price movements and reduce the gains due to favorable price movements or, i.e. hedging tends to reduce the variance of the price outcome.

<u>Contract sales</u> of crops or livestock have an advantage over hedging in that no margin calls or deposits are required. But a contract sale is less flexible than hedging because delivery is required on a contract whereas a hedge can usually be lifted at any time. Bad weather and low yield can subject the producer to making costly off-farm purchases to cover the contract. The producer must be aware of the contract specifications including the adjustments for quality, penalties for early or late delivery, and time of payment. Forward contracts can be developed for any quantity, an advantage compared to the lumpiness of futures market contracts. Corn and soybeans are traded in 1000 and 5000 bushel contracts, while hogs are traded in 30,000 lbs. contracts. The hog contract requires the equivalent of 130 head of slaughter

hogs averaging 230 pounds to fulfill the quantity requirement, a larger number than many farmers have available at one time.

Cash transactions, hedging, and contracting are the three basic methods of pricing agricultural commodities. Some variations occur for crops where a storage strategy can be used to spread the sales, allowing storable commodities to be priced over a longer time period than nonstorable commodities. Farmers may use the same method as a routine strategy at every marketing season no matter how the prices have fluctuated or they may follow a decision rule which specifies the price conditions required to enter the market. Such decision rules may be based on prices, and production costs and the expected yield (or, more precisely, on the level of net returns currently available from establishing forward or futures market positions).

Marketing Strategies For Hogs. Cash sale of the pigs as feeders and as slaughter hogs, and hedging of slaughter hog prices on the futures market at various times during the production process are the only pricing alternatives considered. Contract prices offered over the past fifteen years were not available and too little is known about the way forward contract prices are developed to synthesize what the offers on such contracts would have been over the historical period. Thus, forward contract pricing of hogs was not considered as an alternative.

Six routine or mechanical pricing strategies were considered. Two were cash sales with the animals priced at the time of sale. The first sold all the hogs as slaughter hogs (CSH) and the second one sold them as feeder pigs (CFP). The remaining mechanical pricing strategies involved placing hedges either at 10, 8, 6 or 4 months before the hogs reached market weight. This allows the producer to place a hedge either at the approximate time a decision is made on the number of sows to be bred (10 month hedge, denoted H10) or two months later when the number of sows farrowing is known (8 month hedge, H8) or at farrowing (6 month hedge, H6) or at the beginning of the finishing period (4 month hedge, H4). The analysis assumes that when a hedge is executed it is neither lifted nor reconsidered until the hogs are actually marketed. Furthermore, the futures contracts in the model are permitted for any amount equal to or greater than 30,000 lbs. This assumption ignores the discrete nature of futures contracts, but is realistic in that a forward contract would typically be available to the producer for any amount of production.

In addition to considering the mechanical strategies individually, a selective hog pricing strategy was devised that considers the six alternatives listed above and chooses the best pricing method for the hogs produced in each of the four annual farrowing periods. This requires development and use of an expectations model discussed below.

The contribution margin from the sale of the slaughter hogs on the cash market, π SH, is:

$$\pi\ SH = [CSH \times W] - VCSH$$

where π SH denotes the return above variable costs, CSH is the cash price per hundred weight, W is the market weight in hundred pounds, and VCSH is the variable cost to produce slaughter hogs.[6] The contribution margin from the sale of feeder pigs is:

$$\pi\ FP = CFP - VCFP$$

where CFP is the cash price per head for feeder pigs and VCFP is the variable cost of feeder pig production. The contribution margin from hedging is:

$$\pi\ H_i = [CSH \times W] + [(F_i - F_o) \times W] - VCSH$$

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[6] Since the pricing strategy will be for, at most, a 10 month period, fixed costs will be the same for all decisions and are thus ignored.

$i = 10, 8, 6, 4$

where F_i is the future price per cwt. received i months prior to the expected time of the sale of slaughter hogs from a farrowing, F_o is the price per cwt. from buying a contract at the time of the cash sale of hogs, this can be rearranged as:

$$\pi H_i = [F_i \times W] + [(CSH - F_o) \times W] - VCSH$$

The corresponding expected values of the above equations are:

$$E(\pi SH) = [E(CSH) \times E(W)] - E(VCSH)$$

$$E(\pi FP) = E(FP) - E(VCFP)$$

$$E(\pi H_i) = [E(F_i) \times E(W)] + [E(CSH - F_o) \times E(W)] - E(VCSH).$$

It is assumed that the cash price and the futures price converge (i.e. the difference between them goes to zero) at maturity of the contract. Furthermore, at time i, the futures price F_i is known to the producer, therefore

$$E(\pi H_i) = [F_i \times E(W)] - E(VCSH)$$

The decision maker then compares $E(\pi SH)$, $E(\pi FP)$ and $E(\pi H_i)$ to formulate his/her decision. Note that comparing $E(\pi SH)$ and $E(\pi H_i)$ is the same as comparing the expected cash price E(CSH) i months hence and the futures price for a contract that matures i months hence, F_i. The decision rule can be stated as follows:

"Hedge i months ahead of cash sale of slaughter hogs if the expected contribution margin from placing such a hedge is at least as large as the expected contribution margin from sale of slaughter hogs or feeder pigs - which ever is larger, that is if:

$$E(\pi H_i) \geq \text{Max} \{ E(\pi SH), E(\pi FP) \}$$

If the inequality does not hold at time $i = 10$, check the relationship again for the successive values of i, $i = 8, 6, 4$. If no hedge is placed, select the strategy, either sale of slaughter hogs or sale of feeder pigs, that has the highest expected net (contribution margin) return, or i.e., the one that satisfies:

$$\text{Max } \{ E(\pi SH), E(\pi FP) \}."$$

Holthausen (1979) showed that the relation between the forward price and the subjective expected price determines the amount hedged by the decision maker, and that if the forward (i.e. future) price is less than the expected cash price, the amount hedged increases as the agent becomes more risk averse. In other words, a more risk averse farm operator discounts the expected cash price more for a given risk level than a less risk averse farmer and thus will accept a somewhat lower, certain price (obtained through use of futures positions) to an uncertain (cash) price whose <u>expected</u> value is somewhat higher. This hypothesis can be represented by multiplying the expected cash prices in the decision model by a factor, K, as shown:

$$E(\pi H_i) \geq K \times \text{Max } \{ E(\pi SH), E(\pi FP) \}$$

where K = .90, .92, .94, ..., 1.20 and i = 10, 8, 6, 4. The value of K reflects various behaviors of the decision maker. As K increases in value, the farm operator discounts the expected cash price (or the model that is predicting the price) less. Under the Holthausen hypothesis the relative amount hedged (i.e., the relative frequency with which hedging is the preferred course of action) decreases when shifting from a strategy with a low 'K' factor to a higher one.

The exploration of alternative hog marketing strategies constitute a major contribution of the study. Farmers using alternative marketing strategies for hogs are also likely to consider alternative pricing strategies for crops. In order to be more realistic, some mechanical pricing strategies for crops are built into the model. Time and resources available for this study did not permit also evaluating selective pricing strategies for crops.

Marketing Strategies for Crops. The marketing alternatives considered for cash crops are derived from a similar study by J. Ohannesian. They are:

1. The harvest strategy. This strategy consists of selling the whole crop at the time of harvest.

2. The seasonally high multiple-monthly pricing strategy. The grain is stored and sold during several months of traditionally high price. Seasonally high prices for corn occur mid December to mid February and in late spring or early summer. Half of the production will be sold in each peak season. This strategy assumes equal amounts are sold on the 15th day of December, January and February and also May, June and July. Thus sales are spread over six months with this strategy.

   The typical seasonal pattern of Minnesota soybean prices is such that prices rise in late spring through early summer. Equal amounts of soybeans are assumed to be sold during the months of March, April, May and June.

3. Futures market hedging strategy. Corn is stored at harvest when the price is traditionally low. A July futures contract is sold at harvest (November). The grain is stored for six months and sold at the local cash price in May and at the same time a July futures contract is bought to close out the hedge position.

   The soybean hedging strategy consists of storing the beans at harvest in October and selling a July futures contract at that time. The beans are sold in May with a simultaneous purchase of a July futures contract (to close out the hedge position). Soybeans are thus stored seven months.

Corn and soybean futures contracts are traded in 5,000 bushel lots on the Chicago Exchange. This is equivalent to 50 acres of 100 bushel per acre corn and 167 acres of 30 bushel per acre soybeans. Adequate quantities of these crops were produced in the majority of years on the representative farm to trade at least one contract for each crop. 7/

4. Feeding strategy. Corn grain can be used on the farm to feed hogs. In this case, the net return of the grain is determined endogenously on the farm as a portion of the value added in transforming feeder pigs into slaughter hogs. The income variability that can be associated with corn fed to hogs is the variability in the cost of producing corn. Hence the deviations for corn fed are computed between actual and expected variable costs. Variation in the amount of corn required per hundred pounds of pork produced and the variation in the price of hogs is attributed to the swine enterprise (rather than to the corn enterprise).

Data Requirements and Sources

Slaughter hog prices used are quotations of South Saint Paul Prices for U.S. 1-2 grade barrows and gilts weighing 230-240 pounds. The series is reported weekly by the U.S.D.A. in Livestock, Meat and Wool Market News. Feeder pig prices were quoted weekly at the Little Falls market in Central Minnesota. The prices analyzed were those paid every second Wednesday of the month as reported by the Chicago Mercantile Yearbook. Hog weight and slaughter hog production costs were actual costs for 1967-1981 from the

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7/ In addition, contracts for 1000 bushels are traded for both corn and soybeans on the Mid American Commodity Exchange.

records of the representative farm. The production costs for feeder pigs were derived from the slaughter hog production costs by assuming that the cost of producing feeder pigs is 32.6 percent of the total feed cost of slaughter hogs and the miscellaneous costs are 72.5 percent of the total miscellaneous costs to produce slaughter hogs. These percentages were derived from the study by Greene and Eidman (1979 and 1980).

Cash and forward prices of corn and soybeans were obtained from local country elevators in Worthington and futures market exchanges. Crop and livestock prices as well as input prices are adjusted to the 1982 price level using the index of prices received and paid by farmers. Simple regression analysis was used to test for trend in yields, indexed costs, indexed prices and indexed gross income. No significant trend was found.

<u>Risk Estimation</u>

<u>Production Risk</u>. Table 6 presents the important parameters of the yield distributions for corn and soybeans, and the feed-gain distribution for hogs. No linear trend was found indicating no significant trend in the physical productivity per acre for the crops and in the amount of feed fed per hundred pounds of swine produced was present in the data. Hence, the mean and standard deviation were computed directly from the data. the coefficient of variation (CV):

$$CV = \frac{\sqrt{(Var)}}{mean} \times 100$$

is a measure of the relative variability of the enterprises. Since the CV expresses the standard deviation as a percentage of the mean it is not tied to the units of measurement (bushels or pounds) required. Hog production is relatively less risky than crop production in terms of physical yields. The weather effect is less important in swine and helps explain this result. Soybeans and corn have approximately the same level of relative yield

Table 6: Production Risk Parameters

	Corn bu./ac.	Soybeans bu./ac.	Hogs: Feed Gain Ratio lbs. feed/cwt. pork produced
Mean	104.74	34.10	407.10
Standard Deviation	20.50	3.38	33.33
Coefficient of Variation	19.57%	21.29%	8.19%

variability (CV of 21.29% for soybeans versus 19.57% for corn).

Price Risk Associated with Corn and Soybeans. The price variability over the 14 year period from 1967 to 1980 for the various pricing strategies for corn and for soybeans are given in Table 7. Over the period 1967 to 1980, average harvest prices (November for corn and October for soybeans) were in general lower than prices later in the season for both crops. However, the price of corn and soybeans at harvest had a lower standard deviation (less variance) than selling with the seasonally high multiple-month strategy. The highest average price was obtained for both crops by selling with the seasonally high multiple-month strategy. Hedging with July futures sold at harvest and the cash sale in May, yielded the lowest average prices for both crops. The routine hedging strategy had a higher standard deviation for both corn and soybeans than harvest sale, suggesting it is not an effective means of reducing income variability.

The yearly net prices received each year for corn by cash sale in November (HARV), by hedging (FUT), and by spreading the sale over the seasonally high priced months (SHIGH) are shown in Figure 4. The net price refers to the sale price minus the marketing costs and the storage costs. The net prices for the three pricing strategies fluctuated in a parallel manner prior to 1974 with the strategy of spreading sales yielding the highest prices in all seven years. The pattern during the last seven years, 1974-1980, is less clear, with the relative price levels of the three strategies shifting from year to year. The futures pricing strategy has the highest price in 3 of the last four years.

The net 1967-80 annual prices for soybeans sold on the cash market in October (HARV), hedged with a July futures contract (FUT) at harvest and sold during the four seasonally high months (SHIGH) are presented in Figure 5.

Table 7: Price Variability Faced from 1967 to 1980 on the Cash Market and on the Futures Market for Corn and Soybeans (1981 Dollars)

Crop	Strategy	Month	Mean Price	Standard Deviation	Coefficient of Variation
			$/bu.	$/bu.	%
<u>Corn</u>					
	Harvest Sale	Nov.	2.748	0.448	16.33
	Seasonally High Multiple Month*		2.816	0.463	16.48
	Futures Market Hedge**		2.362	0.652	27.62
<u>Soybeans</u>					
	Harvest Sale	Oct.	7.076	1.412	19.96
	Seasonally High Multiple Month*		7.407	3.468	46.82
	Futures Market Hedge**		7.065	1.602	22.67

* Seasonally High Multiple-Month Price is the average price for December, January, February, May, June and July for corn; and March, April, May and June for soybeans.

** Futures Market Hedge Price is price of July futures sold in November minus price of the July futures bought in May plus the cash sale in May; for soybeans a July futures is sold in October and the cash sale takes place in May when the July futures is bought.

Figure 4: Corn Prices from 3 Strategies over 1967-1980 Period, 1981 Dollars

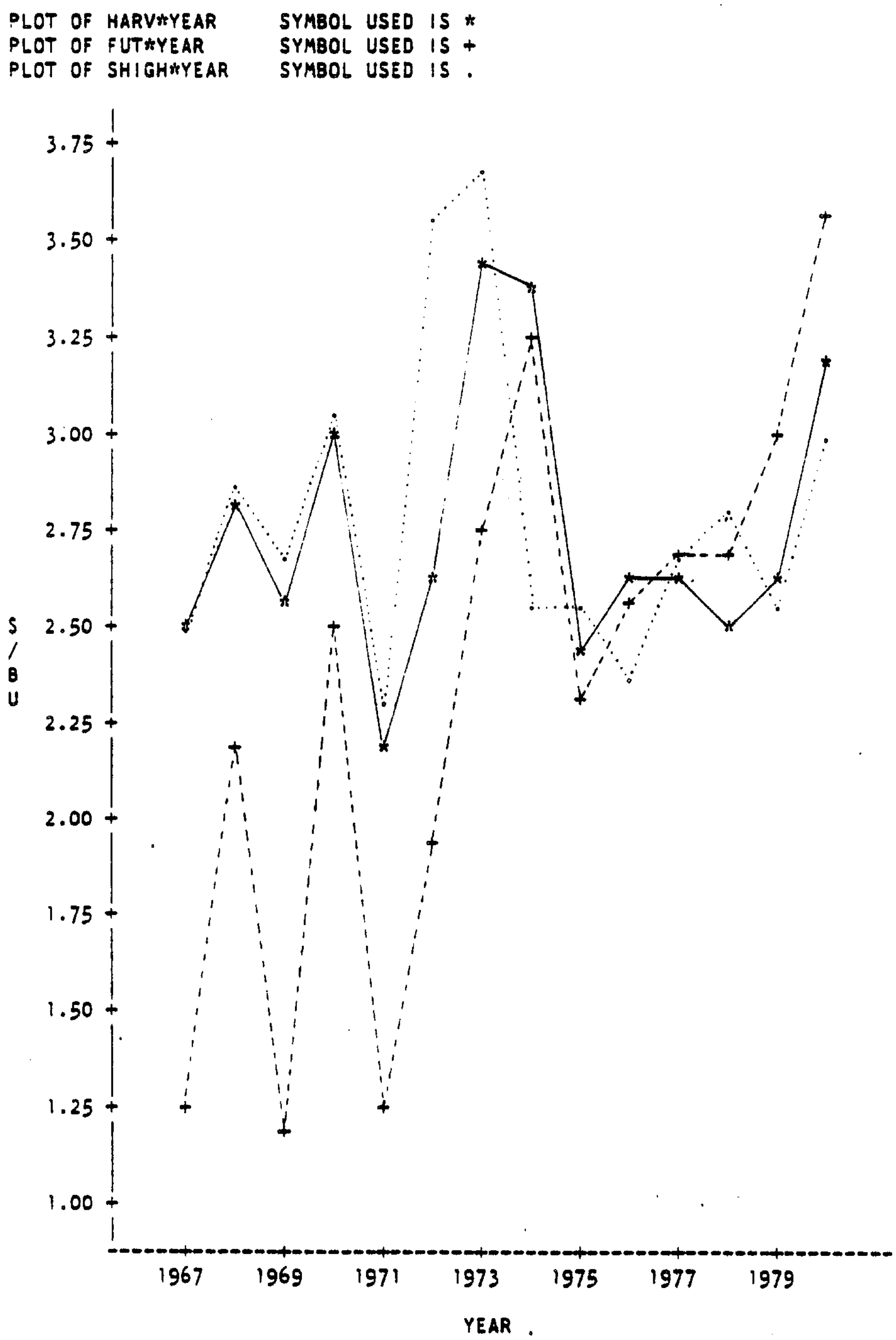
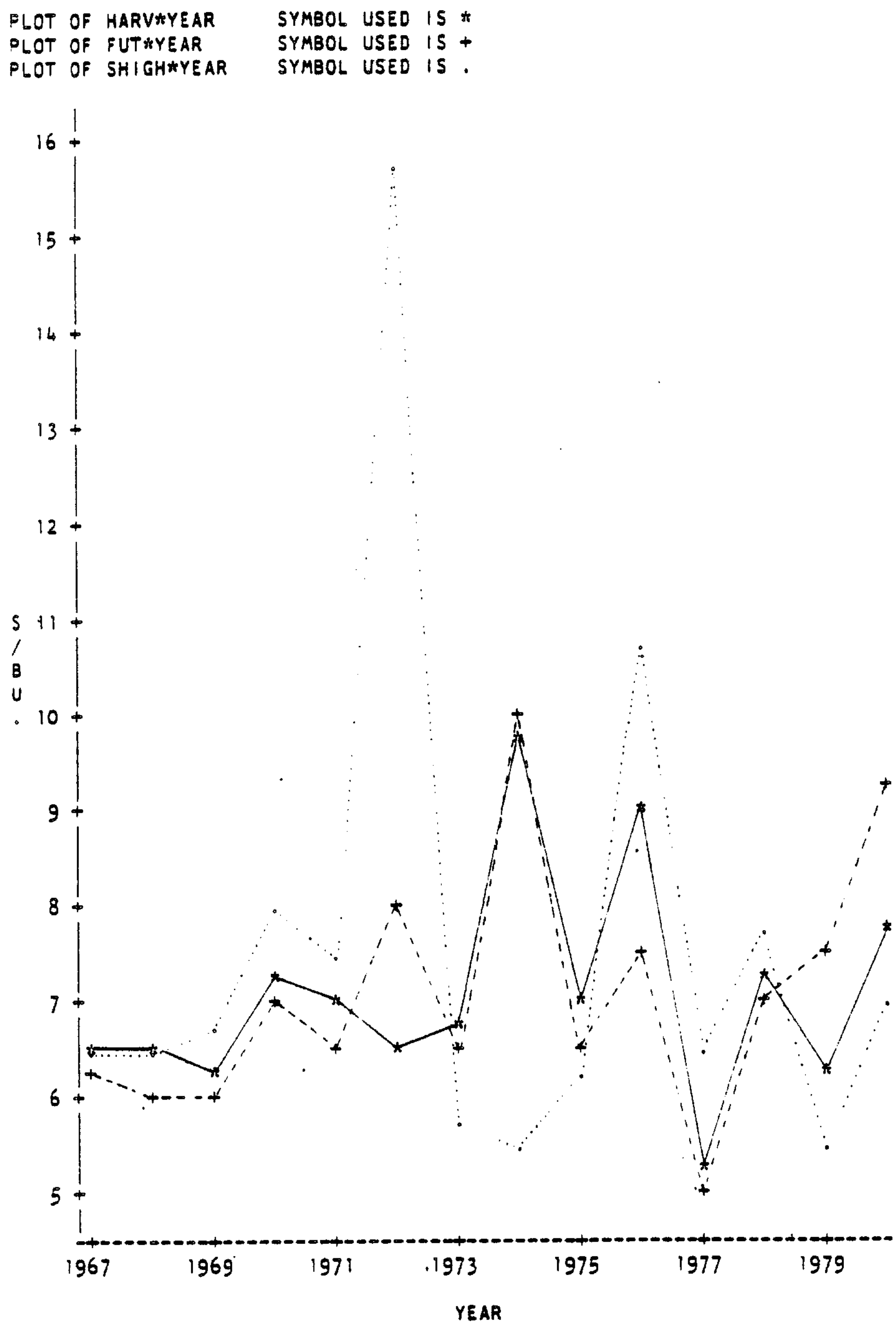


Figure 5: Soybean Prices from 3 Strategies Over 1967-1980 Period, 1981 Dollars



Prices from a cash sale at harvest were the least variable over the period. Selling at the seasonally high periods generated the highest net price in seven of the nine years and the lowest price in five of seven years compared to the other two pricing strategies. Hedging was the most profitable in 1974 and 1980.

Spreading sales during the period of seasonally high prices yields the highest prices for corn and soybeans on average during the period considered, but the sale at harvest is still the least risky for both crops.

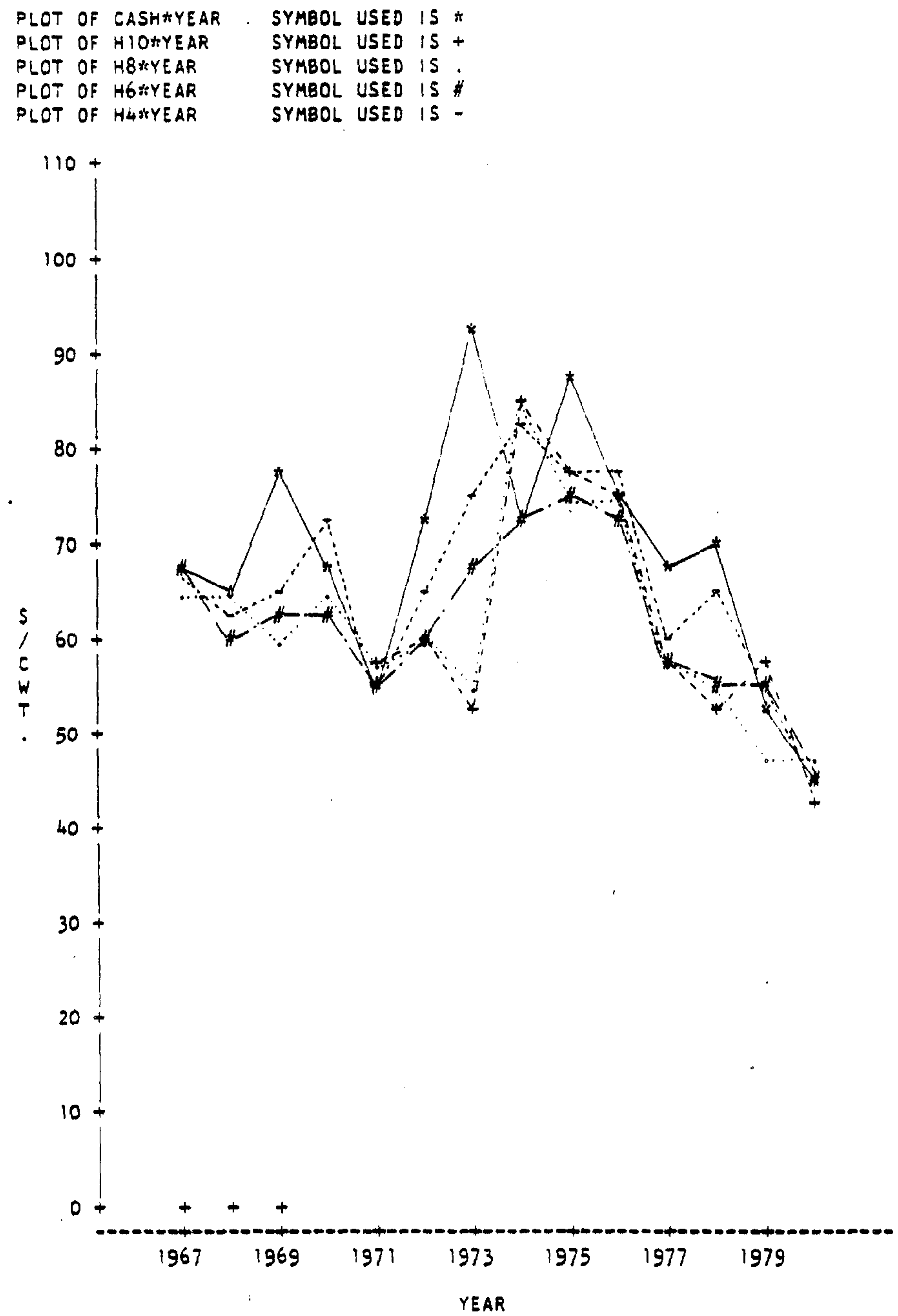
Price Risk Associated with Hogs. The price variability on the cash market and the futures market for slaughter hogs is given in Table 8. February, June, August and December are the four marketing months for hogs for the representative farm. H10, H8, H6 and H4 refer to net prices received from the routine hedging strategy with the hedge placed at 10, 8, 6 and 4 months before the hogs are ready for slaughter, respectively. Average cash prices were higher than the returns from hedging in February, August and December, and higher than all except the four month hedge in June. Many of the hedging alternatives have a lower standard deviation (price risk) than pricing at time of cash sale, but there is no consistent relation between the time of placing the hedge and the reduction in the price risk. On average, hedging stabilizes the net price received for hogs, except when the hedge is placed at the beginning of the production process (H10).

The net prices of slaughter hogs received each year from the pricing strategies over the 1967-1980 period are presented on Figure 6. The average net price over the four sale months is highest for pricing on the cash market for 1968 to 1969, 1972, 1973 and 1975. The strategy of hedging four months prior to cash sale has the highest or second highest net price in eight of the 14 years. H10 has the lowest price in four years, but the highest in three

Table 8: Price Variability Faced from 1967 to 1980 on the Cash Market and on the Futures Market for Slaughter Hogs (1981 Dollars)

Month	Strategy	Mean	Standard Deviation	Coefficient of Variation
		$/cwt.	$/cwt.	$
February	Cash Sale	67.39	10.70	15.88
	H10	60.58	7.58	12.53
	H8	58.30	10.78	18.49
	H6	59.05	15.31	25.91
	H4	62.05	13.58	21.89
June	Cash Sale	68.02	14.41	21.18
	H10	63.97	17.60	26.46
	H6	65.43	12.95	19.79
	H4	68.98	11.37	16.48
August	Cash Sale	72.87	19.97	27.40
	H10	62.77	16.42	26.16
	H8	60.66	15.92	26.24
	H6	64.14	8.50	13.25
	H4	68.36	10.95	16.02
December	Cash Sale	66.97	14.38	21.47
	H10	58.86	11.38	19.33
	H8	60.41	9.73	14.45
	H6	59.81	11.37	19.01
	H4	63.08	16.23	25.73
Average	Cash Sale	68.82	12.50	18.48
	H10	61.46	12.64	20.57
	H8	61.88	10.56	17.07
	H6	62.39	8.30	13.30
	H4	65.99	10.66	16.15

Figure 6: Slaughter Hog Prices from 5 Pricing Strategies
1967-1980 Period, 1981 Dollars



years.

In summary, the data in this section indicate, hedging has a destabilizing effect on the prices for crops, particularly corn, while it reduces the price risk for swine. The corn prices are slightly less variable than soybean prices in general.

Contribution Margin for Various Pricing Strategies

The contribution margin per acre for crops and per hog marketed refers to the sale value minus the operating costs. The variability of net returns per acre or head includes both production and price risk. The discussion in this section describes the combined production and price risk for corn, soybeans and hogs with each of the pricing strategies.

Crops. Price and production variability combine to produce highly variable year to year net returns (contribution margin) for both crops. Table 9 gives the mean, standard deviation and coefficient of variation for yield, net price per bushel and the contribution margin per acre in constant 1981 dollars for corn and soybeans. The coefficient of variation of the contribution margin is larger than the coefficient of variation of either price, production, or input cost variability. For example, the C.V. of corn yield is 19.57% and the C.V. of hedging corn is 27.62%, but the C.V. of the contribution margin is 75.08%. This is the pricing strategy with the largest C.V. of those considered here and compares to a low of 42.71% for harvest sale.

Pricing soybeans in seasonally high months has the highest average return per acre, $237.53, and the largest standard deviation, $152.08. The highest average return for corn is $170.61 for pricing with the seasonally high months strategy. The harvest sale strategy dominates the futures market hedge strategy because it has both a higher return and a lower standard deviation

Table 9: Mean, Standard Deviation, and Coefficient of Variation for the Yield, Price and Contribution Margin Per Acre for Corn and Soybeans, 1967-1980 (1981 Dollars)

		Yield Per Bushel			Net Price Per Bushel			Contribution Margin Per Acre		
Crop	Strategy	Mean	St. Dev.	C.V.	Mean	St. Dev.	C.V.	Mean	St. Dev.	C.V.
Corn	---	104.74	20.50	19.57%	--	--	--	--	--	--
	Harvest Sale				$2.748	.448	16.33%	$160.76	68.66	42.71
	Seasonally High Multiple-Months				2.816	.463	16.48	170.61	89.56	52.49
	Futures Market Hedge				2.362	.652	27.62	118.60	89.05	75.08
Soybeans	---	34.10	3.38	21.29	--	--	--	--	--	--
	Harvest Sale				$7.076	1.412	19.96%	214.83	67.54	31.14
	Seasonally High Multiple-Months				7.407	3.468	46.82	237.53	152.08	64.02
	Futures Market Hedge				7.065	1.602	22.67	214.06	76.97	35.95

for each crop. Thus the harvest sale and the seasonally high months strategies are the only two that are of interest when we consider the crops individually. However, the covariance of the contribution margin for the two crops (the extent to which the contribution margin for the two crops tends to be high or low at the same time) must be considered before excluding any pricing strategies from consideration.

As mentioned, part of the variation in contribution margin per acre is a result of variation in production costs. Figures 7 and 8 graph the cash price at harvest, the variable costs of production (CORNPR, SOYPR, CORNVC, SOYVC, respectively), and the contribution margin per bushel for corn and soybeans, respectively. Corn prices and cost of production moved in opposite directions for 1967-1972 resulting in a highly variable contribution margin per bushel. The later years exhibit somewhat less variability. Relatively constant production costs for soybeans (except for 1979) results in the contribution margin variability per bushel paralleling the variability in prices.

In short, hedging was the least profitable strategy on average for both crops and it introduced more variability in the contribution margin of corn and soybeans than the harvest sale strategy. The seasonally high strategy gave the highest average contribution margin for both crops, but it also resulted in greater variability of the contribution margin than the harvest sale strategy for the period considered.

Hogs. Contribution margin variability in hog production also includes a combination of production and price risk. Production risk encompasses variation in the amount of inputs, such as feed required per unit of gain, and variation in the cost of variable inputs. The production costs, cash price, and contribution margin per hundred pounds of slaughter hogs are graphed in Figure 9. The variable costs (SHTC) can be decomposed into feed cost and the

Figure 7: Contribution Margin, Harvest Cash Price and Variable Costs of Corn Production, (1981 Dollars)

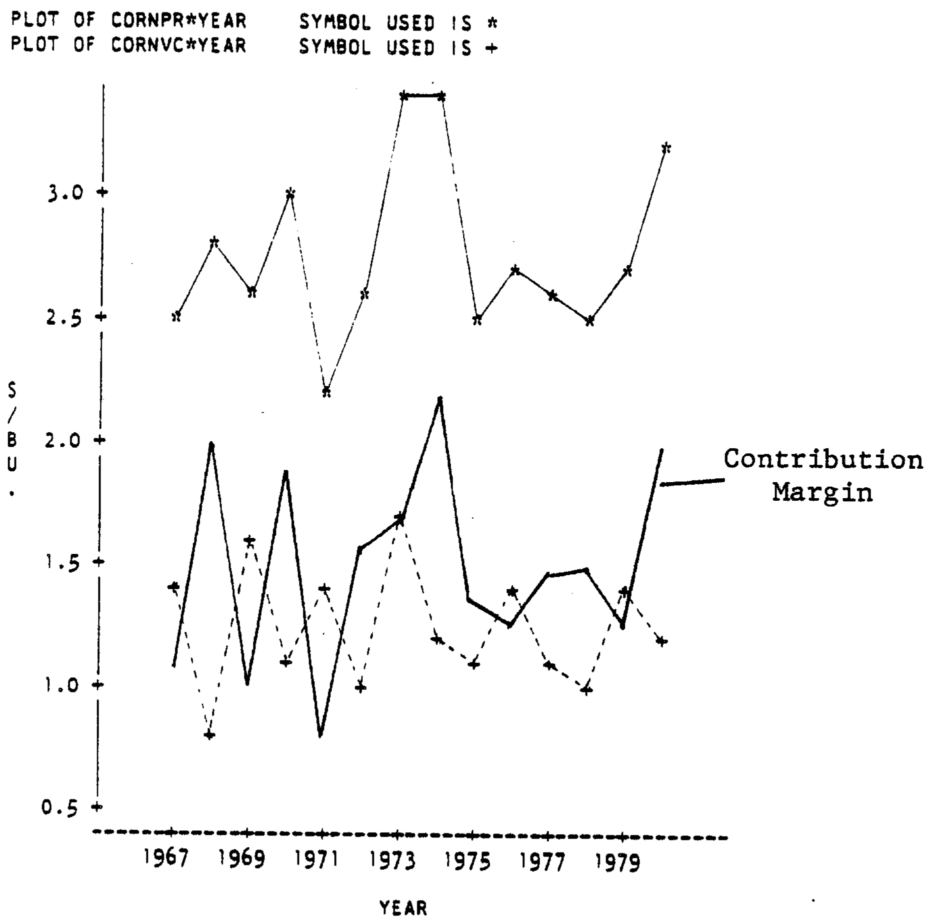


Figure 8: Contribution Margin, Harvest Cash Price and Variable Costs of Soybean Production (1981 Dollars)

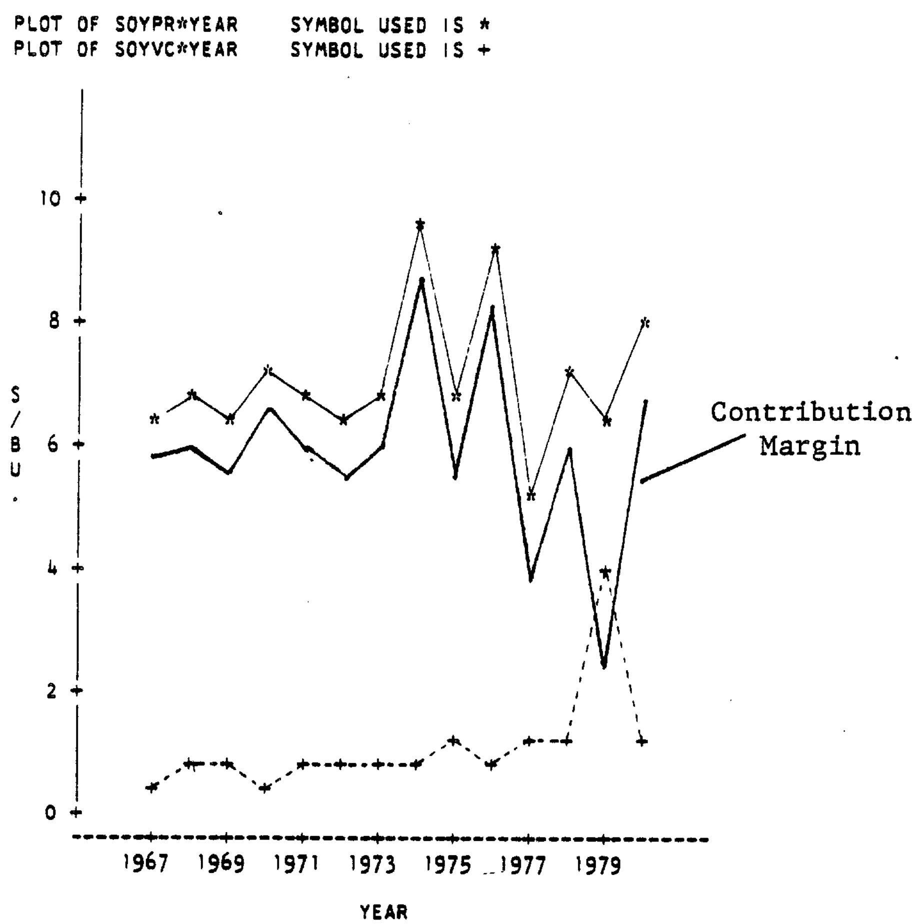
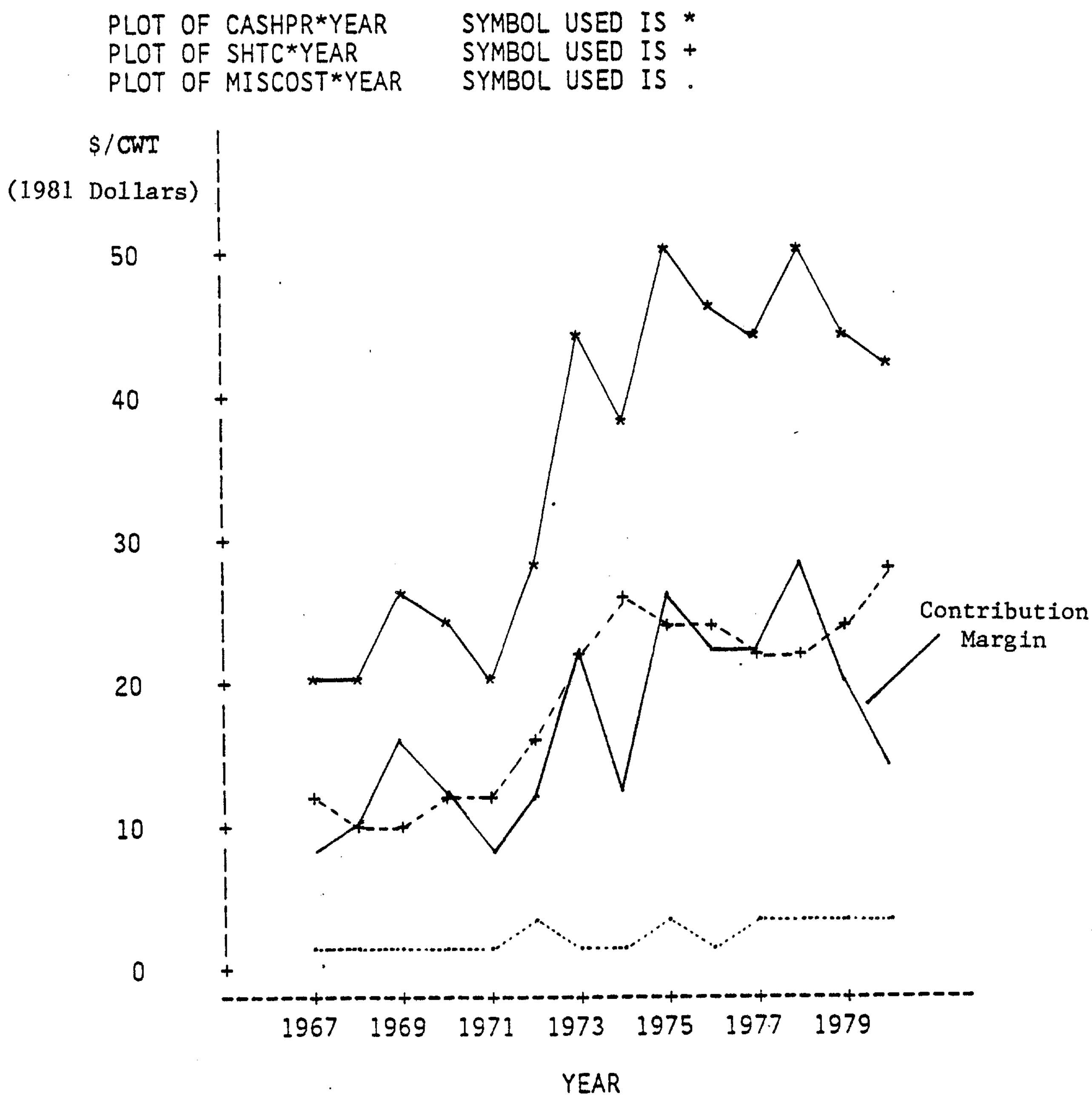


Figure 9: Contribution Margin, Cash Price and Production Costs of a Farrow-to-Finish Operation



other miscellaneous variable costs (MISCOST) such as veterinary expenses. Feed costs are represented by the band lying between SHTC and MISCOST. They are the major production cost and they increased over the period. The cash price (CASHPR) variability was the major source of the variability in contribution margin per cwt.

The highest possible contribution margin per hog for each contract month for 1967 through 1980 is presented in Table 10. For example the highest return strategy for marketing in June 1970 was to hedge four months ahead, for which a contribution margin of $109.27 per hog would have been earned. A margin in excess of $100 per head could have been earned in 1969, 1970, and 1973 to 1976 if the highest return strategy was chosen. Considering the total period of 56 monthly decision periods (4 months for each of 14 years) the cash sale strategy was optimal 29 times (59%), while the hedge strategy was optimal 27 times. (Hedge of 10, 8, 6 and 4 month ahead were used 7, 7, 4 and 9 times, respectively.) When only the last 7 years are considered, however, the cash strategy was the best 43% of the time. The data in this table do not suggest a consistent pattern of hedges for any month that is superior.

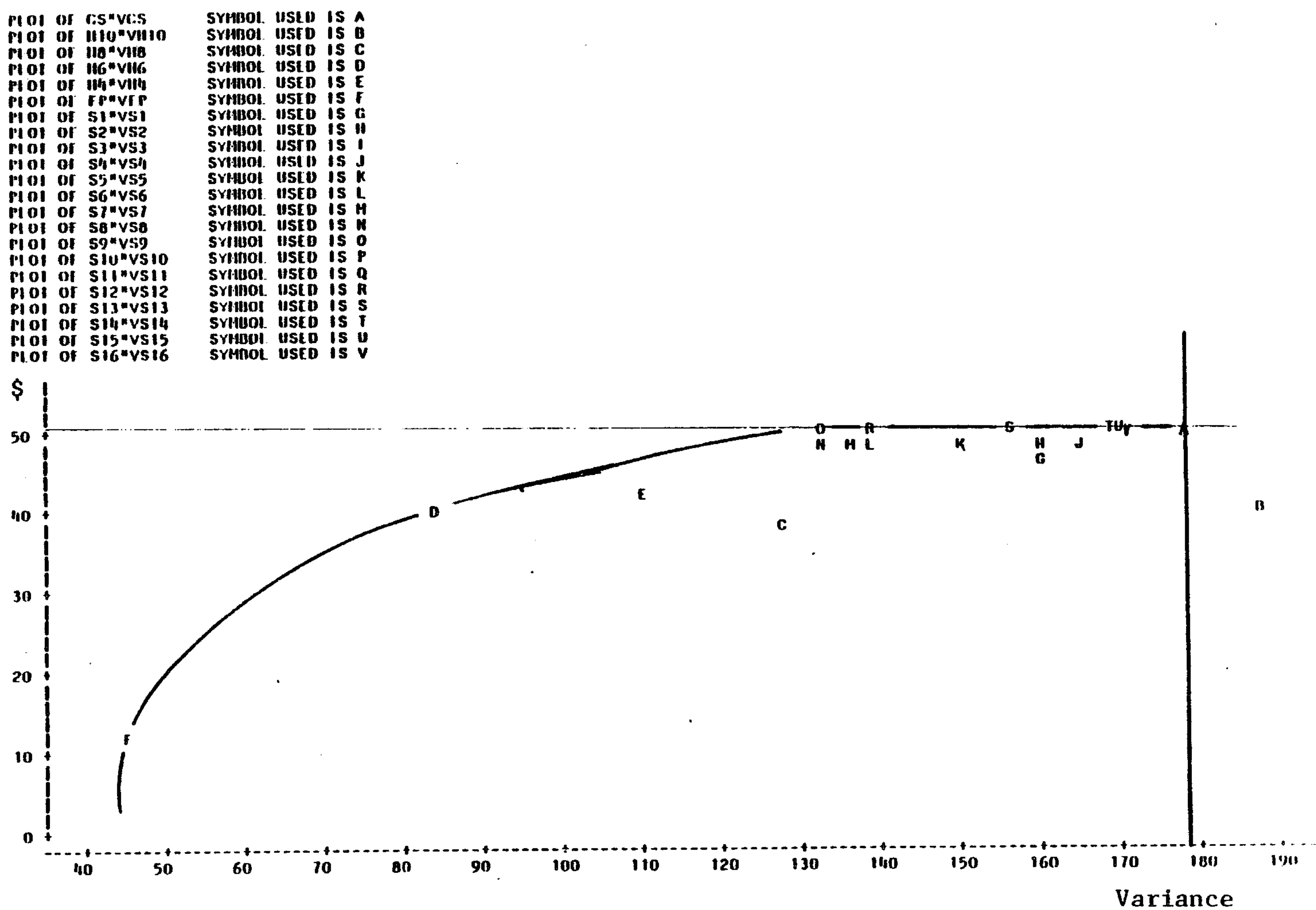
Additional insight can be gained by examining the impact of using a single marketing strategy over the entire 14 years. The mean and variance of the contribution margin per hog using alternative strategies are shown in Figure 10. Point A on the graph shows that if the cash sales strategy had been followed for this 14 year period the mean contribution margin per hog would have been just over $50 with variance of just less than $180. Points B, C, D, and E represent the mean and variance of following a routine hedging strategy for each group of hogs 10, 8, 6 and 4 months prior to marketing, respectively. The 10 month hedge (B) is dominated by the cash sale since it yields a lower mean return and greater variance. The 8, 6 and 4 month hedges

Table 10: Highest Possible Contribution Margin Per Hog, 1967-1980 (1981 Dollars)

	February		June		August		December	
Year	Strategy	Contribution Margin Per Hog	Strategy	Contribution Margin Per Hog	Strategy	Contribution Margin Per Hog	Strategy	Contribution Margin Per Hog
1967	Cash	$69.92	Cash	$92.05	H8	$91.58	H4	$80.63
1968	Cash	65.81	Cash	76.09	H4	79.82	Cash	64.17
1969	Cash	76.59	Cash	113.29	Cash	124.40	Cash	128.55
1970	Cash	114.55	H4	109.27	H6	97.75	H8	74.65
1971	H4	57.06	H8	68.55	H10	90.85	H8	76.49
1972	Cash	63.33	H4	71.85	Cash	82.19	Cash	94.43
1973	Cash	66.73	Cash	81.35	Cash	177.52	Cash	94.09
1974	H6	99.38	H10	120.41	H8	97.98	H10	91.83
1975	H10	71.96	Cash	115.57	Cash	142.24	Cash	107.83
1976	H4	142.93	H8	118.73	H10	106.08	H4	84.51
1977	H8	77.15	Cash	79.36	Cash	61.01	Cash	79.91
1978	Cash	92.49	Cash	94.03	H4	99.16	Cash	97.02
1979	Cash	90.53	H4	86.31	H6	80.77	H10	73.95
1980	H10	41.74	H6	46.55	Cash	52.54	Cash	45.76
Frequency of Sales Strategy								
Cash	8		7		6		8	
H10	2		1		2		2	
H8	1		2		2		2	
H6	1		1		2		0	
H4	2		3		2		2	

H10 = Hedge 10 months ahead of sales
H8 = Hedge 8 months ahead of sales
H6 = Hedge 6 months ahead of sales
H4 = Hedge 4 months ahead of sales

Figure 10: Mean and Variance of Yearly Net Return Per Hog, 1967 to 1980 Expressed in 1977 Real Dollars



(C, D and E) and point F, the sale of feeder pigs strategy, all provide lower mean returns and lower variance (risk) than the cash sale strategy. Of these mechanical strategies, F (sale of feeder pigs), D (hedging 6 months prior to marketing) and A (pricing on the cash market at slaughter weight) are in the efficient set.

The marketing decision model discussed previously examines the use of combinations of the above 6 routine strategies (sell slaughter hogs, sell feeder pigs and the four hedging strategies). In brief, the decision model is:

Hedge at time i months ahead of cash sales of slaughter hogs if the expected contribution margin from placing an i month ahead hedge is greater than K times the larger of the expected contribution margin from the cash sale of slaughter hogs or the expected contribution from the cash sale of feeder pigs, i.e.

$$E(\pi\ \text{Hedge}_i) \geq K \times \text{Greater of } \{E(\pi\ \text{slaughter hogs}),\ E(\pi\ \text{feeder pigs})\}$$

$$i = 10,\ 8,\ 6,\ 4 \text{ successively}$$

If no hedge is chosen then the non-hedge strategy is chosen which has the highest expected contribution margin, i.e.

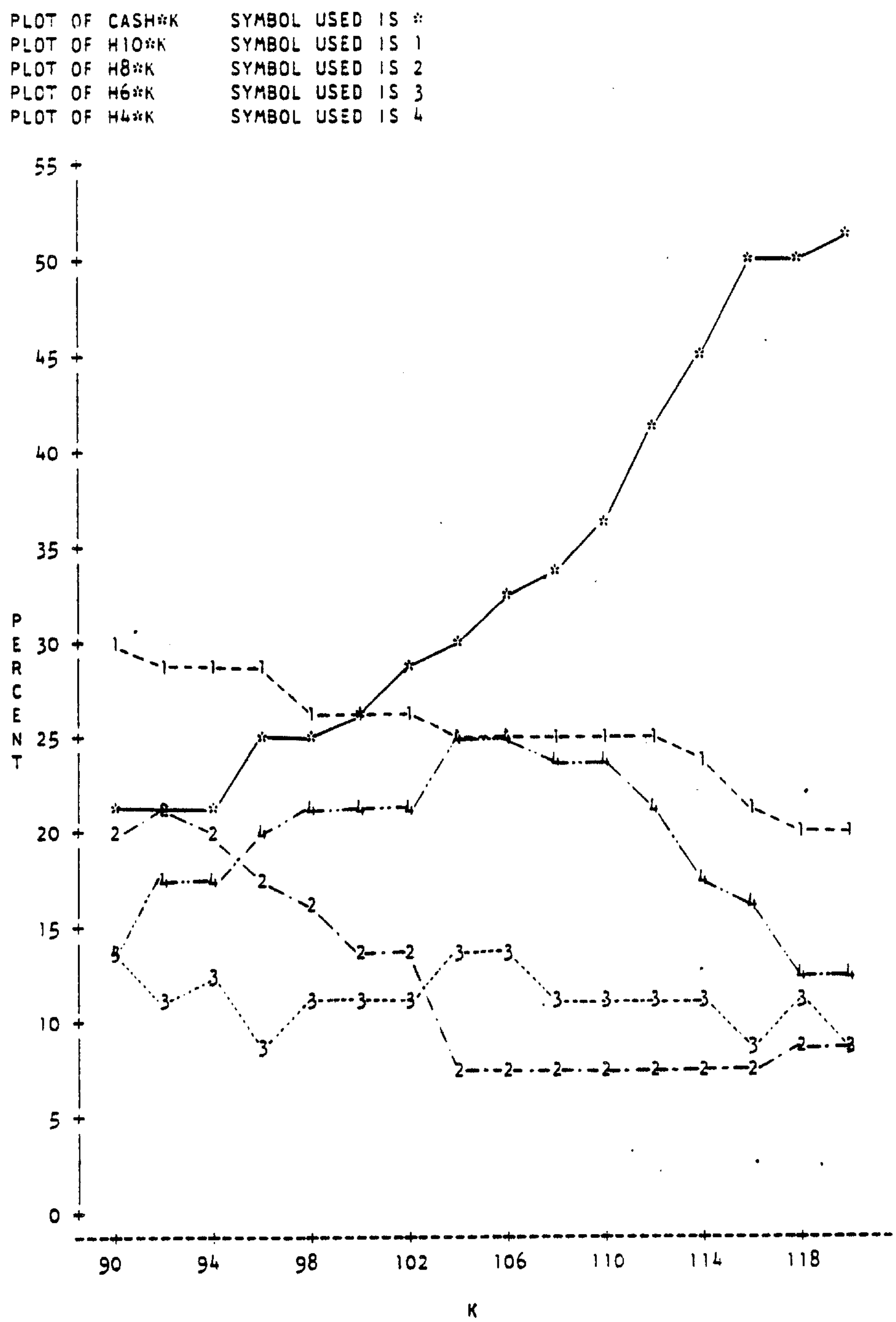
$$\text{Max } \{E(\pi\ \text{slaughter hogs}),\ E(\pi\ \text{feeder pigs})\}.$$

The value of the parameter K is ranged from .90 to 1.20 by increments of .02. The corresponding strategies are identified as G (K=.90) through (K=1.20) respectively. The selective strategies O, P, Q, (O, P and Q are equivalent in that they make the same marketing decisions each period and only O is represented) R, S, T, U, and V (representing a value of K from 1.06 (strategy) to 1.20 (strategy) have approximately the same level of expected net returns as A (cash sales), but less variance. Hence, hedging based on the criterion that expected contribution margin exceeds the net return from the cash market by at least 6 percent would have been almost as profitable on average of the four contracted months as pricing on the cash market at time of sale for the period 1967-1980. The scenarios of risk taking with K equal to 1.06 through 1.20 all dominate the cash sale strategy (A) over this time period with equivalent yearly net returns and lower variance. In general, these strategies have lower variance for lower values of K. These specific relationships hold only for the price expectations model employed in this study. 8/

It was hypothesized earlier that the various decision rules would represent various attitudes towards risk. A more risk averse decision maker will tend to hedge more often to reduce price risk. The decision rule implies less risk averse behavior as the parameter K increases in that the decision maker is willing to accept a lower and more certain return by pricing on the future's market instead of accepting the more variable and higher expected return offered by the cash market. Figure 11 shows that as K is increased from .90 to 1.20 the use of the cash market strategy increased from 22% to 52% of the time. The frequency of the hedge at the beginning of the production process (H10) decreased from 30% to 14%, and the hedge at 8 months ahead of marketing (H8) decreased from 20% to 8% as K increased over the designated range. These results support the hypothesis. The mix of marketing strategies chosen by a very risk averse person as defined above includes a higher percentage of hedges on the futures market than the mix chosen by a less risk averse person.

8/ Multiply regression models were used to represent producers expectations of net returns for slaughter hogs and feeder pigs. For more detail and discussion see Gois (1983).

Figure 11: Hog Marketing Strategies Chosen by Decision Rule Frequency Over 1967-1980 Period



In summary, the analysis of various marketing strategies for both crop and livestock suggests that the best strategy depends on the commodity traded. This analysis demonstrates that pricing strategies other than pricing slaughter hogs on the cash market or sale of crop at harvest can be as profitable for an enterprise and, in the case of hogs, less risky. Hedging had a destabilizing (i.e., risk increasing) effect on the contribution margin for the crop enterprises, while it reduced the price risk for swine.

The average price and contribution margin were reduced for all three commodities by using a routine hedging strategy. A selective hedging strategy resulted in almost equal returns and lower risk than the strategy of always pricing slaughter hogs when they are ready to market.

Efficient Farm Plans

A minimization of total absolute deviations model was used to derive the efficient set of farm plans under the various risk situations. A linear programming algorithm was used to solve for the optimal farm plan subject to a set of constraints on resource availability and the level of risk.[9/] The optimal farm plan selected is the cropping mix, and level of swine production (production strategy) and marketing strategies that provide the maximum expected contribution margin for the specified risk level. The programming model is solved for each of several alternative levels of risk and the solutions provide the efficient frontier - the farm plan at each level of

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9/ The risk level is measured within the model as the total absolute deviations about the expected contribution margin. The variance of the contribution margin was calculated from the total absolute deviations using the formula variance = $[TAD/S]^2 \left[\frac{\pi \cdot S}{2\,(S-1)}\right]$, where S is the number of years of data (14 in this study), π is 3.1416 and TAD is total absolute deviations over the 14 years.

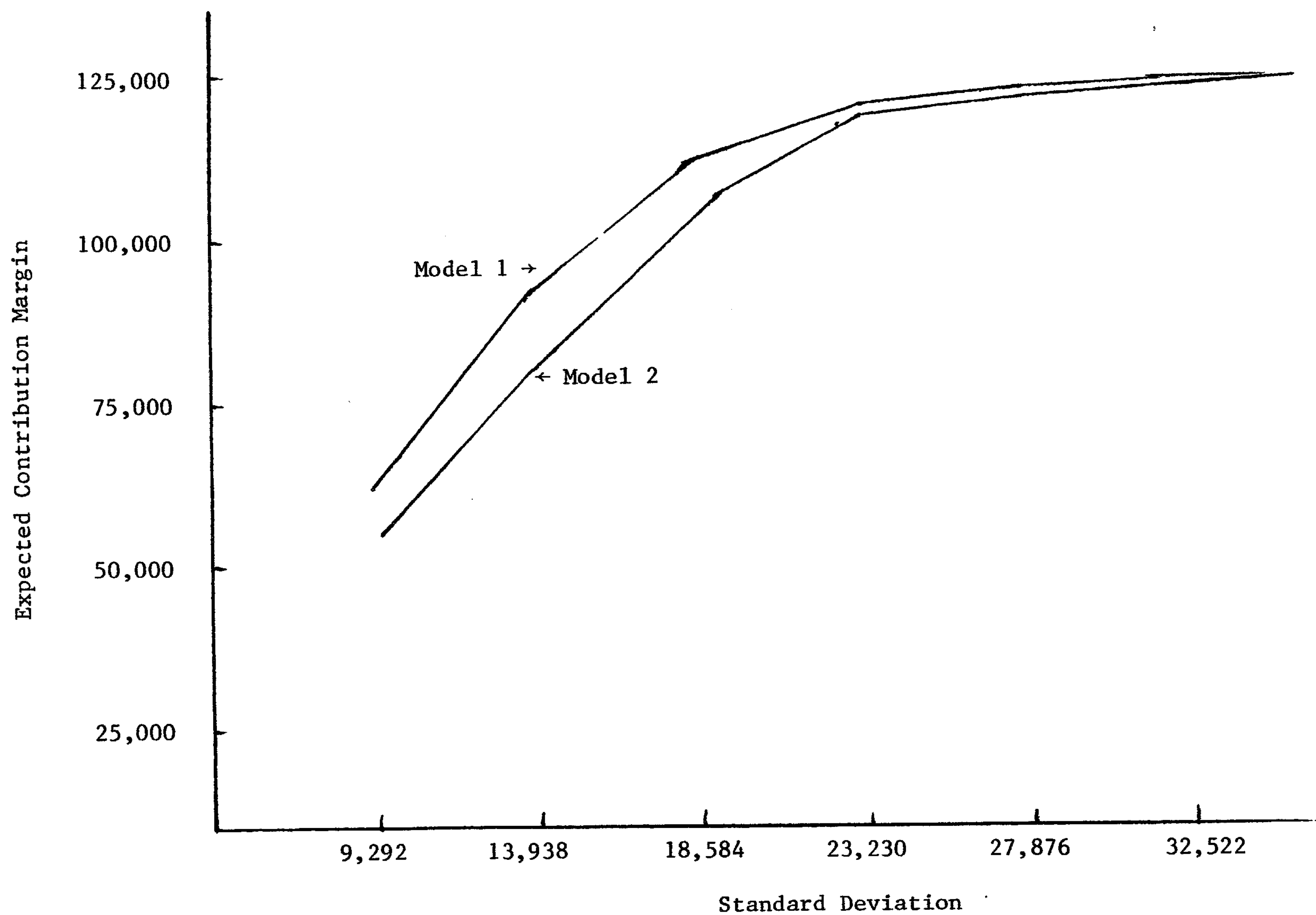
expected income having the lowest level of risk. These farm plans make up the efficient set of farm plans described earlier.

Two sets of efficient farm plans were derived. In the first, referred to as Model 1, acreage of corn and soybeans was selected ignoring rotation constraints on the crop mix. In the second, Model 2, the acreage of corn and soybeans was constrained to be equal which is consistent with the two-year corn-soybean rotation commonly followed by operators in the area.

In this discussion, the expected contribution margin, again, refers to the sale values minus the variable operating costs such as pesticides, fuel, lubrication, repairs, and variable storage cost for the crops. Feed costs, veterinary expenses, and buildings and equipment repairs are the variable operating costs for hogs. Furthermore, the charge for hired labor has been included. However, the costs of family labor, equity capital, building and equipment depreciation, and insurance are considered fixed. They have not been deducted since, by their fixed nature, they will not affect the final plan selected. All of the net income and total absolute deviations reported are in 1977 dollars.

The Trade-off Between Risk and Expected Contribution Margin. Expected contribution margin-standard deviation (E-S) frontiers for Model 1 and Model 2 are presented in Figure 12. The expected contribution margin is graphed on the vertical axis and standard deviation (the square root of the variance) is shown on the horizontal axis. Points below the frontiers are inefficient since they represent less expected contribution margin for a given level of risk (S) or greater risk for a given level of expected contribution margin (E). Points above the frontier are unobtainable given the resource availability, prices and technology assumed by the models. On the frontier the higher the expected contribution margin, the more risk that must be

Figure 12: Expected Contribution Margin - Standard Deviation Frontier for Model 1 and Model 2 (1977 Dollars)



accepted. The two E-S frontiers for Model 1 and Model 2 lie very close to each other at high levels of risk and expected contribution margin. They depart from each other at risk levels corresponding to S levels of $20,000 or less. This is shown by the small difference that exists between the risk trade-off coefficient of the two models presented on the right hand side of Table 11. This coefficient corresponds to the slope of the E-S frontier, and can be interpreted as the per dollar increase in expected contribution margin per dollar increase in risk (measured as dollars of standard deviation). This coefficient is decreasing as the expected contribution margin increases, indicating that the producer must accept more risk per dollar increase in expected contribution margin as one moves to the right along the efficient frontier.

For Model 1 the maximum expected contribution margin of $123,653 is obtained with a standard deviation of $35,393. At low levels of risk (standard deviation of $13,938 or less) and contribution margin, crop sales constitute about 55.5% of total sales (hog sales equal 44.5%). Increases in the expected contribution margin result from increases in both crop and hog sales with a relatively larger proportion coming from crop sales. The solution with the maximum expected contribution margin derives 63.2 percent of total sales from crops and 36.8 percent from livestock sales. The risk tradeoff coefficients indicate the expected contribution margin can be increased by $6.78 if the standard deviation is increased from $9,292 to $9,293. The increase in expected contribution margin per dollar increase in standard deviation is less for the higher risk-higher expected contribution margin solutions. The increase in the expected contribution margin is only $.04 for each dollar of additional standard deviation when the standard deviation is increased from $32,522 to $35,393, the solution with the largest

Table 11: Expected Contribution Margin of Crop and Hog Sales for MODEL 1 and MODEL 2 (1977 Dollars)

MODEL 1

Standard Deviation $	Expected Contribution Margin $	Crop Sales $	Crop Sales % of Total Sales	Hog Sales $	Hog Sales % of Total Sales	Risk Trade-off Coefficient a/
$ 9,292	63,315	73,262	55.56	58,604	44.44	$6.78
13,938	93,315	110,042	55.54	88,073	44.46	6.01
18,584	113,112	136,435	59.24	93,873	40.76	3.36
23,230	121,846	155,176	62.77	92,034	37.23	1.13
27,876	122,797	155,929	63.08	91,272	36.92	.17
32,522	123,529	156,676	63.19	91,272	36.81	.04
35,393	123,653	156,676	63.15	91,396	36.85	

MODEL 2

Standard Deviation $	Expected Contribution Margin $	Crop Sales $	Crop Sales % of Total Sales	Hog Sales $	Hog Sales % of Total Sales	Risk Trade-off Coefficient a/
$ 9,292	53,609	59,313	58.54	42,009	41.46	$5.73
13,938	80,109	88,998	58.52	63,077	41.48	5.64
18,584	105,515	119,472	59.09	82,728	40.91	4.81
23,230	119,599	147,646	63.01	86,689	36.99	1.43
27,876	122,733	156,231	64.05	87,686	35.95	.17
32,522	123,449	156,962	64.16	87,676	35.84	.15
35,656	123,614	157,022	64.18	87,681	35.82	

a/ The risk trade-off coefficient is the increase (decrease) in the expected contribution margin for a one dollar increase (decrease) in the standard deviation.

expected contribution margin. While many farmers would prefer a plan that provides $6.00 of additional contribution margin for a $1.00 increase in risk, relatively few farmers would prefer accepting an additional dollar of risk for only $.04 of additional expected contribution margin.

Model 2 has a lower expected contribution margin for each risk level because returns are foregone to meet the rotation constraint. Model 2 shows increases in both crop sales and hog sales as risk increases. Like Model 1, however, crops make up a larger proportion of total sales for the higher return-risk solutions.

Effect of Risk on Production Strategies. Both production and marketing decisions are considered in minimizing risk. Production decisions which correspond to the number of acres grown of each crop and the number of hogs raised are presented in Table 12 for Model 1. As the tolerable risk level is increased, the crop acreage increases, the number of acres left idle decreases and the number of hogs that are produced increases initially and then declines. This result suggests the farrow-to-finish swine enterprise is less risky than the crop enterprises considered. Some land remains idle at low risk levels because this is the lowest risk combination of the enterprises to provide the expected contribution margin indicated. The percentage of land planted to corn decreased from 71% to 56% as the risk level (standard deviation) increased from $9,292 to $35,393. This demonstrates that soybeans are the more risky crop. Those solutions utilizing all of the cropland have 58 to 56 percent of the land planted to corn and from 42 to 44 percent planted to soybeans. This proportion of corn and soybeans is commonly observed on Southwestern Minnesota crop farms.

The crop acreage and size of hog enterprise for the equal mix of corn and soybean crop rotation farm plan (Model 2) is given in Table 13. Land is idled

Table 12: Crop Acreage and Size of Hog Enterprise Under Selected Risk Levels with Model 1

Expected Contribution Margin	Standard Deviation	Acreage		Percentage Planted in		Idle Acres	Number of Hogs
		Corn	Soybeans	Corn	Soybeans		
$ 63,315	$ 9,292	290.49	117.07	71.28	28.72	375.44	1177.5
93,315	13,938	435.26	175.65	71.25	28.75	149.08	1766.5
113,112	18,584	437.86	261.39	62.62	37.38	60.75	1841.1
121,846	23,230	444.04	315.96	58.43	41.57	0	1765.9
122,797	27,876	429.95	330.04	56.57	43.43	0	1746.6
123,529	32,522	429.95	330.04	56.57	43.43	0	1746.6
123,653	35,343	429.95	330.04	56.57	43.43	0	1746.6

Table 13: Crop Acreage and Size of Hog Enterprise Under Selected Risk Levels with Model 2

Expected Contribution Margin	Standard Deviation	Acreage Corn	Acreage Soybeans	Idle Acres	Number of Hogs
$ 53,609	9,292	152.9	152.9	454.1	840.7
80,109	13,938	229.4	229.4	301.2	1261.1
105,515	18,584	304.4	304.4	151.3	1650.0
119,599	23,230	360.2	360.2	39.6	1661.0
122,733	27,876	380.0	380.0	0	1677.7
123,449	32,522	380.0	380.0	0	1677.7
123,614	35,656	380.0	380.0	0	1677.7

at even higher risk levels with Model 2 than Model 1 because there is no other way to reduce risk associated with the cropping enterprise once a shift in the crop mix is precluded.

The plan that maximizes the expected contribution margin for Model 1 includes 1746 hogs, 69 more than the 1677 included in the high profit plan with Model 2. Fewer hogs are produced in the Model 2 solution because of the increased soybean acreage in the farm plan. Soybeans and hogs compete for labor during early June.

Effect of Risk on the Crop Marketing Strategies. The crop marketing decisions concern how many bushels to sell with each pricing strategy. This decision is quantified in terms of acres of corn or soybeans for which output is marketed by each of the pricing strategies to analyze the interaction effect of corn and soybean marketing and production decision. These results are presented in Table 14. The notation Harv., Shigh., Fut. denotes sale at the time of harvest, during the seasonally high price months, and with use of the futures hedging strategies, respectively. (This notation is used in subsequent tables as well.)

A decision maker who desires to maximize expected returns (highest risk) would hedge corn and soybeans at harvest and sell the grains (and close out the futures position) in May.[10] In the first farm plan (Model 1), no corn is priced on the futures market until the acceptable risk level reaches a standard deviation of $27,876, or more. Below that level, corn is sold at harvest and fed to hogs. Part of the soybeans are sold in the seasonally high priced months when the risk level is in the standard deviation range from

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[10] This result is specific to the expectations for the particular year 1981. It is not a general conclusion.

Table 14: Crop Acreage by Marketing Strategy Under Selected Risk Levels

	Model 1							Model 2						
Standard Deviation	Corn Sale Harv.	Corn Sale Shigh.	Corn Sale Fut.	Corn Fed	Soybeans Sale Harv.	Soybeans Sale Shigh.	Soybeans Sale Fut.	Corn Sale Harv.	Corn Sale Shigh.	Corn Sale Fut.	Corn Fed	Soybeans Sale Harv.	Soybeans Sale Shigh.	Soybeans Sale Fut.
$ 9,292	162.1	-	-	128.3	-	18.0	99.1	61.3	-	-	91.6	101.4	30.4	21.2
13,938	243.3	-	-	192.0	-	26.9	148.7	91.9	-	-	137.5	152.1	43.5	31.8
18,584	237.8	-	-	200.0	-	34.6	226.7	125.1	-	-	179.3	179.4	59.9	67.2
23,230	252.0	-	-	192.0	-	-	315.9	179.8	-	-	180.4	-	39.9	320.3
27,876	136.3	-	103.8	189.9	-	-	330.0	143.7	-	53.8	182.5	-	-	380.0
32,522	-	-	240.1	189.9	-	-	330.0	11.1	-	186.4	182.5	-	-	380.0
35,393	-	-	240.1	189.9	-	-	330.0	-	-	-	-	-	-	-
35,656	-	-	-	-	-	-	-	-	-	197.5	182.5	-	-	380.0

$9,292 to $18,584. However soybeans are hedged in increasing amounts as the acceptable risk level is raised.

The marketing strategies chosen in the crop rotation farm plan (Model 2) do not differ greatly when one considers equal acreage of the two crops must be produced. As noted earlier, the acreage of corn is less and the acreage of soybeans is greater with Model 2 for a comparable income level. The reduction in the quantity of corn priced due to the rotation constraint occurs primarily in the harvest strategy. The other important difference is that the sale at harvest pricing strategy for soybeans is used at a risk level of $18,584 and below, and the sale in the seasonally high priced months strategy is used at a higher level of risk than in the first plan.

<u>The Effect of Risk on the Hog Marketing Strategies</u>. The hog marketing decision refers to the number of head priced with each strategy. The decisions for various risk levels are presented in Table 15. A combination of cash sales, hedging and the selective rule is chosen to price hogs for all risk levels for both Model 1 and Model 2, except the solution having the highest level of expected contribution margins. At standard deviations of $9,292 to $18,584 cash sales and routine hedging are the principal pricing strategies used. The selective decision strategy does enter for Model 1 with K equal 92 and for Model 2 with K equal 102 at standard deviations of $9,292 and $13,938. As the allowable risk level is increased beyond a standard deviation of $18,584, the overall marketing strategy becomes a combination of cash sales and the selective decision rule for both models. In both models as the risk level increases the value of K associated with the selective strategy chosen increases.

The hog marketing strategies chosen by Model 1 are consistent with a "more risk averse behavior" in the sense that the hedges are placed earlier in

Table 15: Hog Marketing Decisions Selected Under Various Risk Levels (Number of Hogs Sold by Strategy)

Standard Deviation	Model 1						Model 2				
	Cash Sale	H8	H4	K=92	K=112	K=114	Cash Sale	H4	K=102	K=112	K=114
$ 9,292	674.0	127.5	69.2	306.7	-	-	398.3	206.0	236.4	-	-
13,938	1011.2	191.9	104.7	458.7	-	-	597.5	308.9	354.6	-	-
18,584	1112.1	188.3	-	-	540.7	-	812.1	372.4	466.5	-	-
23,230	888.8	-	-	-	877.2	-	1128.6	-	-	532.5	-
27,876	921.5	-	-	-	-	825.1	948.7	-	-	-	729.1
32,522	807.0	-	-	-	-	939.5	880.0	-	-	-	975.2
35,393	1746.6	-	-	-	-	-	-	-	-	-	-
35,656	-	-	-	-	-	-	1677.8	-	-	-	-

the production process and a more conservative selective strategy is followed (K=92 instead of K=112) than in Model 2. Recall that at low levels of risk, the best production strategy for Model 2 with the crop rotation constraint imposed was to leave more than 50 percent of the land idle and to significantly reduce the hog enterprise. At low risk levels Model 1 selects pricing strategies for hogs that have a smaller standard deviation than those included in the Model 2 solutions because this combination of crop and livestock production and pricing strategies provides, the maximum expected income for the magnitude of the standard deviation given.

Increasing the acceptable risk level results in the selection of hog marketing decisions that correspond to more risk taking behavior; i.e. the K value of the selective strategies increased from 92 to 114 and less hogs are hedged on the futures market. The model also calculates the marginal value of a nonoptimal pricing strategy, that is the reduction in expected returns that would result from selecting a nonoptimal pricing strategy for swine. The selective strategies with a K value ranging from 108 to 120 have marginal values that are less than $3 per head lower than the optimal ones when the standard deviation is above $18,584. Therefore, they could be substituted for the efficient strategy selected by the model without a great loss in the expected contribution margin. The routine hedges denoted by H10, H8, H6 and H4 have a much higher marginal value (that is, using them would reduce the contribution margin by a larger amount) than any of the selective strategies at a standard deviation above $18,584. The sale of feeder pigs has been included in this study as an alternative strategy, but the marginal value shows that this strategy will be efficient only at very low risk levels. The analysis of the marginal value of the hog marketing strategies with the crop rotation farm plan (Model 2) gives similar results.

Effect of Risk on Resource Use. The optimum farm plan is constrained by the availability of land, labor, machinery and the number of good field days, as well as level of risk. The marginal value (or shadow price) of the resources indicate the increase in expected contribution margin that would result if one more unit of the resource was available. For example, the shadow price of the land represents the change in contribution margin of an additional acre in the most profitable crop-price strategy. In the case of land, one additional acre available at no cost would increase expected contribution margin of the high risk solution $36.10 for Model 1 and $35.36 for Model 2. The value of an additional acre declines as the acceptable level of risk is reduced. For Model 2, the value of an additional acre decreases to $10.16 at a standard deviation of $23,230 and it is zero when the standard deviation is $18,589 or less, because the optimum plan includes unused land. Obviously, adding another acre to unused land would not increase the expected contribution margin. The solutions for Model 2 include unused land when the standard deviation is $23,230 or less. Thus, the marginal value of land is zero when the standard deviation is $23,230 or less.

Two full time workers and one part time worker are assumed to be available on the farm. The total number of hours required for the farm plans selected at the various risk levels is shown in Table 16. The total hours required vary from 3620 to 2261 for the farm plans chosen with Model 1 and from 3464 to 1641 for the plans selected by the Model 2. The most constraining periods are June 1 to June 8 when the post planting activities must be done, October 9 to October 16 when soybeans are harvested, November 9 to November 16 when some corn is harvested and the land must be prepared for the next crop year. The same periods are found to be constraining with Model 2.

Table 16: Labor Use for Selected Farm Plans (Number of Hours)

	Model 1			Model 2		
Standard Deviation	Total	Full Time	Part Time	Total	Full Time	Part Time
$ 9,292	2261.9	2227.9	34.0	1641.1	1641.1	0
13,938	3392.7	2947.4	445.3	2461.8	2385.3	76.5
18,584	3620.5	2990.8	629.7	2923.8	2886.3	346.5
23,230	3587.7	2995.8	591.9	3388.9	2953.6	435.3
27,876	3560.5	2996.1	564.4	3463.7	2987.9	477.8
32,522	3560.5	2996.1	564.4	3463.7	2985.9	477.8
35,393	3560.5	2996.1	564.4	-	-	-
35,656	-	-	-	3463.7	2985.9	477.8

Summary

This part of the analysis estimated the magnitude of production and commodity price risk for a diversified corn, soybean and hog business in Southwestern Minnesota. It also identified and evaluated alternative production and pricing strategies farmers can use to maximize the expected contribution margin for given levels of risk. The analysis considered the major commodity pricing alternatives available to farmers in the area for these three commodities. The static optimization model used in the analysis maximized the expected contribution margin subject to constraints on land, labor, capital use and the level of risk. The model was solved for each of several levels of risk to obtain data on the combination of production and pricing strategies that maximizes contribution margin for each level of risk.

Several pricing strategies for the crops and hogs were identified. Those considered for crops were cash sale at harvest, cash sale during months that have historically experienced highest price for the marketing season, and placing a hedge at harvest and lifting it in May at the time of cash sale of the corn and soybeans. In addition, corn could be fed to hogs. The pricing strategies considered for hogs included selling feeder pigs on the cash market at slaughter weight, and selling hog futures contracts at 10, 8, 6 or 4 months before the animal reached slaughter weight with the futures contract repurchased at the time the hogs are sold on the cash market. In addition, a selective hedging strategy for hogs was implemented based on the relationship between the expected return from a cash sale and the return from a hedge strategy.

A risk linear programming model was developed to integrate the various production and pricing strategies in a whole-farm planning context. Two possible scenarios were analyzed. In the first, the model selected the most efficient combination of corn and soybean acreage (Model 1). In the second, Model 2, corn and soybeans were constrained to rotate each year and therefore, the same corn and soybean acreage had to be grown. The efficient farm plan was selected for each of several risk levels for the two scenarios.

For livestock marketing, the analysis indicates that following a routine hedging strategy lowers both the expected value and the variance of the contribution margin compared to a cash sale or a selective strategy. Placing a hedge very early in the production process results in lower average returns and more variability than hedging later. Another result is that more hogs were hedged early in the production process when more risk averse behavior was specified.

Only pricing on the cash market and routine hedging strategies were analyzed for corn and for soybeans. Selling corn and soybeans at the high seasonal price was the most profitable on the average for the historical period, but pricing on the cash market at harvest was the least risky. More research could be undertaken to develop and evaluate a flexible pricing strategy for each crop. The results for pricing of swine suggest such flexible strategies may be preferable to the more mechanical strategies analyzed here.

Considering all production and pricing possibilities, the analysis indicates the farm plan that maximizes the expected contribution margin is composed of 430 acres of corn, 330 acres of soybeans and the sale of 1746 head of hogs annually (Model 1). Model 2 required equal acreage of corn and soybeans (380 acres of each) and included 1677 head of hogs in the plan that maximizes the contribution margin. Both of these plans hedged corn and soybeans on the futures markets and hogs are priced on the cash market.

As the risk level is reduced with Model 1 more corn is grown, hog production increases and soybean production decreases. More corn is priced on the cash market at harvest and fed to hogs while less is priced on the futures market. The decreased production of soybeans is hedged on the futures, while approximately one-half of the hogs are priced on the cash market and the other one-half are sold with the selective strategy.

As the limit on risk is reduced to a standard deviation of less than $23,230, the production of both crops declines and some land remains idle. At this level of risk, all corn is sold at harvest, while soybeans are priced using a combination of hedging and the seasonally high strategy. Hogs are priced primarily on the cash market at slaughter weight, with a smaller amount hedged at 8 months and 4 months, and with the selective strategy.

In the crop rotation farm plan scenario, Model 2, similar results were derived for the crop and hog marketing strategies. The main difference occurs when risk is limited to a standard deviation of less than $18,584. In this case one half of the hogs are priced on the cash market and one-fourth are priced with a selective hedge placed only if the expected returns from doing so are greater than 1.02 times the expected cash returns, and one-fourth are priced using a routine hedge placed 4 months prior to marketing.

This study shows that increasing the livestock enterprise and reducing the crop activities decreases the combined production and price risk, and that farmers should consider alternative pricing methods for their crop and livestock enterprises. Use of the futures market was found to reduce the risk in pricing hogs, but not in pricing crops. Routine hedging decreased the expected net return per head of hogs, but a selective hedging strategy was nearly as profitable and somewhat less risky than a cash sale strategy. This study implies that Minnesota swine producers should consider selective hedging as a common marketing practice. Selective hedging could increase income, improve the cash flow of the enterprise and decrease the risk. However, they must also be aware that any hedging strategy is a source of financial risk, because a hedger must be ready to meet the margin calls.

This part of the analysis was limited to price and production risk. Financial risk, the third type discussed in the introduction, is analyzed in the following section.

ANALYSIS OF FINANCIAL RISK

Beyond business risk, a farmer also faces financial risk if he/she employs debt financing in the farming operation. Financial risk differs from business risk, which results from the variations in product prices, yields, and nonfinance input costs that face all firms - including those which use no debt financing. Financial risk concerns the additional variability of net cash flows which results from the debt service requirements and lease payments which accompany the use of debt or quasi-debt (e.g., long term leasing) sources of funds. Although both business and financial risk relate to each other, they are separate risks that a farmer faces. Until recently, farmers were primarily concerned with business risk. However, increased interest rate variability and debt use has resulted in financial risk becoming an increasingly important farmer concern.

Financial risk encompasses two main components, credit availability and price variability. Credit availability depends upon a lender's available funds position and a lender's evaluation of the loan request. Certain lenders, particularly rural banks, occasionally face fund shortages. The usual response is to ration credit among the lender's borrowers. The lender may, for example, elect to prioritize credit requests and service the highest priority ones first (e.g., requests for operating credit) while financing lower priority requests (e.g., those to finance expansions or other fixed asset acquisitions) only to the extent permitted by available funds. In addition, credit availability hinges upon the lender's evaluation of the loan request. The evaluation includes an examination of the borrower's credit history, loan purpose and financial position. If the credit is obtained, a farmer then faces price variability of credit if the loan agreement provides for a variable interest rate. 11/

A farmer's credit needs arise from either the farm's operating cycle or capital investment cycle. The operating cycle requires funds to bridge the gap between purchase of an input, such as seed or feeder pigs, until the sale of an output, such as grain or finished hogs. The capital investment cycle, however, requires funds to obtain buildings and equipment which provide services over several operating cycles. In a general sense, farmers borrow to close cash flow gaps in their production patterns - including those generated by the capital investment cycle as well as those resulting from the operating cycle. Borrowing, however, introduces the financial risks of credit availability and interest rate fluctuations.

Method of Analysis

A relatively recent method for analyzing economic problems is simulation analysis. The popularity of this method rests in its ability to allow for interaction between variables and time. In contrast, optimization techniques are best suited for dealing with static, single period problems. Obviously the major disadvantage of simulation analysis is that these models do not in general define what is best or suggest the normative rules of maximization.

11/ A variable interest rate on a loan calls for the interest rate to vary over the loan period in response to changes in a key interest rate such as the prime rate.

Simply, simulation analysis consists of two basic steps. First is the development of the basic or base model economic problem. Mathematical models suitable for computer applications are used. This base model needs to capture, as accurately as possible, the true relationship between the. variables being examined. The second step of simulation analysis is to examine the effect that changes in the key variables have on the performance variables of the basic model. The simulation analysis for this study will be: a) nonstochastic, in that it does not include any random components, and b) dynamic in the sense that it covers several periods of time.

Representative Farm Simulation

To gain insights into the financial risk that farmers face the representative farm used in the analysis of price and production risk was simulated over time to analyze differing financing situations. However, for all the different financial situations the production and marketing patterns and, therefore, business risk are held constant to enable isolation of financing related effects. The simulation used farm data for the period 1967 through 1982. The actual cropping patterns and hog production levels for this period for the crop farm in Cottonwood County and the hog farm in Scott County provide the production basis for the model. The data are taken from the detailed records maintained by the Minnesota Farm Management Associations. The nominal prices are specific to southwestern Minnesota. Nominal (actual) prices are used in this portion of the study since the impact of inflation over time is a primary factor contributing to interest rate variation and thus financial risk. Debt financing is assumed to be obtained from either the local bank or local Farm Credit System (FCS) agencies.

The following summarize the data employed in the simulation model. Figure 13 and Table 17 show the actual variation in corn yields experienced on

Figure 13: Corn and Soybean Yields on the Representative Farm, 1967-1982

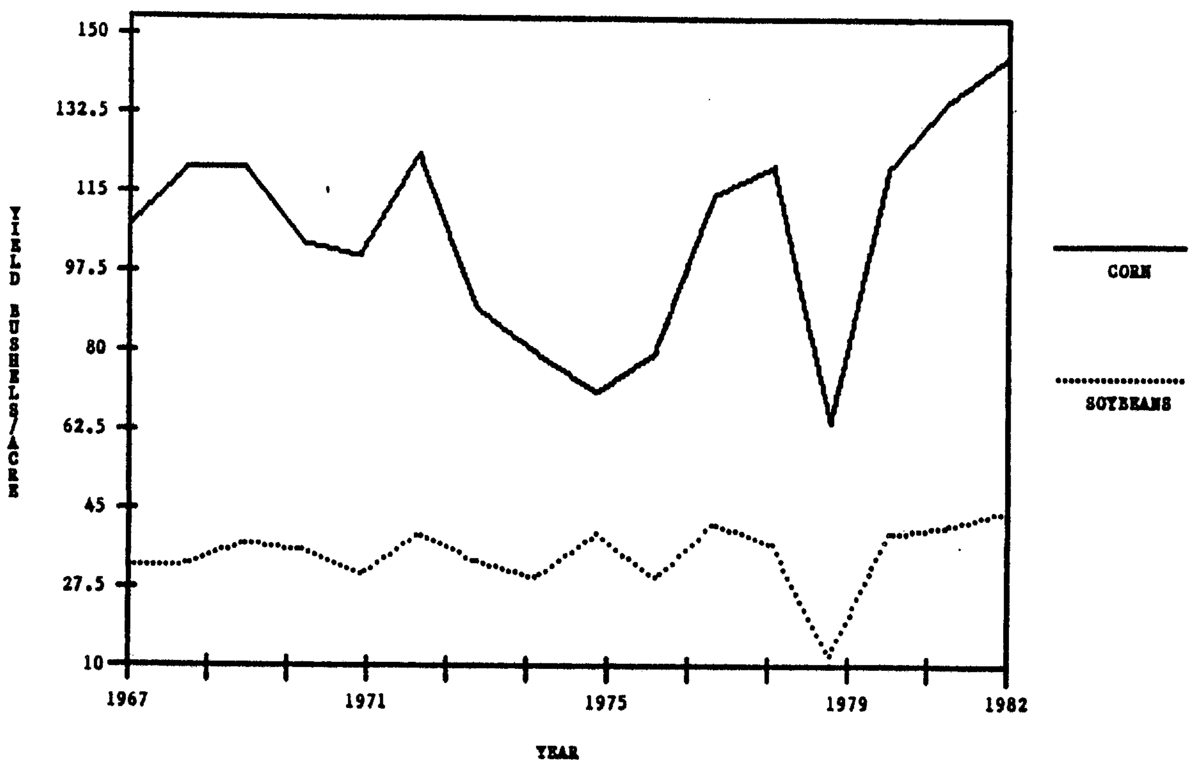

Table 17: Representative Farm Corn Data, 1967-1982

			Cash Costs/Acre			
Year	Acres	Yield (bu)	Seed,Fert,Chem	Other,Dry	Farm Mach	Total
1982	398	145.5	$78.50	$14.13	$31.94	$124.57
1981	374	135.9	83.76	20.24	35.19	139.19
1980	393	121.2	73.54	16.51	28.29	118.34
1979	352	64.5	57.97	0.30	14.17	66.44
1978	323	121.3	60.05	0.00	13.17	73.22
1977	329	115.2	57.38	0.00	12.70	70.08
1976	333	80.0	49.00	0.00	10.18	59.18
1975	231	71.4	26.00	0.00	6.91	32.91
1974	234	80.0	32.00	0.00	7.28	39.28
1973	230	90.0	55.00	0.00	10.61	65.61
1972	228	123.5	31.00	0.00	7.14	38.14
1971	252	101.3	37.00	0.00	7.96	44.96
1970	236	104.7	27.00	0.00	5.88	32.88
1969	220	120.9	43.00	0.00	9.73	52.73
1968	225	121.0	19.00	0.00	4.47	23.47
1967	234	107.9	36.00	0.00	7.00	43.00

the farm from 1967 through 1982. Soybean yields in Figure 13 and Table 18 for this farm are more stable except for a significant drop in 1979.

The local prices in Figure 14 and Table 19 are for crops raised and hogs finished in the simulation analysis. These are the yearly average of prices taken the second Wednesday of every month from a local grain terminal. This simulation follows an assumed pricing strategy of selling the stored crops during the seasonally high-price months. The two seasonally highest price months for corn proved to be January and July. Since for this analysis the farm stores 100 percent of its crop, the previous year's corn crop is marketed by selling one-half in January and one-half in July. The previous year's soybean crop marketing plan has sales of one-half the crop in March and one-half in May, since March and May proved to be the two seasonally high priced months for soybeans.[12]

The variation in actual corn cash costs of production is given in Figure 15 and Table 17. The seed-fertilizer-chemical component makes up the majority of total costs. The farm machinery component remains fairly constant until 1979. Drying and other expenses are only accounted for from 1979 onward.

Figure 16 shows the per acre gross cash returns, (per acre yield times price) against per acre (cash) operating costs for corn. The contribution margin or net return is fairly steady until 1974. After 1974 net returns exhibit a great deal of year-to-year variability.

Soybean cost per acre shows seed-fertilizer-chemicals as the major cost component until 1980 as seen in Figure 17 and Table 18. In 1980, the farm

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[12] These are modified versions of the seasonally high marketing strategy used previously. The corn seasonally high strategy sold equal amounts in December, January, February, May, June and July; the soybean seasonally high strategy had equal sales in March, April, May and June.

Table 18: **Representative Farm Soybean Data, 1967-1982**

Year	Acres	Yield (bu)	Cash Costs/Acre			
			Seed,Fert,Chem	Other,Dry	Farm Mach	Total
1982	368	44.4	$31.26	$2.86	$26.13	$60.25
1981	362	41.8	21.48	0.00	28.79	50.27
1980	370	40.0	20.74	1.26	23.15	45.15
1979	490	12.7	27.20	0.72	12.81	40.73
1978	367	37.4	21.36	1.42	10.77	33.55
1977	353	42.2	22.07	0.00	10.39	32.46
1976	358	30.0	7.00	0.00	5.39	12.39
1975	175	40.0	14.00	0.00	7.18	21.18
1974	242	30.0	7.00	0.00	4.62	11.62
1973	249	34.1	8.00	0.00	4.56	12.56
1972	186	40.0	7.00	0.00	3.70	10.70
1971	179	30.8	5.00	0.00	3.31	8.31
1970	198	36.5	3.00	0.00	2.14	5.14
1969	152	38.0	6.00	0.00	3.41	9.41
1968	150	33.2	6.00	0.00	2.63	8.63
1967	137	32.5	1.00	0.00	1.14	2.14

Figure 14: Corn and Soybean Prices - Yearly Averages

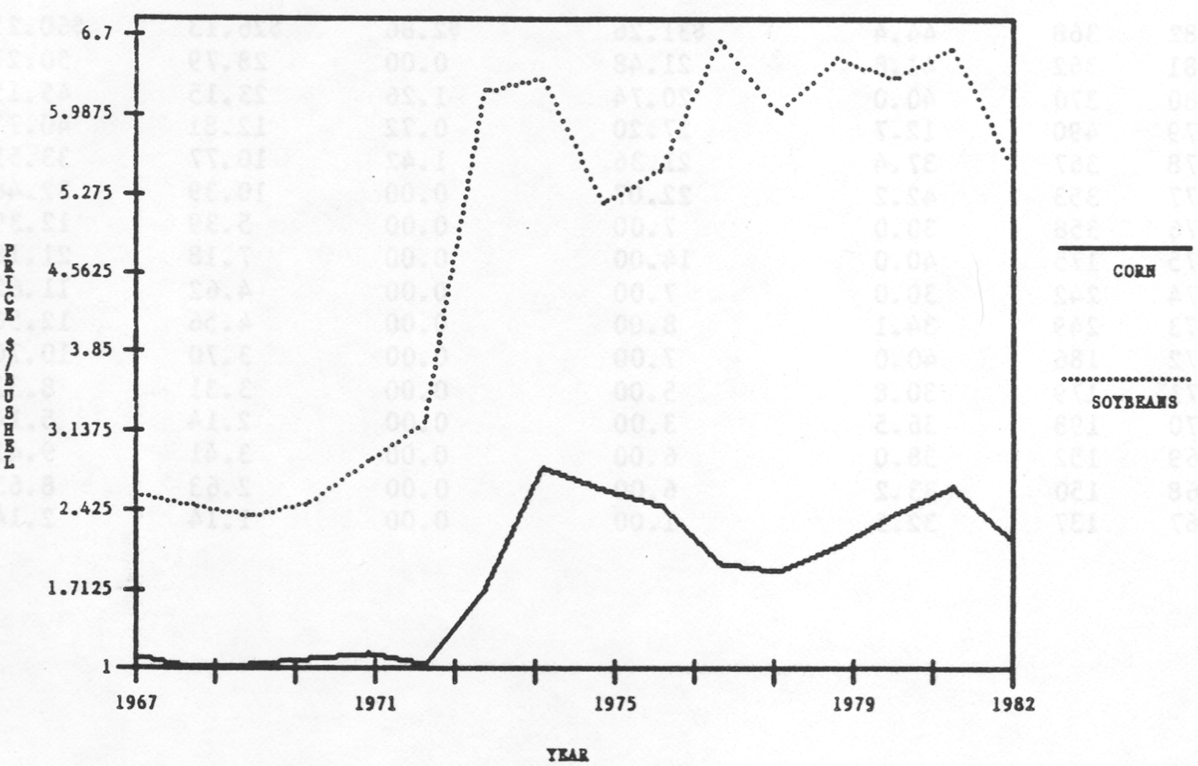


Table 19: Representative Farm Output Price Data, 1967-1982

Year	Corn ($/bu)	Soybeans ($/bu)	Finished Hogs ($/cwt)
1982	$2.20	$5.59	$55.12
1981	2.67	6.62	44.47
1980	2.42	6.39	40.19
1979	2.12	6.52	42.98
1978	1.90	6.02	49.02
1977	1.97	6.66	45.17
1976	2.48	5.53	44.64
1975	2.64	5.21	50.02
1974	2.83	6.35	36.73
1973	1.72	6.22	41.38
1972	1.07	3.25	27.75
1971	1.17	2.87	19.04
1970	1.11	2.51	23.43
1969	1.07	2.40	24.59
1968	1.03	2.48	20.41
1967	1.13	2.58	20.32

Figure 15: Corn Costs Per Acre

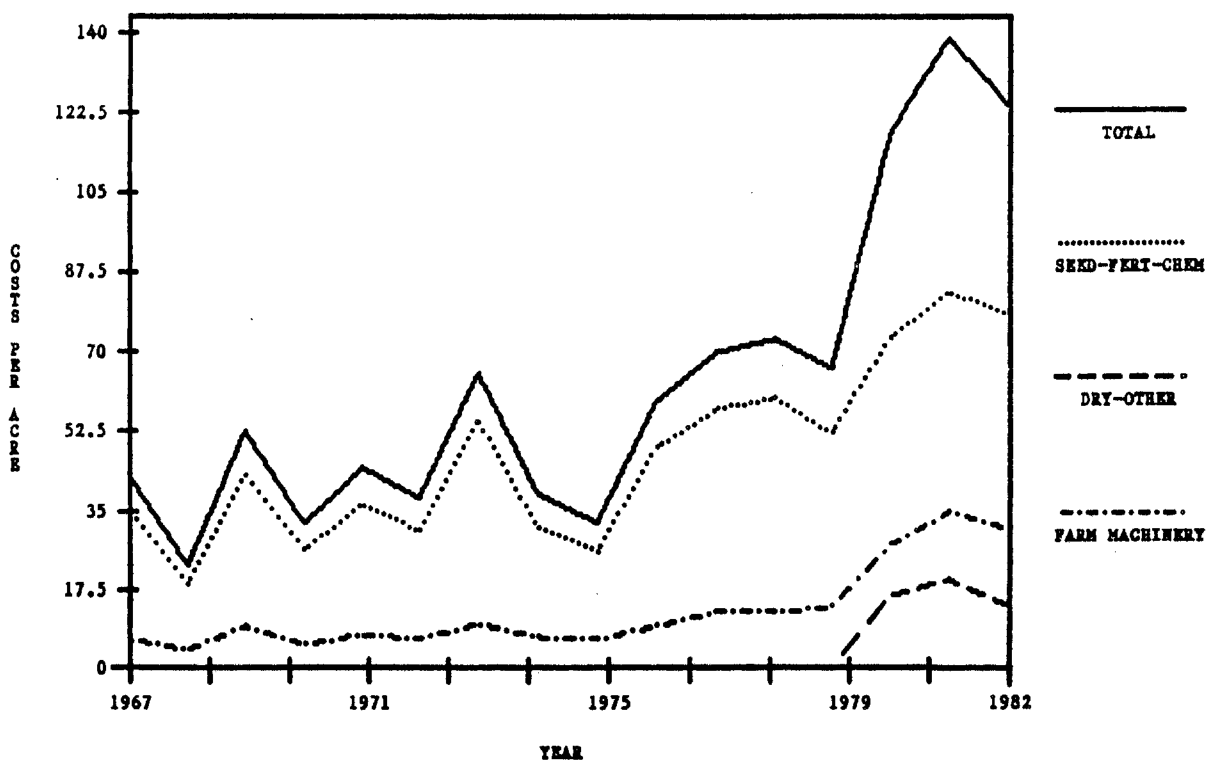


Figure 16: Corn Cash Returns and Costs Per Acre

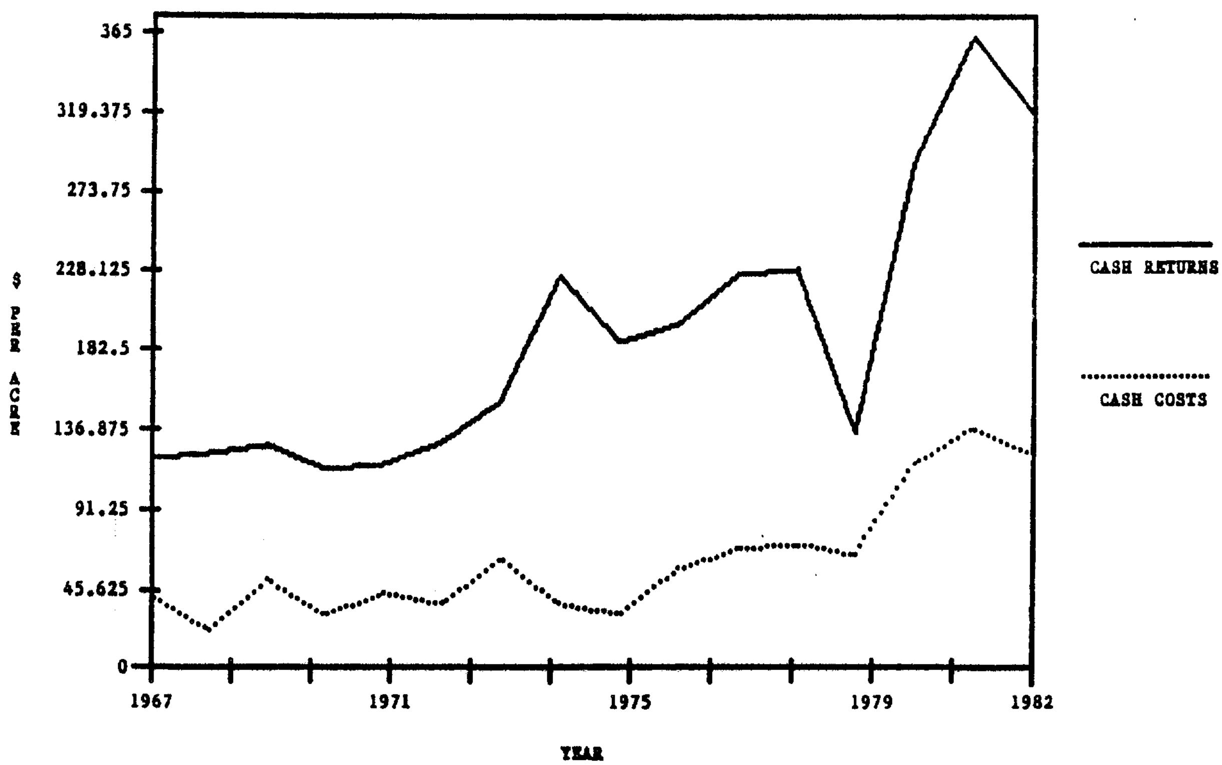
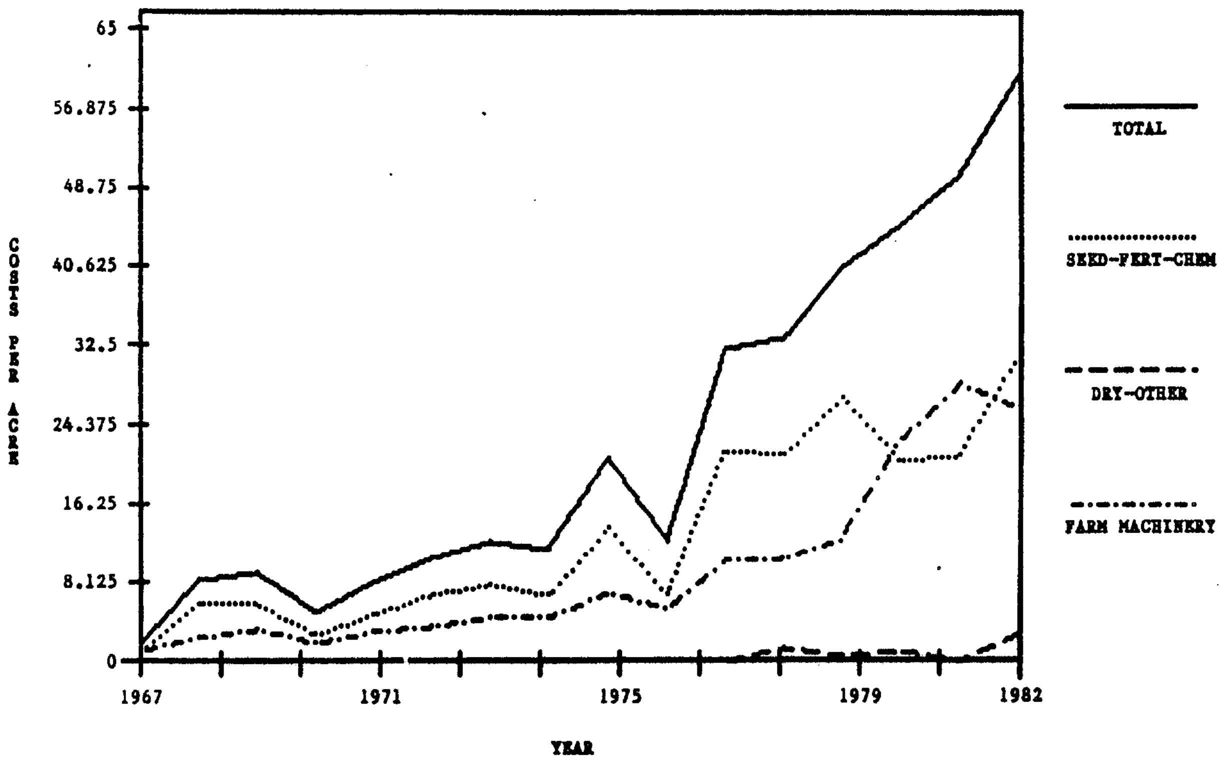


Figure 17: Soybean Costs Per Acre



machinery expense becomes the major component until 1982. Other expenses remain a fairly small component of the total cost of raising soybeans. Figure 18 shows the variability of the difference between cash return and cash costs for soybeans.

Figure 19 and Table 20 show feed as the major operating cost in swine production. Veterinary and miscellaneous and farm machinery operating costs remain low throughout. The margin between hog price and costs rises throughout the period. Significant reductions in the margin occur in 1971 and 1980.

The simulated farm's equipment is a full complement of machinery and buildings designed for a corn, soybean, and swine operation. The cropping equipment is depreciated according to the Accelerated Cost Recovery System, and is replaced after seven years of service. Longer-term crop structures such as grain bins and a pole barn for equipment storage are depreciated and replaced after fifteen years of service. The swine production equipment is replaced after eight years while the buildings are placed on a 15-year replacement schedule. The equipment and building replacements were placed on a staggered age cycle so as not to require replacement of significant portions of equipment in any one year. The major purchases, however, were placed in higher income years to facilitate cash flow (and conform most closely with probable actual purchasing behavior).

The actual crop farm began 1967 with 290 acres. The farm then purchased 80 acres in 1970 and 130 acres in 1973. These land purchases were financed through long-term loans.

Simulation Scenarios

All simulations use the same enterprise mix, price data, size data and assumptions throughout the analysis. Only the financing source, interest

Figure 18: Soybean Cash Returns and Costs Per Acre

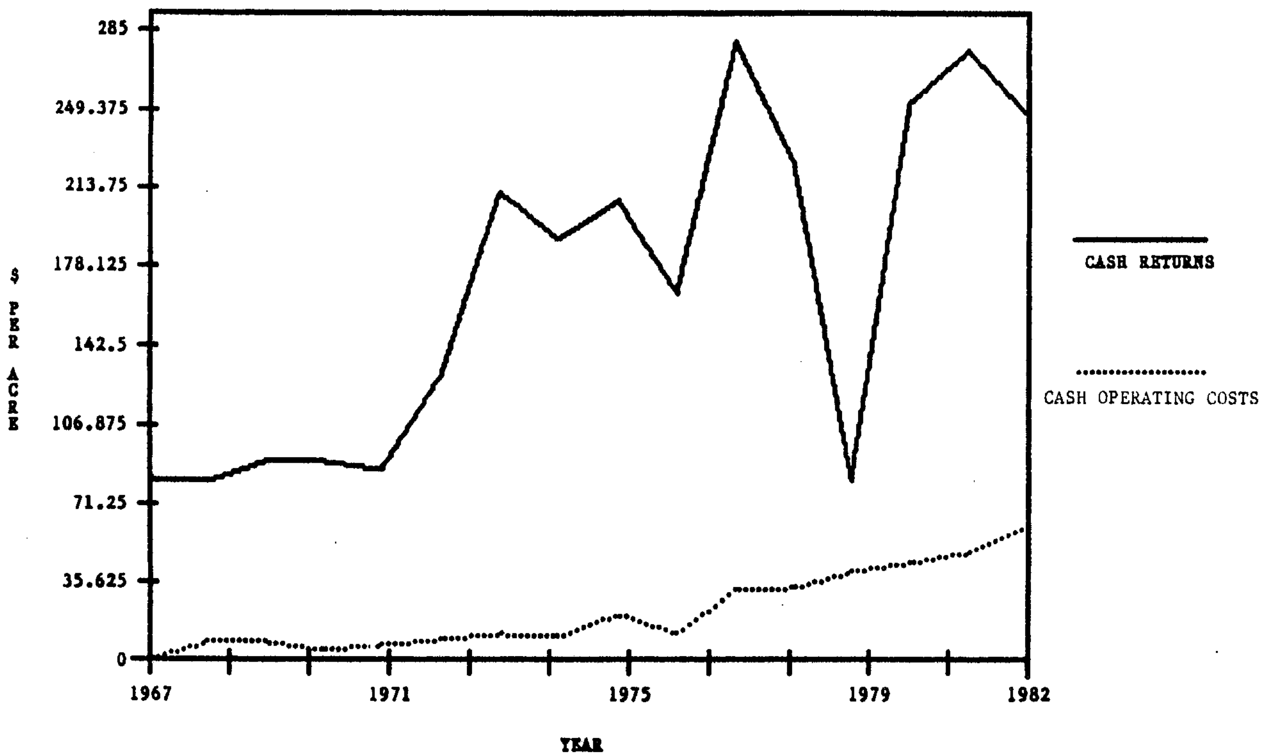


Figure 19: Swine Costs and Prices

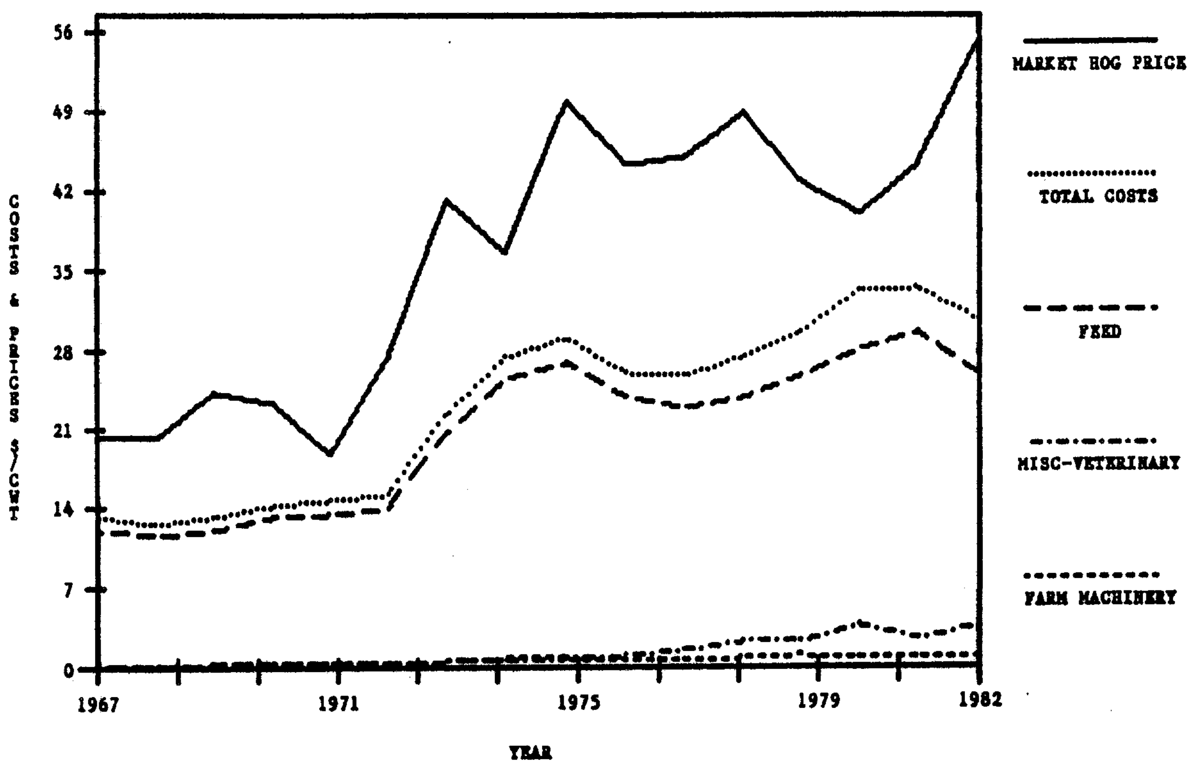


Table 20: Representative Farm Hog Production Cost Data, 1967-1982

Year	Cash Cost/cwt			
	Feed	Misc,Vet	Farm Mach	Total
1982	$26.24	$3.65	$1.18	$31.07
1981	29.81	2.76	1.18	33.75
1980	28.37	3.97	1.19	33.53
1979	25.90	2.58	1.29	29.77
1978	23.92	2.55	1.07	27.54
1977	23.14	1.86	0.83	25.83
1976	23.97	1.32	0.96	26.25
1975	27.10	1.17	1.07	29.34
1974	25.72	0.82	1.01	27.55
1973	20.95	0.76	0.82	22.53
1972	14.06	0.68	0.56	15.30
1971	13.74	0.59	0.54	14.87
1970	13.30	0.55	0.53	14.38
1969	12.30	0.50	0.49	13.29
1968	11.68	0.48	0.46	12.62
1967	12.29	0.59	0.49	13.37

rate, or beginning debt situation is altered, making a valid comparison of differing financing sources/strategies possible. Table 21 lists the different simulations.

Comparisons between simulations examine effects on the farm's income statements, balance sheets and financial ratios over time. The major difference appearing on the income statement between simulations is the level of net interest expense. Net interest expense equals the sum of interest on all interest bearing debt, charged at the applicable rate and based on the average debt level outstanding during the year, less any interest received on savings. Savings interest is calculated by applying the current long term rate on any excess cash reserves. Net farm income differs between simulations only due to variation in net interest expense (including hedging profits or losses in one simulation). Noninterest production expenses, yields, selling prices are all held constant over the various simulations. Within the balance sheet, total liabilities will vary due to differences in interest rates and the implied amortization schedule. In general, for those simulations for which the effective interest rate was higher, reduction of debt principal will be correspondingly lower. Net worth varies primarily due to net interest expense and total liabilities differences and the amount of stock purchases required by FCS lenders [Federal Land Bank (FLB) and Production Credit Association (PCA)] for those simulations utilizing the FCS lenders as a source of credit. The ratios which point to simulation differences used in this study are:

Current (Liquidity) Ratio = Total Current Assets ÷ Total Current Liabilities

Leverage Ratio = Total Liabilities ÷ Total Assets

Rate of Return on Equity = (Net Farm Income - Family Living Expenses) ÷ Net Worth

Table 21: Simulation Scenarios

Case	Beginning Leverage (Debt/Assets)	Financing Source	Interest* Rate	Debt Term Mix Ratio:** Long Term Debt to Intermediate Term Debt
A (Base)	.3	Bank	Fixed	1:1
B	.3	Bank	Variable	1:1
C	.3	FCS	Variable	1:1
D	.7	Bank	Fixed	1:1
E	.7	FCS	Variable	1:1
F	.3	Bank	Fixed-Proxy	1:1
G	.3	FCS	Variable-Proxy	1:1
H	.7	Bank	Fixed	2:1
I	.7	FCS	Hedged	1:1

* FCS issued fixed rate loans until approximately 1971.

** Longer term debt is typically used to purchase land and buildings, intermediate term debt is used to purchase machinery, equipment and breeding livestock.

Earning to Debt Service = (Net Farm Income + Net Interest Expense - Family Living Expenses) ÷ (Interest Payment + Principal Payment)

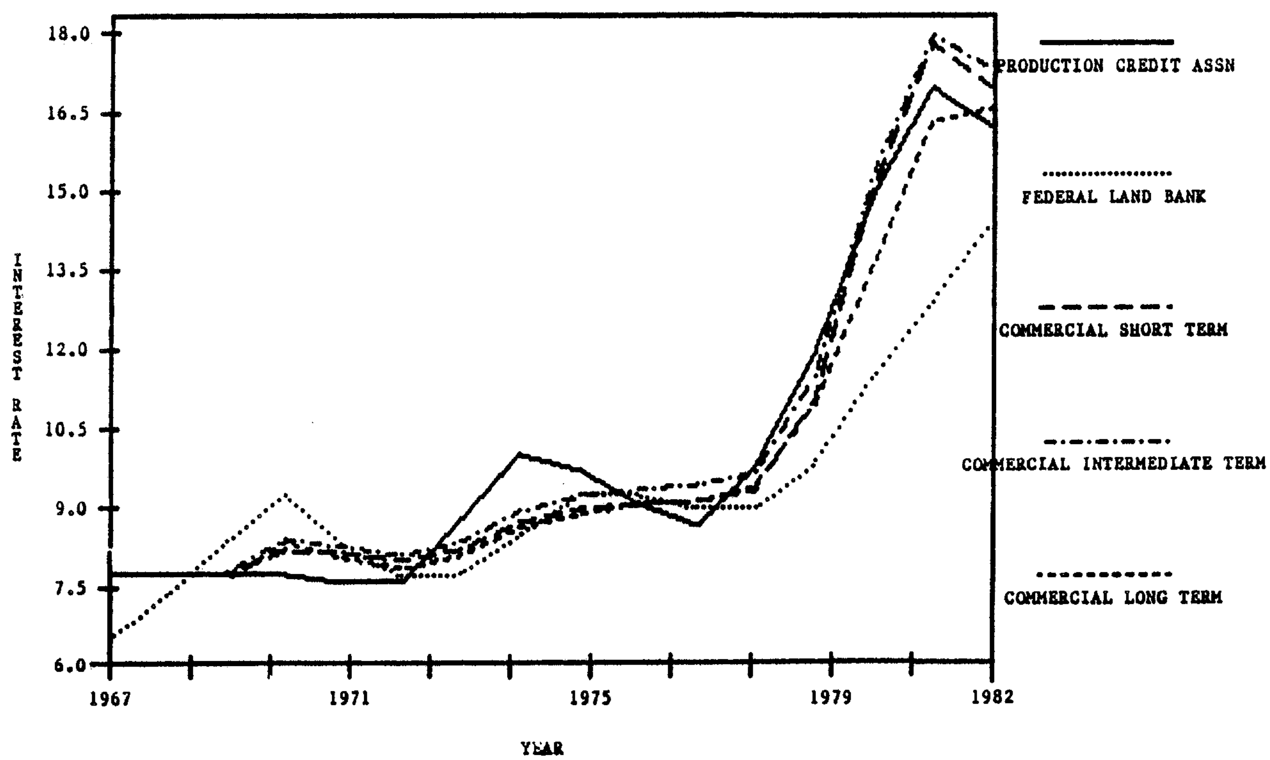
Family Living Expenses is used as an estimate of the value of unpaid family labor.

Proxy Interest Rates. Agricultural loan rates were somewhat insulated from national money market rates until the late 1970's. Previously, agricultural loan rates were fairly stable, exhibiting only a slight upward trend over the early years of the study period. Some have speculated that the recent deregulation of financial markets will result in agricultural loan rates that are on average higher and/or more variable than they were previous to deregulation. This could represent a significant new source of additional financial risk to farm producers. Simulations F and G represent an attempt to analyze the consequences upon the representative farm had this insulation not existed in earlier years by relating agricultural loan rates to basic money market interest rates. The relationship between agricultural loan rates and basic money market rates was estimated using regression analysis on monthly data in the period subsequent to 1978 (which is taken as the deregulation period). These relationships, described below, are used to estimate (i.e. "backcast") what the level of agricultural loan rates would have been in the earlier years if the post-1978 spreads between money market rates and agricultural loan rates prevailed in those (earlier) years. This will provide a better estimate of a farmer's interest rate risk prior to 1979 if agricultural loan rates moved with money market interest rates in a manner similar to their current relationship. The difference between the two rates, the actual rate and the proxy rate, shows the extent of the buffer from market rate variations that a borrowing farmer enjoyed during this period. If financial system deregulation per se, has had a significant risk increasing effect upon agricultural loan markets, the proxy interest rate series should exhibit more variability and (possibly) a higher average level when compared to the actual interest rate time series.

An examination of the interest rates' interrelationship is useful before proceeding with a description of the proxy agricultural interest rate modeling. Figure 20 displays all five agricultural interest rates that will be modeled in terms of their actual, historical values. The interest rates depicted represent the following interest rates: 1) Production Credit Association - yearly averages of the monthly effective interest rates at the southwestern Minnesota PCA serving the case farm's market area (supplied by Farm Credit Services (FCS) of St. Paul), 2) Federal Land Bank Association - yearly averages of the monthly effective interest rates at the southwestern Minnesota FLBA serving the case farm's market area (supplied by FCS of St. Paul), and 3) Commercial Bank - yearly averages of quarterly interest rates reported in the Agricultural Credit Condition Surveys for the Ninth Federal Reserve District for the most commonly charged interest rates on farm loans - average rate for the district.

This figure shows the commercial bank rates for short term, intermediate term and long term debt were generally bunched closely together during most of the historic period - and, as noted, were quite stable until the late 1970's. The Farm Credit System's rates, however, fluctuate early in the time period and then follow a path similar to that of the commercial bank rates. The Federal Land Bank rate is noticeably below the other rates from 1978 and onward. This lower rate is due to the average cost pricing policy it employs interacting with greater use of longer term liabilities (FCS Bonds) which 'turn over' more slowly and hence result in the average cost of funds to the

Figure 20: Interest Rates - Yearly Averages



FLB adjusting more slowly, and with a significant time lag, to changes in money and bond market interest rates.

The base period for estimation of the proxy interest rates to money market rate relationships is January 1979 to June 1982. Agricultural loan rates reacted to financial market rate changes during this period, but with some discernible lag time involved. Therefore, to construct more accurate proxy interest rates, the lagged relationship between the money market rates and the agricultural loan rates was examined by estimating these rate relationships for several alternative lag periods. The lag period producing the closest relationship was then selected for each proxy series. Proxy loan rates are estimated first for the Production Credit Association, then the Federal Land Bank Association, and finally Commercial Bank's short, intermediate and long term loans. The financial market rates used to project the proxy agricultural interest rates are:

1) Six month Treasury Bill Rate,[13]
2) Three to five year Treasury Note rate,[14]
3) Twenty year Treasury Bond rate,[15] and
4) Prime rate.[16]

These rates were chosen to construct the proxy interest rates because of their

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13/ Monthly average auction rate. Source: Federal Reserve Bulletin.

14/ The three to five year Treasury note rate was no longer reported as of March 1980. The three to five year Treasury note rate was approximated by averaging the three year and the five year Treasury note rate after March 1980. Source: Federal Reserve Bulletin.

15/ Monthly auction average. Source: Federal Reserve Bulletin.

16/ The prime rate is the rate charged by banks to their most creditworthy borrowers. The prime quoted is the rate that was effective during the first week of the month. Source: Federal Reserve Bulletin.

varying maturities. These base rates allow matching of the interest rate term structure for debt of varying length of term. Further, Treasury instrument rates represent an essentially (credit) risk free interest rate. The Farm Credit System's bonds and notes are relatively similar in terms of risk, issue size, and maturities to the Treasury instruments. Employing Treasury instruments as a base further assumes that any risk premium included in agricultural loan rates, as well as the charge to cover all administrative costs in the system and increase capital, is constant over the time period.

Production Credit Association. The local PCA interest rate correlated most closely with the six month Treasury bill rate lagged four months, the three-to-five year Treasury note rate lagged three months, the twenty year Treasury rate lagged two months and the prime rate lagged two months. This short lag period of two to four months reflects the relatively short maturity of the outstanding bond and note liabilities of the PCA's funds supplier, the St. Paul Federal Intermediate Credit Bank. Yet, the rates are not perfectly correlated due to administrative lags and an average cost of funds pricing policy which should tend to produce more gradual responses of PCA rates to changes in basic financial market interest rates.

Regression analyses using the above financial market rates lagged as independent variables determined that a suitable model to construct the proxy PCA rate was:

$$PCA = 2.7083 + .3273\ (L4\text{-}6MTB) + .7351\ (L2\text{-}20YTB)$$

where:

PCA = effective local PCA rate.

L4-6MTB = six month Treasury bill lagged for four months, and

L2-20YTB = twenty year Treasury bond lagged two months.

In the above proxy equation, intercorrelation between variables may represent a problem affecting the accuracy of this analysis. 17/ Since both of the independent financial market variables are highly correlated with each other, it may be impossible to use more than one independent variable without introducing an intercorrelation problem. In this analysis, however, the results of using two independent variables were sufficiently superior to the one independent variable models to warrant use of the two independent variable models.

Using the chosen PCA model to forecast backwards in time ('backcast') a proxy interest rate from 1967 to 1982 produced the results shown in Figure 21. The model's proxy rate provides a close mapping of the actual PCA rate from 1979 onward, the period over which the proxy relationship was estimated. Before 1979, however, the proxy rate consistently overestimated the actual PCA rate by as much as two percent. This may be the result of the PCA's average cost of funds having contained some amount of lower cost funds early in the period which were of lesser importance after 1979 or the charge for administrative expenses and building of retained equity and loss reserves simply increased in the post 1979 period. If the recent PCA to financial market relationship persists in the future, it will mean that PCA borrowers will be facing credit costs that are higher - relative to basic market rates - than those which they faced in the pre 1979 period. Except for the period from 1967 to 1971, however, the proxy rate does not appear to be distinctly more volatile than the historic actual rate series.

<u>Federal Land Bank Association</u>. The local FLBA rate also displays a

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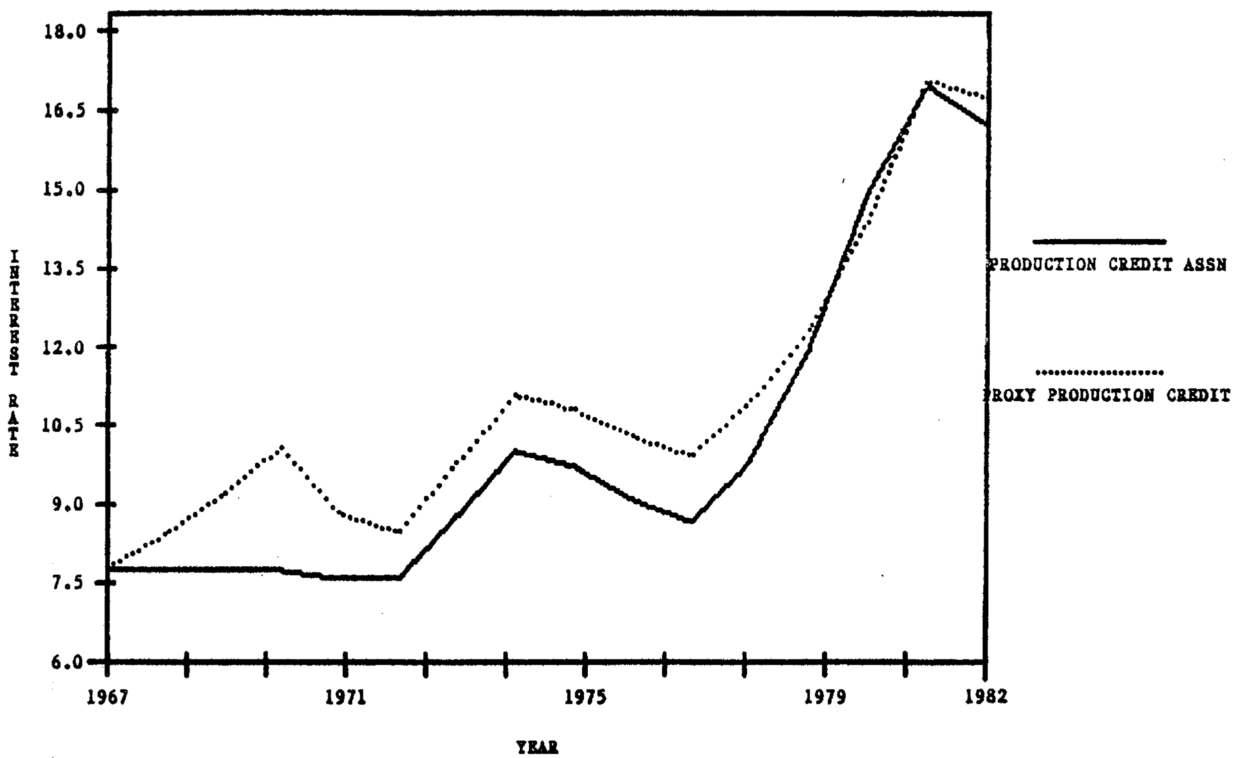
17/ Intercorrelation would pose a problem for testing which of the independent variables is most closely correlated with the PCA rate; however, it does not preclude the development of a model that predicts accurately, which is the current concern.

Figure 21: Production Credit Association Interest Rates - Yearly Averages



lagged relationship with respect to the base money market rates. The FLBA rate correlated best with the six month Treasury bond rate lagged eight months, the three-to-five year Treasury note rate lagged six months, the twenty year Treasury bond rate lagged five months and the prime rate lagged seven months. Furthermore, the effective FLBA rate lagged three months behind the FICB-SP rate which confirms the longer lag period anticipated above. Regression analysis using the above lagged financial market rates as independent variables determined that a suitable model was:

FLBA = 2.7148 + .8194 (L5-20YTB)

where:

FLBA = Local FLBA rate,

L5-20YTB = Twenty year Treasury Bond rate lagged five months.

Using the above FLBA model to forecast backwards to 1967 produced the proxy interest rate shown in Figure 22. The proxy rate very closely models the actual local FLBA rate charged. The FLBA rate, therefore, appears to reflect the market rates fairly closely, but with a lag period. And, that relationship does not appear to have changed greatly over time. This suggests little change in the level or variability of FLBA rates - compared to basic financial market rates - in the post deregulation period.

Commercial Banks. The suitable models for construction of proxy commercial bank interest rates are:

Short term production loan rate.

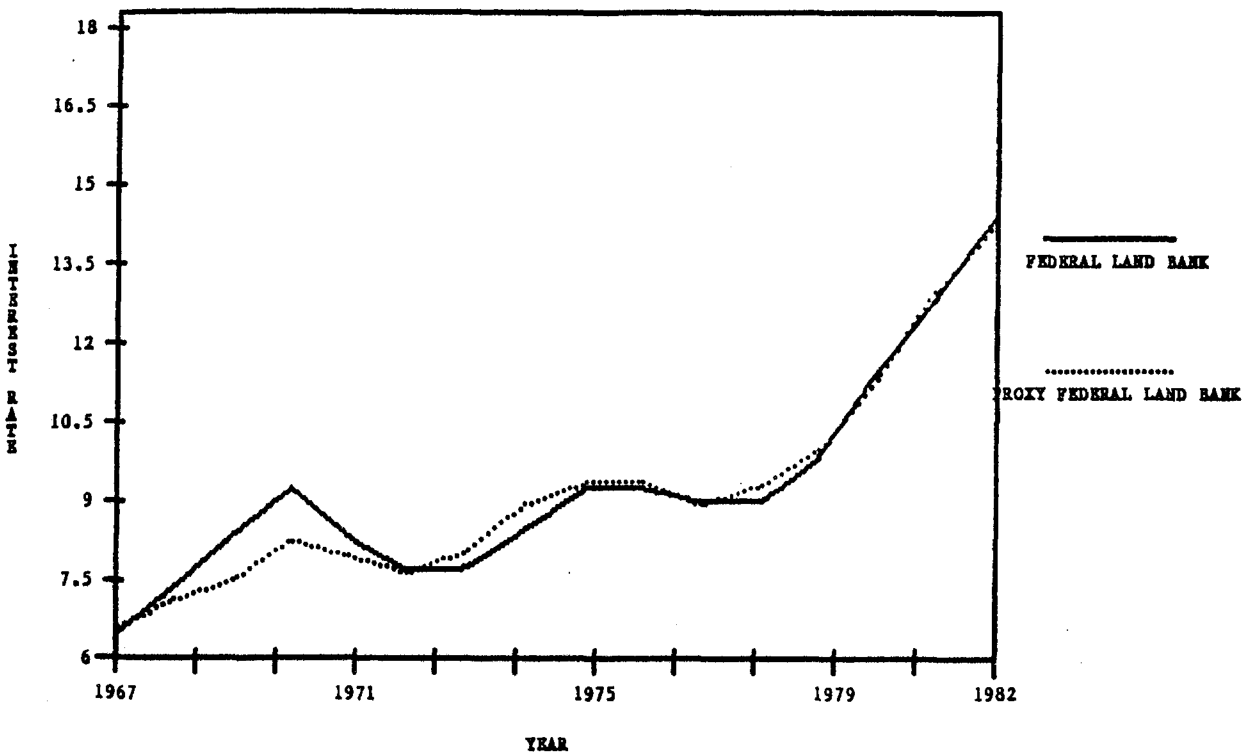
CBST = 0.9062 + 1.1839 (L2-35YTN)

where:

CBST = Commercial Bank Short Term agricultural interest rate,

L2-35YTN = Three-to-five year Treasury note interest rate lagged two months.

Figure 22: Federal Land Bank Interest Rates - Yearly Averages



Intermediate term loan rate.

CBIT = 1.6052 + 1.1464 (L2-35YTN)

where:

CBIT = Commercial Bank Intermediate Term agricultural interest rate,

L2-35YTN = Three-to-five year Treasury note rate lagged two months.

Long term loan rate.

CBLT = 1.6448 + 1.0652 (L3-35YTN)

where:

CBLT = Commercial Bank Long Term agricultural interest rate for long term, farm real estate loans,

L3-35YTN = Three-to-five year Treasury note rate lagged three months.

Using this model to forecast backwards produced the proxy interest rates shown in Figures 23, 24 and 25. Figure 23 shows that commercial bank short term rates would have been more volatile had bank loan rates in the prederegulation period been more influenced by market interest rates in a manner similar to that observed in the post 1978, deregulation period. It also appears that rates would have, on average, been higher thus suggesting that the effects associated with deregulation may contribute to an increase in the financial risk faced by borrowers.

The model does a relatively good job of following actual interest rates from 1979 onward. Thus indicating that the model captures rate relationships quite well over the period for which they were estimated. The intermediate term and the long term rates displayed in Figures 24 and 25 show similar patterns as those exhibited for short term bank rates. These figures indicates that bank deregulation and financial innovations including new products appear to have made bank loan rates more sensitive to financial market interest rates.

Figure 23: Commercial Bank Short Term Interest Rate - Yearly Averages

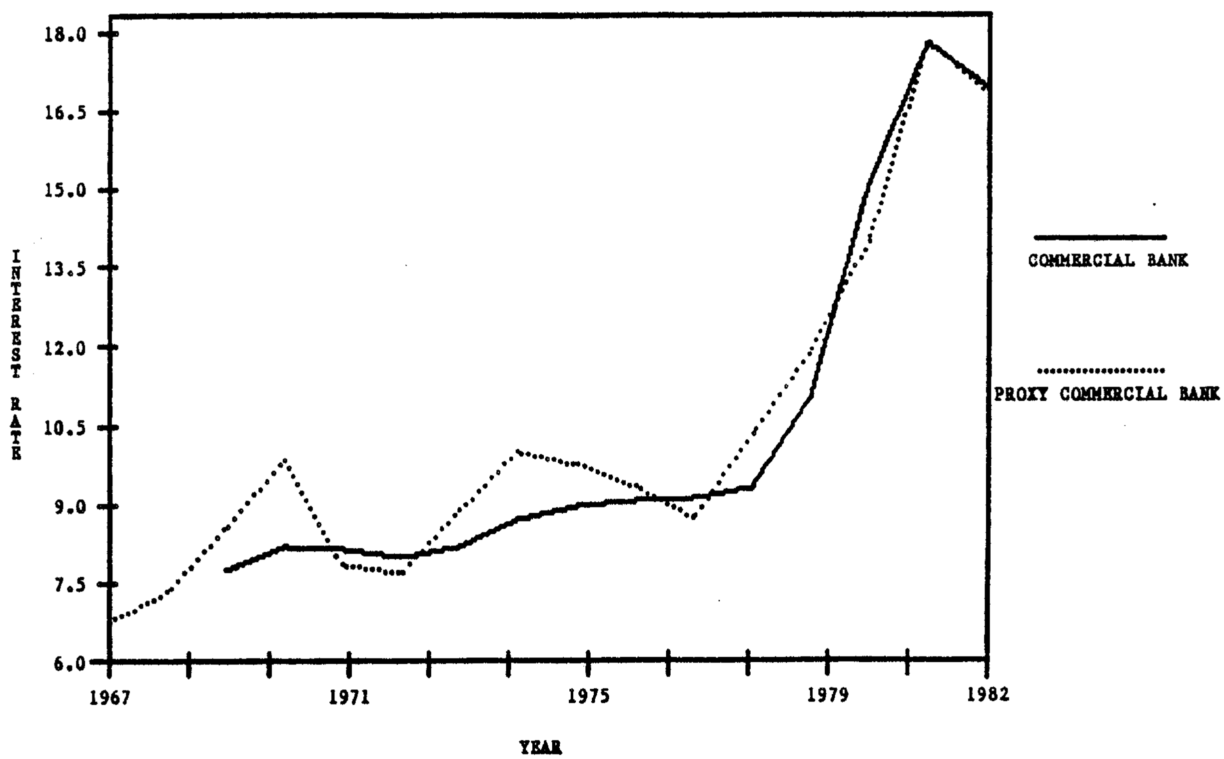
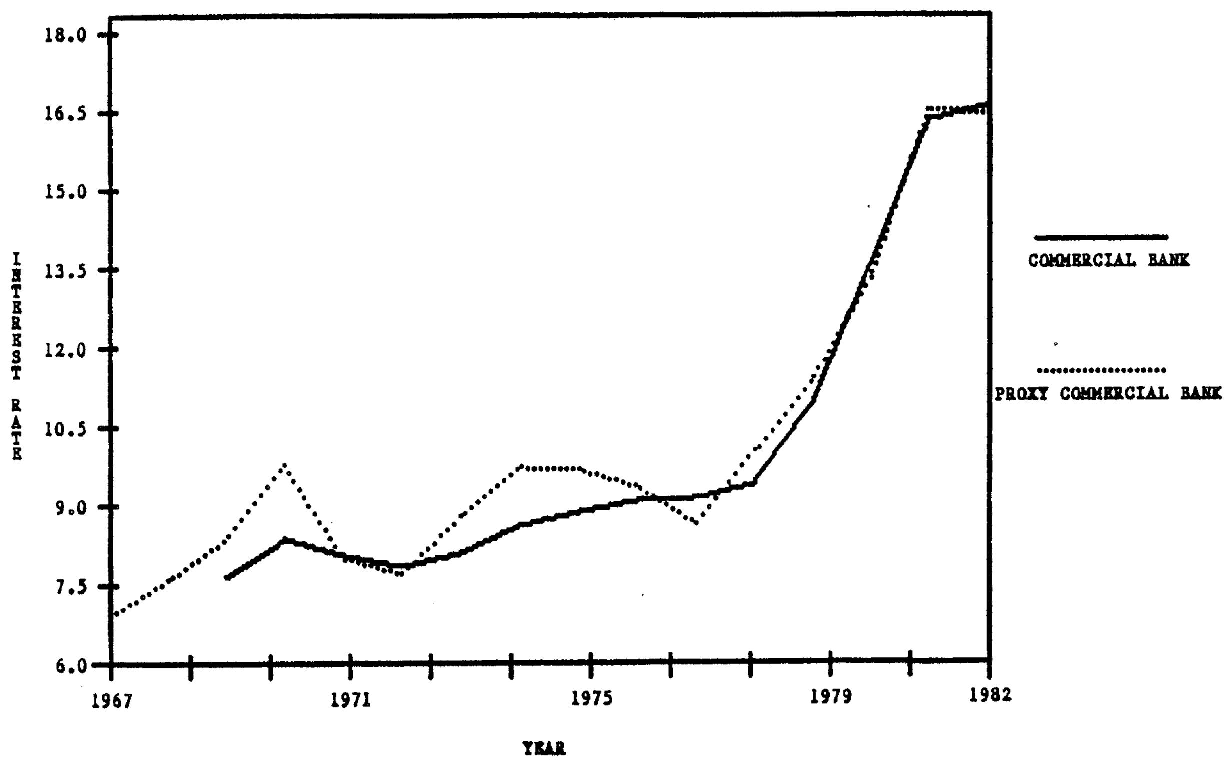


Figure 24: Commercial Bank Intermediate Term Interest Rate - Yearly Averages

Figure 25: Commercial Bank Long Term Interest Rates - Yearly Averages



Simulation Results

This section presents the results for the various simulation scenarios presented in Table 21.

Case A: Base Farm. The base farm simulation began with a debt-to-asset ratio of .3. Debt financing is obtained at a fixed interest rate from the local commercial bank, with equal amounts of intermediate and long term debt. Short term credit is utilized, as needed, to finance seasonal cash flow deficits. Table 22 gives the simulated net interest expense and net farm income for 1967-1982. The net interest expense due to rising interest rates and greater (absolute) use of debt has grown from $2,227 in 1967 to $15,527 in 1982 (not corrected for inflation). This represents a rise in interest expense from 6.2% of net farm income in 1967 to 16.5% in 1982. Overall, however, the farm proved profitable. Net farm income rose from $36,071 in 1967 to $94,029 in 1982. But, the year 1979, proved a poor one with a net farm income of $9,408. This decline is accounted for, in large part, by poor crop yields on the representative farm in that year.

The base farm's balance sheet results in Table 23 show the result of inflation on farm assets and the required financing for these assets. The total assets of the farm grew in nominal dollar terms from $145,333 in 1967 to $1,435,320 in 1982. Total liabilities, however, grew from $29,990 in 1967 to a high of $159,454 in 1980. Net worth likewise, grew in nominal dollar terms from $115,343 in 1967 to $1,303,250 in 1982, somewhat outpacing growth in assets. Thus, the balance sheet reflects the basic profitability of this farm as well as the gains from inflation experienced during this time.

Financial ratios further demonstrate these effects. In Table 24 the current ratio (current assets divided by current liabilities) started at 6.33 in 1967, then fell to a low of 3.48 in 1971 and grew to a high of 45.70 in

Table 22: **Base Farm Income Statement Summary in Nominal Dollars, 1967-1982**

Year	Net Interest Expense	Net Farm Income
1982	$15,527	$ 94,029
1981	11,314	81,560
1980	12,344	127,079
1979	9,339	9,408
1978	9,391	120,274
1977	12,940	130,602
1976	9,768	88,122
1975	11,314	38,458
1974	7,520	96,730
1973	8,487	117,256
1972	5,676	62,433
1971	6,221	19,444
1970	6,847	31,506
1969	3,901	26,674
1968	3,757	27,939
1967	2,227	36,071

Table 23: Base Farm Balance Sheet Summary in Nominal Dollars, 1967-1982

Year	Total Assets	Total Liabilities	Net Worth
1982	$1,435,320	$132,067	$1,303,250
1981	1,321,930	106,437	1,215,490
1980	1,226,790	159,454	1,067,330
1979	1,010,500	106,984	903,536
1978	1,011,550	110,656	900,899
1977	941,771	135,986	805,784
1976	777,786	114,451	663,335
1975	587,460	112,380	475,080
1974	516,931	102,666	414,264
1973	399,251	106,021	293,229
1972	257,238	62,695	194,543
1971	224,461	76,476	147,986
1970	238,927	84,069	154,857
1969	194,136	45,120	149,017
1968	177,487	46,121	131,366
1967	145,333	29,990	115,343

Table 24: Base Farm Ratio Analysis, 1967-1982

Year	Current	Total Liabilities/ Total Assets	Rate of Return (ROR) Equity	Earnings to Debt Service
1982	5.41	0.09	0.06	1.90
1981	18.05	0.08	0.05	2.17
1980	4.33	0.13	0.11	3.25
1979	24.00	0.11	-0.01	0.32
1978	45.70	0.11	0.12	2.83
1977	7.23	0.15	0.11	2.29
1976	13.46	0.15	0.11	1.83
1975	15.73	0.19	0.06	1.05
1974	34.86	0.20	0.21	3.48
1973	30.72	0.26	0.38	3.03
1972	8.86	0.24	0.29	2.20
1971	3.48	0.34	0.09	0.42
1970	3.62	0.35	0.16	1.04
1969	5.90	0.23	0.14	0.48
1968	4.99	0.26	0.18	1.19
1967	6.33	0.21	0.26	1.89

1978. The fluctuation in the current ratio primarily reflects the ability of the farm to pay down debt and build excess cash. The leverage ratio (ratio of total debt divided by total assets) began at .21 at the end of 1967 (after debt principal payments for that year are credited), then grew to .35 in 1970 and finished at .09 in 1982. This ratio displays the farm's ability to reduce debt in real dollar terms with its earnings, capture asset appreciation gains, and maintain a reasonable level of solvency.

The rate of return on invested equity (net income less the family living charge divided by net worth) shows the farm's ability to use its investment in a profitable manner. The farm starts with a return of 26% in 1967, then rises to a high of 38% in 1973 and finishes with 6% in 1982. The general decline in rate of return after 1973 shows the farm's declining ability to successfully use debt to enhance ('leverage upward') the rate of return on equity as it did earlier in the period. The decline is attributable, in part, to the inflationary growth in equity and, in part, to the decline in real returns from farm product sales. And, indeed by the end of the period, the impact of financial leverage was negative - the average interest rate paid on debt exceeded the average rate of return earned on assets and thus lowered the rate of return on net worth (relative to what it would be if the farm were unleveraged).

The base farm's rate of earnings (net farm income plus interest expense) to debt service requirements show an irregular pattern. The ratio mainly reflects the net farm income level and the generally declining debt service requirements as the farm pays off debt. This ratio also demonstrates the declining rate of return to assets discussed above.

The base farm maintained a positive net farm income through a period when agriculture enjoyed very profitable years, such as 1973, and suffered poor years, such as 1979 and the early years of the 1980's. Furthermore, the base farm managed to reduce its relative debt level through this period. The net interest expense, however, still grew despite the reduction in leverage due to increases in the level of interest rates on recently added debt. It should be noted that the base farm was not very heavily leveraged by the end of the 1970's when interest rates rose to record levels. Had it carried a debt load comparable to the one it carried in the early 1970's, most of the farm's reported net income would have been consumed by additional interest expense. In summary, the base farm proved generally successful throughout the simulated period.

Case B: Variable Commercial Bank Financing. For Case B the base farm's production plan was run assuming variable rate commercial bank financing for all interest bearing debt. In this simulation, the farm must, in effect, pay the current going interest rates on the entire amount of its outstanding loans. All other variables are held constant for this simulation run. Since interest rates rise over the simulated period, the variable interest rate simulation experiences higher interest expense. The results comparing the variable rate bank financing with the fixed rate bank financing show the dollar impact of this difference in loan arrangement in the environment of the late 1960's and the 1970's.

Figure 26 (and Tables 25 versus 22) show the growing net interest expense difference which becomes quite significant by 1979. By 1982, the variable rate financing inflicted a 72% greater net interest expense burden ($26,700 versus $15,500) upon the simulated farm as compared to the base farm with fixed rate bank financing. This higher interest expense resulted in a 12% decline in net farm income in 1982 compared to the base run shown in Figure 27.

Figure 26: Net Interest Expense: Variable Commercial Bank Financing (Case B) Compared to Fixed Rate (Case A)

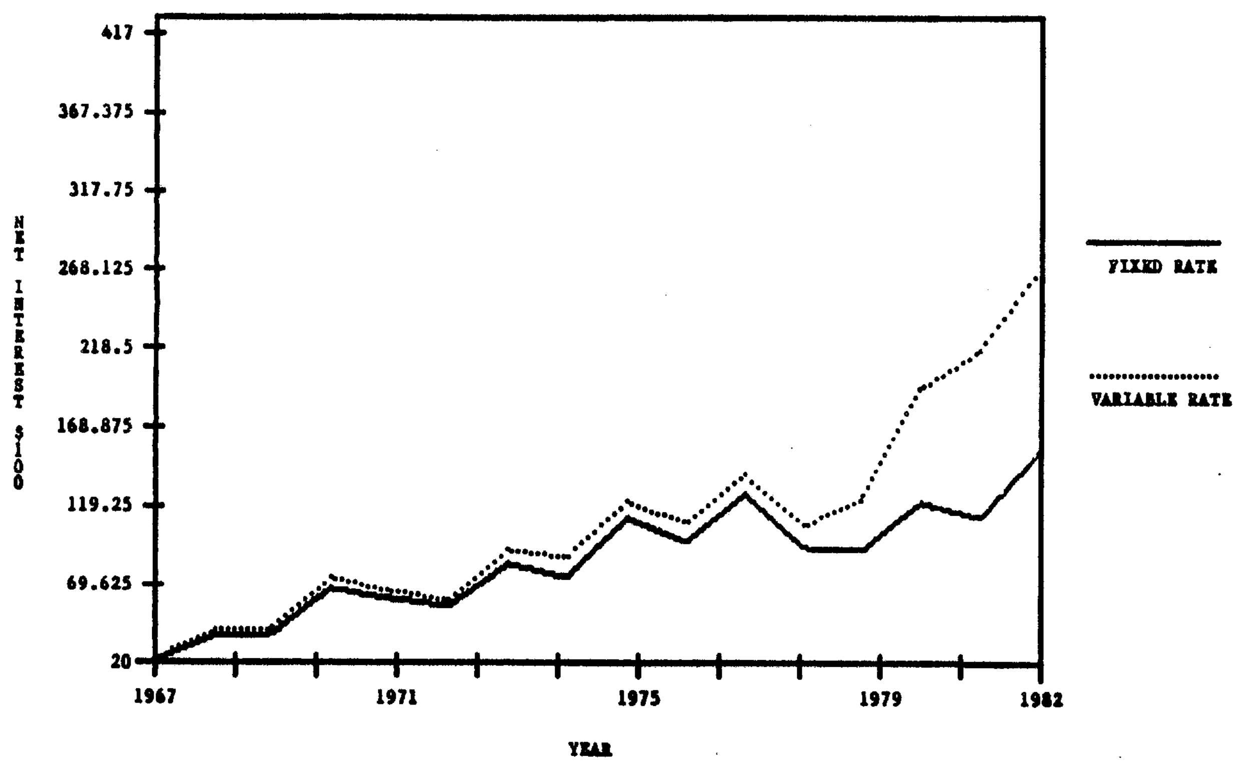
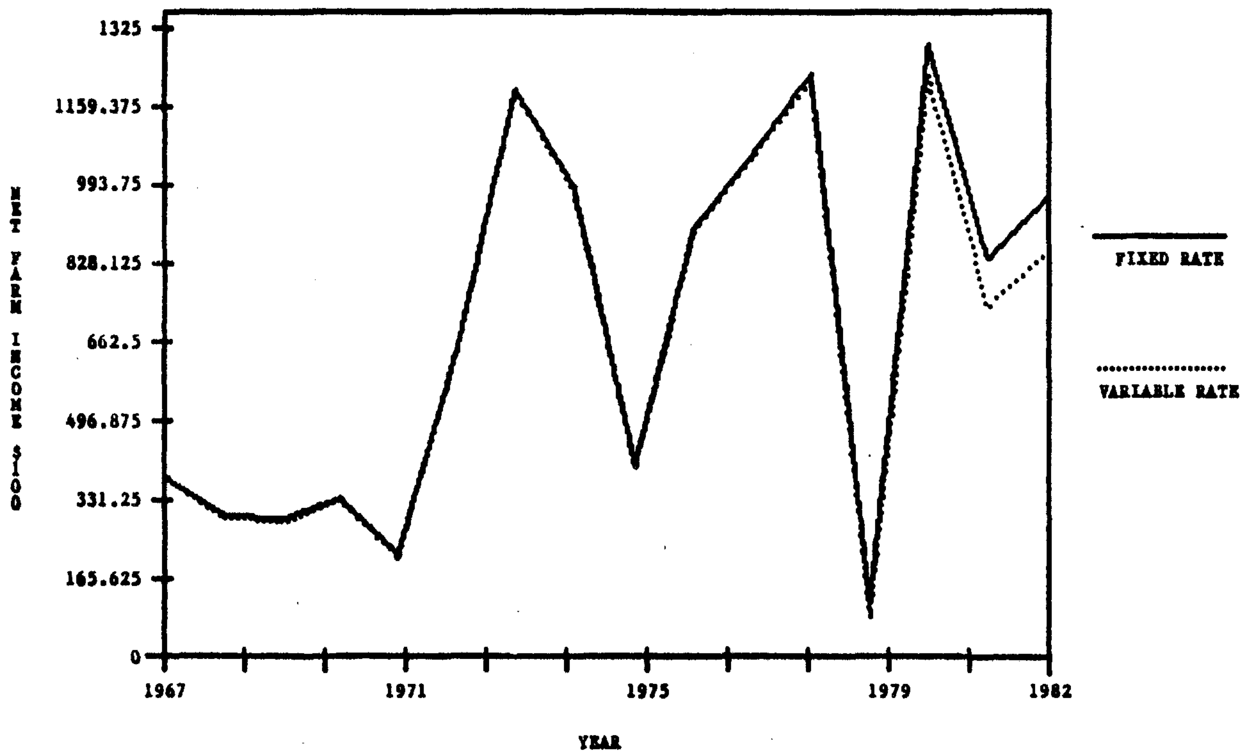


Table 25: Case B - Farm Simulation Results

Leverage= Low (.3)
Financing- Bank
Interest Rate- Variable
Debt Mix LT/IT=EVEN 1/1

					Ratios			
Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Current	Leverage (Total Liabs./ Total Assets)	ROR-Equity	Earn/ Debt Serv.
1982	267	828	1570	12784	4.6	.11	.05	1.81
1981	217	711	1260	11959	8.2	.10	.05	1.95
1980	195	1199	1733	10535	3.9	.14	.10	2.73
1979	126	62	1108	8969	17.6	.11	-.01	.19
1978	108	1188	1125	8965	44.4	.12	.12	2.65
1977	141	1025	1397	8021	7.0	.15	.11	2.31
1976	110	869	1179	6599	11.3	.15	.11	1.85
1975	123	375	1150	4724	12.3	.19	.06	1.02
1974	87	956	1036	4118	34.2	.20	.21	3.30
1973	92	1166	1067	2915	30.3	.27	.38	2.93
1972	60	621	640	1932	8.6	.25	.29	2.21
1971	67	190	777	1468	3.4	.35	.08	0.47
1970	76	308	852	1537	3.6	.35	.16	1.05
1969	43	263	458	1439	5.8	.24	.13	.49
1968	41	276	466	1309	4.9	.26	.17	1.18
1967	25	358	303	1151	6.2	.21	.26	1.84

Figure 27: Net Farm Income: Variable Commercial Bank Financing (Case B) Compared to Fixed Rate (Case A)



The resultant lower net farm income caused a decreased reduction of outstanding debt. Figure 28 displays that total liabilities for variable financing increased to a level 19% greater than those for the base fixed rate financing case. Correspondingly, net worth which amounted to $1.303 million with fixed rate financing ended at $1.278 million (Table 26) with variable rate financing. In this increasing interest rate environment, the result of using variable rate commercial financing was, of course, higher interest expense resulting in lower net farm income. The resulting decreased net cash flow generally prohibited debt reduction (in absolute terms). Thus, the farm was supporting higher debt levels at increased costs.

Selected financial ratios in Table 25 further display the increased debt servicing requirements and the financial impact on the farm of using variable rate bank financing. The current ratio is lower for variable rate financing due to the higher short term borrowing needed to close cash flow gaps given the higher level of interest expenses. As expected, the higher leverage ratio reflects the higher outstanding debt and lower net worth due to reduced retained earnings. The rate of return to equity again shows the overall decline during the simulation period. The earnings to debt service ratio is also lower, again demonstrating the result of increased interest expenses and debt principle payments.

Case C: Variable Farm Credit System Financing. The variable rate commercial bank financing simulation also produces a higher net interest expense when compared to a variable rate Farm Credit System financing simulation. Since Figure 20 showed commercial bank rates were, particularly in the later part of the study period, slightly higher than the Farm Credit System rates, this result could be expected. As seen in Figure 29 (or Tables 26 versus 25) below, the lower Farm Credit System interest rates produce a 14%

Figure 28: Total Liabilities: Variable Commercial Bank Financing (Case B) Compared to Fixed Rate (Case A)

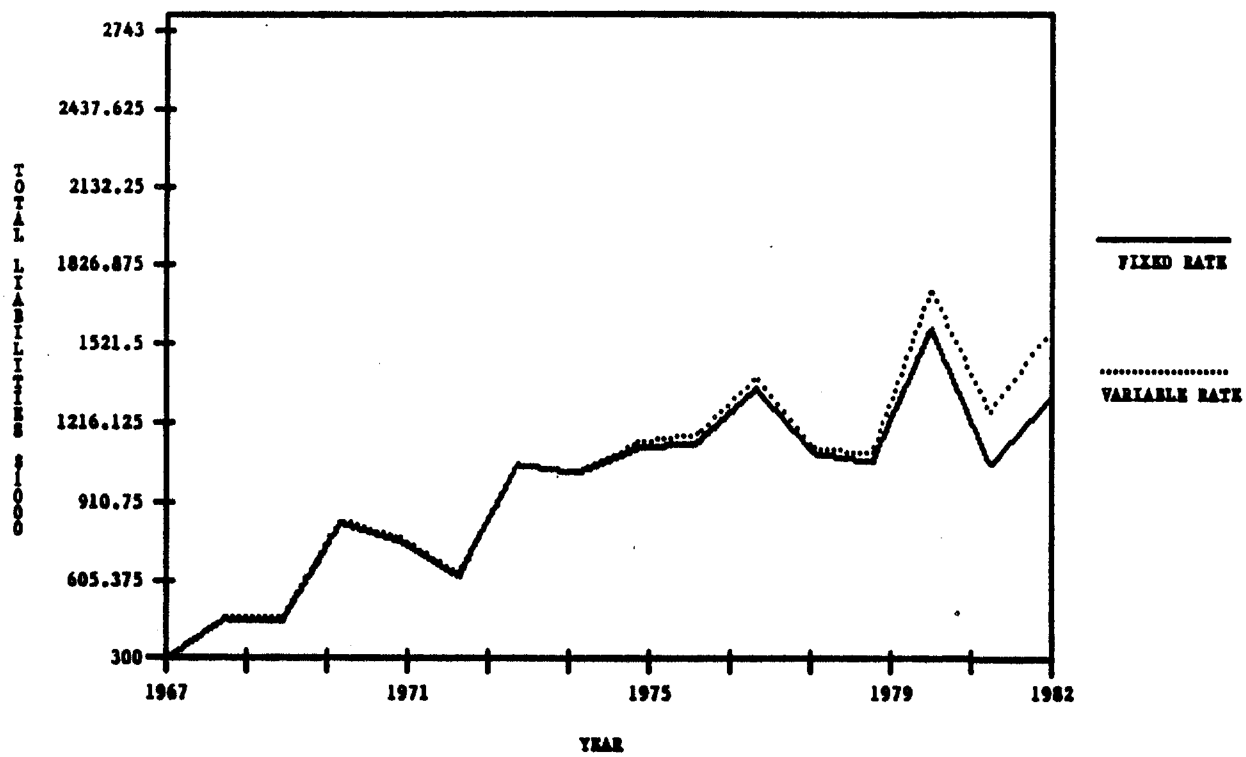
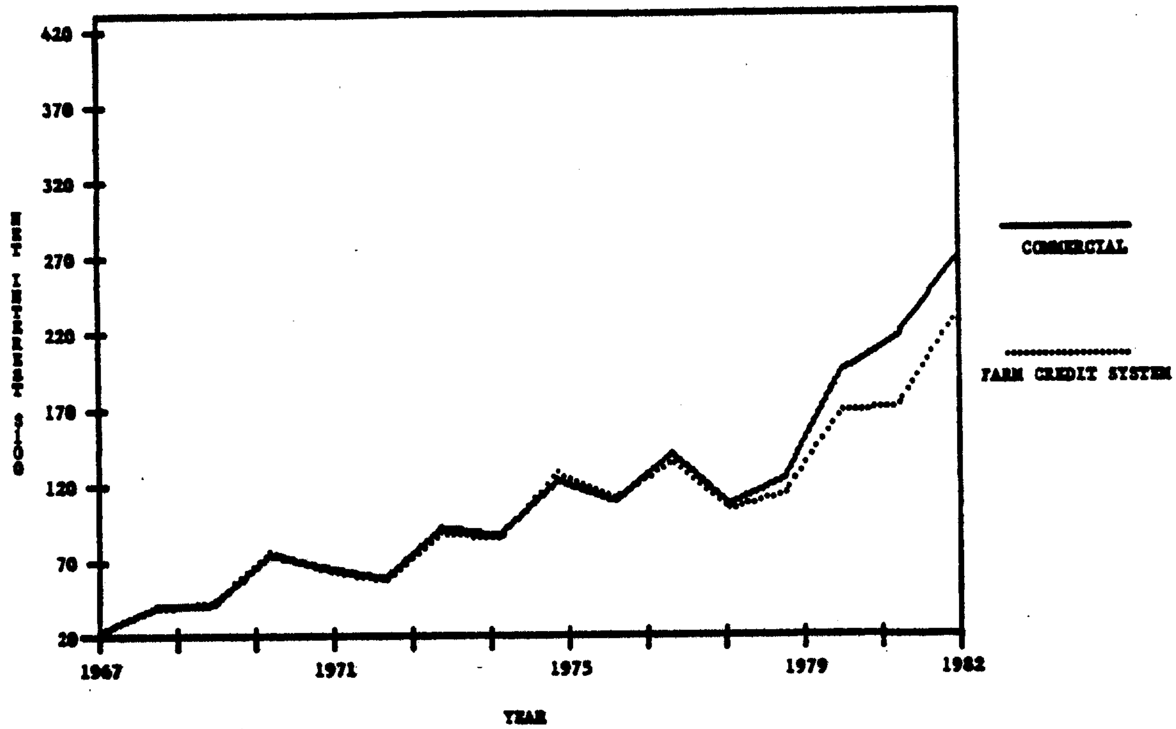


Table 26: Case C - Farm Simulation Results

Leverage= Low (.3)
Financing- Farm Credit System
Interest Rate- Variable
Debt Mix LT/IT=EVEN (1:1)

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios: Current	Leverage	ROR-Equity	Earn/Debt Serv.
1982	230	865	1489	12963	4.8	.10	.05	1.85
1981	171	757	1191	12096	10.4	.09	.05	1.93
1980	168	1226	1693	10691	4.1	.14	.10	2.89
1979	115	73	1096	9037	20.8	.11	-.01	0.25
1978	104	1193	1125	9027	44.5	.11	.12	2.75
1977	136	1029	1394	8106	7.1	.15	.11	2.30
1976	112	867	1181	6660	11.2	.15	.11	1.74
1975	129	369	1154	4780	11.8	.19	.06	1.13
1974	86	956	1036	4172	34.2	.20	.21	3.40
1973	89	1169	1067	2972	30.4	.26	.37	3.03
1972	58	623	638	1977	8.7	.24	.29	2.20
1971	66	191	777	1524	3.4	.34	.08	0.46
1970	77	306	854	1598	3.5	.35	.15	1.06
1969	44	262	458	1519	5.7	.23	.13	0.49
1968	40	277	465	1347	4.9	.26	.17	1.18
1967	25	358	303	1171	6.2	.21	.26	1.84

Figure 29: Net Interest Expense: Variable Farm Credit System Financing (Case C) Compared to Variable Commercial Bank Financing (Case B)



lower net interest expense by 1982. The resulting 4% higher net income, 5% lower total liabilities and higher current and earnings-to-debt service ratios as depicted in Table 26 reflect the effects of the lower variable FCS interest rates (particularly lower real estate debt interest rates). These lower interest rates result in large part from the Farm Credit System use of average cost pricing compared to commercial banks' marginal cost based pricing. During a period of rising interest rates, the average cost pricing lags behind current trends. This effect is especially significant in the case of Federal Land Bank loan pricing. Conversely, when interest rates decline, average cost pricing maintains a higher interest rate than marginal pricing. Hence, much of the observed difference would have been offset (reversed) had the simulation been continued through a period of interest rate decline.

Case D: High Leverage Position and Fixed Rate Bank Financing. In this simulation the farm began 1967 with a 0.7 debt-to-asset ratio as compared to the 0.3 debt-to-asset ratio of the base farm. With the fixed rate bank financing, the expected results are that net interest expense and total debt load will be (remain) higher for the highly leveraged farm. Figure 30 and Table 27 versus Table 22 show the net interest expense difference growing over the simulation period. The absolute difference in net interest expense between the differently leveraged farms more than quadrupled from a $3,700 difference in 1967 to a $16,400 difference in 1982.

Figure 31 shows the slow growth in total liabilities differential. At the end of 1967, the higher debt farm had total liabilities which exceeded the base farm's liabilities by $59,200 or 297%, but by 1982 the difference had grown to $116,400 or 188%. The net worth differences, of course, also reflect this absolute liabilities divergence. Again it is useful to note that even the high leverage farm was able to reduce its relative leverage position to a

Figure 30: Net Interest Expense: High Leverage Position (Case D) Compared to Low Leverage (Case A)

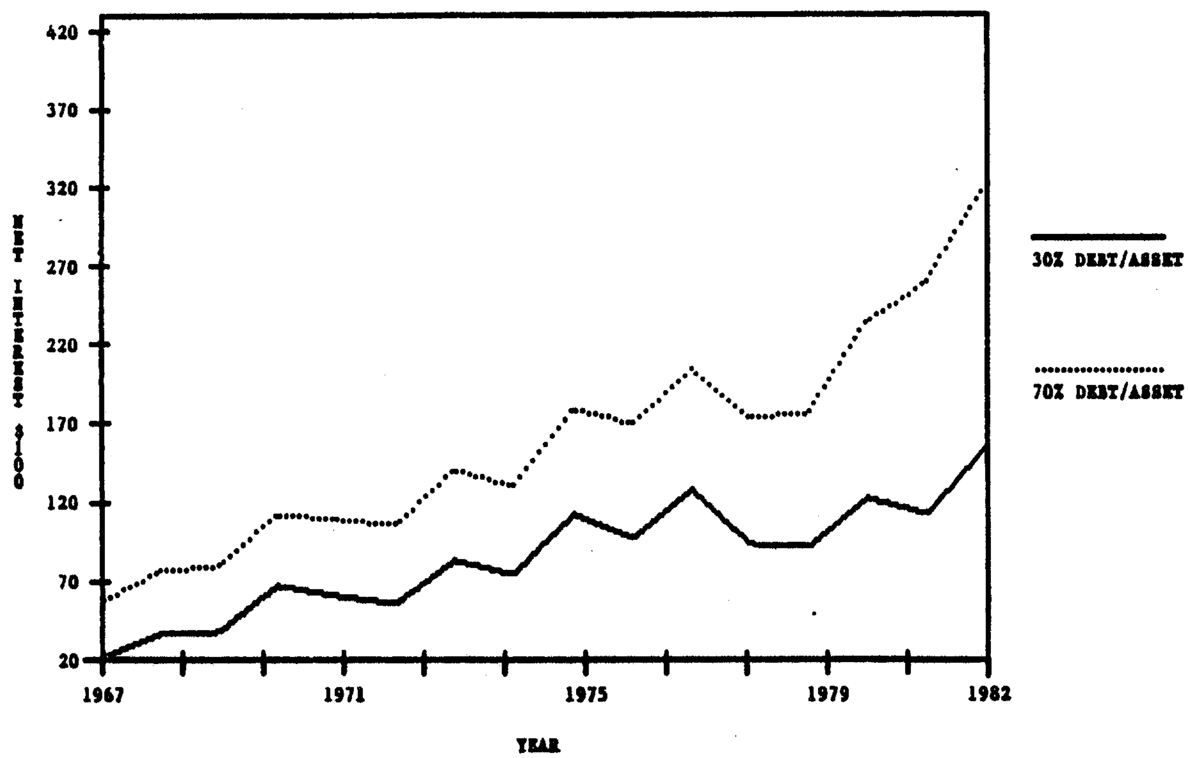
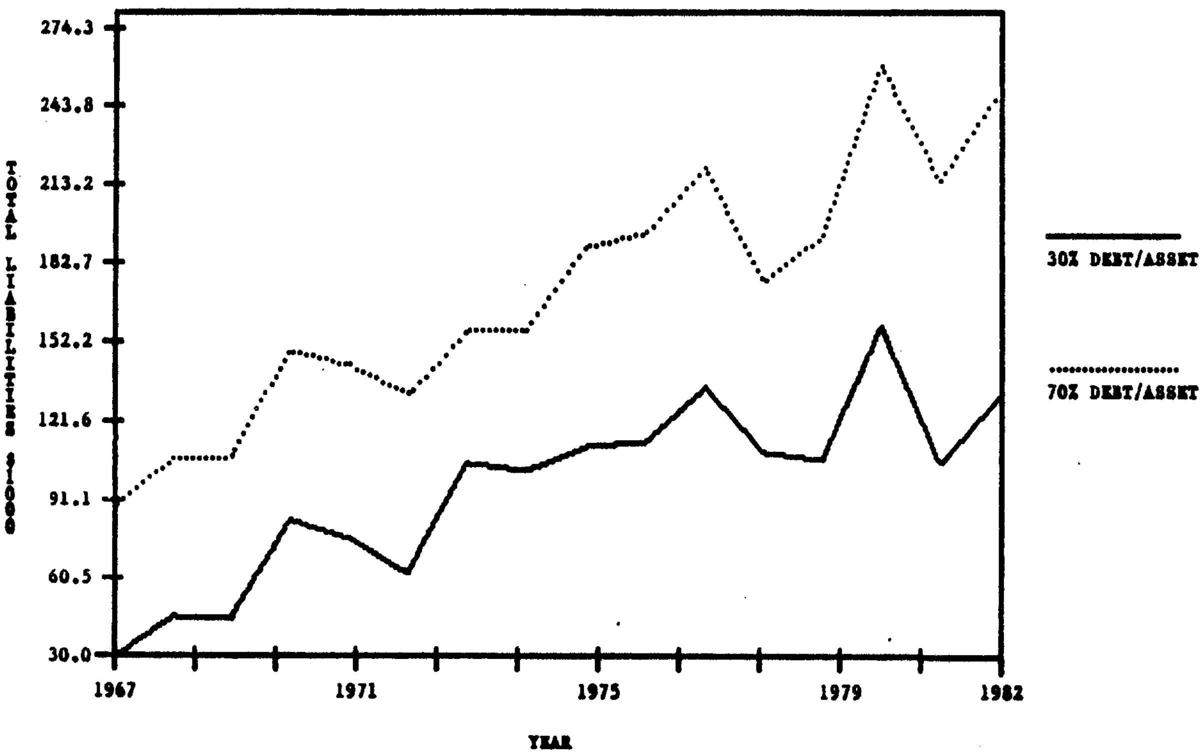


Table 27: Case D - Farm Simulation Results

Leverage= High (.7)
Financing- Bank
Interest Rate- Fixed
Debt Mix LT/IT=EVEN 1/1

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios: Current	Leverage	ROR-Equity	Earn/Debt Serv.
1982	319	776	2485	11868	3.4	.17	.05	1.36
1981	258	671	2145	11074	3.0	.16	.05	1.05
1980	235	1159	2602	9666	2.4	.21	.10	1.60
1979	177	11	1938	8139	2.1	.19	-.02	0.08
1978	173	1124	1757	8145	5.8	.18	.12	1.53
1977	204	962	2196	7222	4.3	.23	.12	1.49
1976	169	810	1948	5830	4.1	.25	.11	1.01
1975	179	319	1891	3983	3.8	.32	.05	0.73
1974	131	912	1566	3404	4.1	.32	.24	1.62
1973	140	1118	1566	2209	6.2	.42	.47	1.63
1972	107	574	1329	1243	3.4	.52	.42	1.20
1971	110	147	1439	805	1.6	.64	.10	0.48
1970	113	271	1493	897	2.0	.62	.23	0.77
1969	80	226	1081	861	2.3	.56	.19	0.30
1968	77	240	1071	704	2.0	.60	.27	0.70
1967	59	324	892	562	2.6	.61	.48	0.85

Figure 31: Total Liabilities: High Leverage Position (Case D) Compared to Low Leverage (Case A)



comparatively low level prior to the rapid escalation of interest rates in the late 1970's. Even with this decline in relative leverage position, interest expense at the end of the period was claiming nearly one third of the total of pre-interest earnings, i.e. the sum of interest expense and net farm income.

Case E: High Leverage Position and Variable Farm Credit System Financing. A comparison of the variable Farm Credit System financing (Case C) but with a higher beginning leverage position shows results similar to those found when comparing high versus low leverage scenarios for fixed rate bank financing. Figure 32 exhibits the gradually increasing difference in net interest expense. Again, the highly leveraged farm faces higher net interest expense and, thus, lower net income. Figure 33 and Table 28 (versus Table 26 for the comparable low leverage scenario) show the expected results in total liabilities. While the high leverage farm did not generally reduce its level of total liabilities - due in part to the purchase of additional assets - it did reduce its relative use of debt quite markedly over the period as shown by the decline in the leverage ratio. Again, even with this decline in the relative use of debt to very moderate levels near the end of the period, interest expense was, by 1982 claiming nearly 40% of pre-interest earnings. This is roughly double the proportion that debt capital is of total (debt plus equity) capital.

The increased interest payment requirements decreased principal repayment capacity of the leveraged farm. Both graphs indicate the growing absolute difference between the two farms as interest rates rise.

Case F: Proxy Fixed Rate Bank Financing. Using the proxy interest rates the farm experienced slightly higher net interest expenses as seen in Figure 34. Since the proxy commercial bank rates were predicted to be marginally higher than the actual rates, the fixed financing farm displayed marginally

Figure 32: Net Interest Expense: High Leverage and Variable FCS Financing (Case E) Compared to Low Leverage and Variable FCS Financing (Case C)

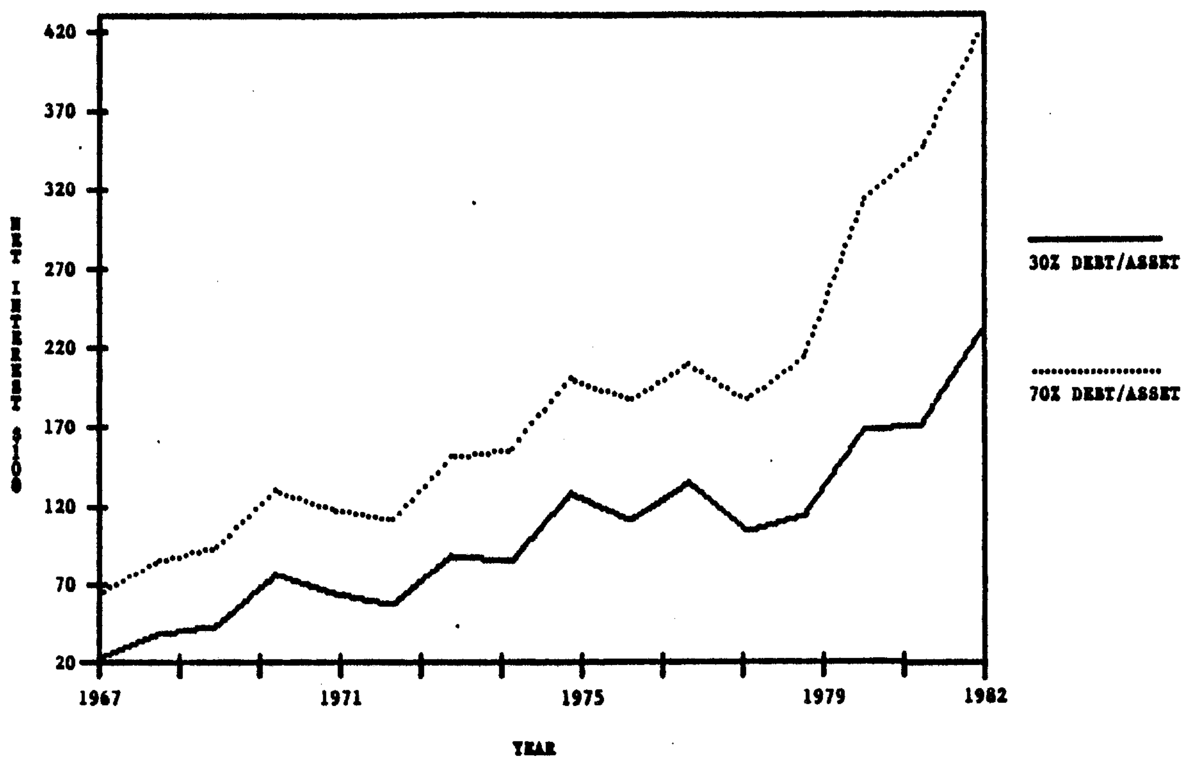


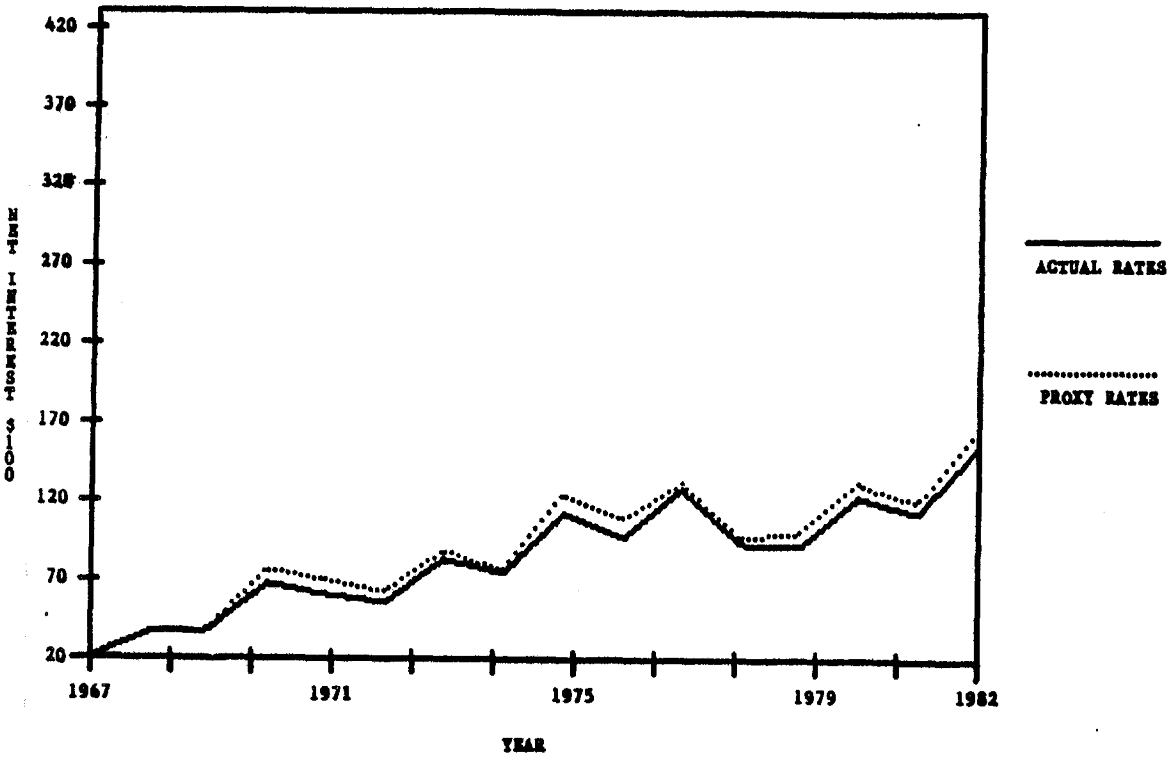
Figure 33: Total Liabilities: High Leverage and Variable FCS Financing (Case E) Compared to Low Leverage and Variable FCS Financing (Case C)

Table 28: Case E - Farm Simulation Results

Leverage= High (.7)
Financing- Farm Credit System
Interest Rate- Variable
Debt Mix LT/IT=EVEN 1/1

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios: Current	Leverage	ROR-Equity	Earn/Debt Serv.
1982	417	678	2743	11827	3.1	.19	.04	1.44
1981	345	584	2351	11043	2.6	.17	.04	1.26
1980	312	1083	2774	9709	2.2	.22	.10	1.60
1979	214	-26	2033	8184	2.0	.20	-.02	0.05
1978	187	1110	1824	8194	5.6	.18	.12	1.55
1977	209	956	2253	7232	4.2	.24	.11	1.50
1976	186	793	2016	5899	4.0	.26	.11	1.03
1975	201	297	1954	4049	3.4	.32	.05	0.81
1974	156	887	1623	3447	3.9	.32	.23	1.67
1973	151	1107	1606	2266	5.9	.42	.46	1.60
1972	111	570	1361	1315	3.1	.51	.39	1.21
1971	119	138	1471	887	1.5	.62	.08	0.54
1970	131	253	1524	982	1.9	.61	.19	0.85
1969	94	212	1102	928	2.1	.54	.16	0.49
1968	86	231	1083	777	2.0	.58	.23	0.74
1967	66	316	900	620	2.6	.59	.42	0.88

Figure 34: Net Interest Expense: Proxy Fixed Rate Commercial Bank Financing (Case F) Compared to Actual Fixed Rate Commercial Bank Financing (Case A)



higher net interest expense under this condition. As a result, the total liabilities in Table 29 grew only a little more than the base farm's in Table 23. A graphic comparison is presented in Figure 35. Therefore, the quantitative effect of the "insulation" from national money market rates received by commercial bank agricultural borrowers prior to financial system deregulation and innovations of the late 1970's proved to be small when compared to the differences which emerge for variations of financing and relative debt load. Given the relatively minor variations in interest rate levels plus the fact that money market rates on occasion moved lower to offset the effects of peaks, the net result is that no large noticeable difference in interest expenses would have been experienced during the 1970's had deregulation and other `deinsulation' changes occurred at the start of the decade rather than at its end.

Case G: Proxy Variable Rate Farm Credit System Financing. A comparison among Farm Credit System rates produced results similar to those of Case F, the proxy Commercial Bank fixed rate. Figure 36 (and Table 30 versus Table 26) shows the small difference in net interest expense that arise under the proxy versus actual interest rate scenarios. Figure 37 displays the almost unnoticeable difference in the levels of total liabilities. The small difference between the results for the proxy FCS interest rate series versus the actual series is probably not too surprising. Since the FCS ultimately obtains its loanable funds in the national money and bond markets, their rates have thus always reflected - but with a lag - conditions in those markets.

Case H: Highly Leveraged Fixed Rate Bank Financing With Greater Long Term Debt. The base farm began with an even mix of intermediate and long term debt. A farm with more long term debt compared to intermediate debt may be able to handle debt service requirements more easily since scheduled, annual

Table 29: Case F - Farm Simulation Results

Leverage= Low (.3)
Financing- Proxy Bank
Interest Rate- Fixed
Debt Mix LT/IT=EVEN 1/1

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios: Current	Ratios: Leverage	Ratios: ROR-Equity	Ratios: Earn/Debt Serv.
1982	165	930	1415	12938	5.0	.10	.06	1.82
1981	120	808	1133	12087	11.5	.08	.05	2.13
1980	132	1262	1662	10606	4.2	.14	.11	3.02
1979	101	88	1100	8977	13.8	.11	-.01	0.35
1978	98	1198	1108	8955	44.5	.11	.12	2.73
1977	132	1034	1411	8007	6.9	.15	.11	2.29
1976	109	870	1201	6577	8.9	.15	.11	1.73
1975	125	373	1175	4699	9.5	.20	.06	1.02
1974	77	966	1025	4135	34.7	.20	.21	3.48
1973	89	1168	1064	2918	30.4	.26	.38	3.03
1972	63	618	641	1931	8.5	.25	.29	2.11
1971	70	187	777	1468	3.4	.35	.08	0.48
1970	78	306	851	1539	3.5	.35	.16	1.06
1969	40	266	452	1489	5.9	.23	.14	0.48
1968	38	279	461	1314	5.0	.26	.18	1.17
1967	22	360	300	1153	6.3	.21	.26	1.93

Figure 35: Total Liabilities: Proxy Fixed Rate Commercial Bank Financing (Case F) Compared to Actual Fixed Rate Commercial Bank Financing (Case A)

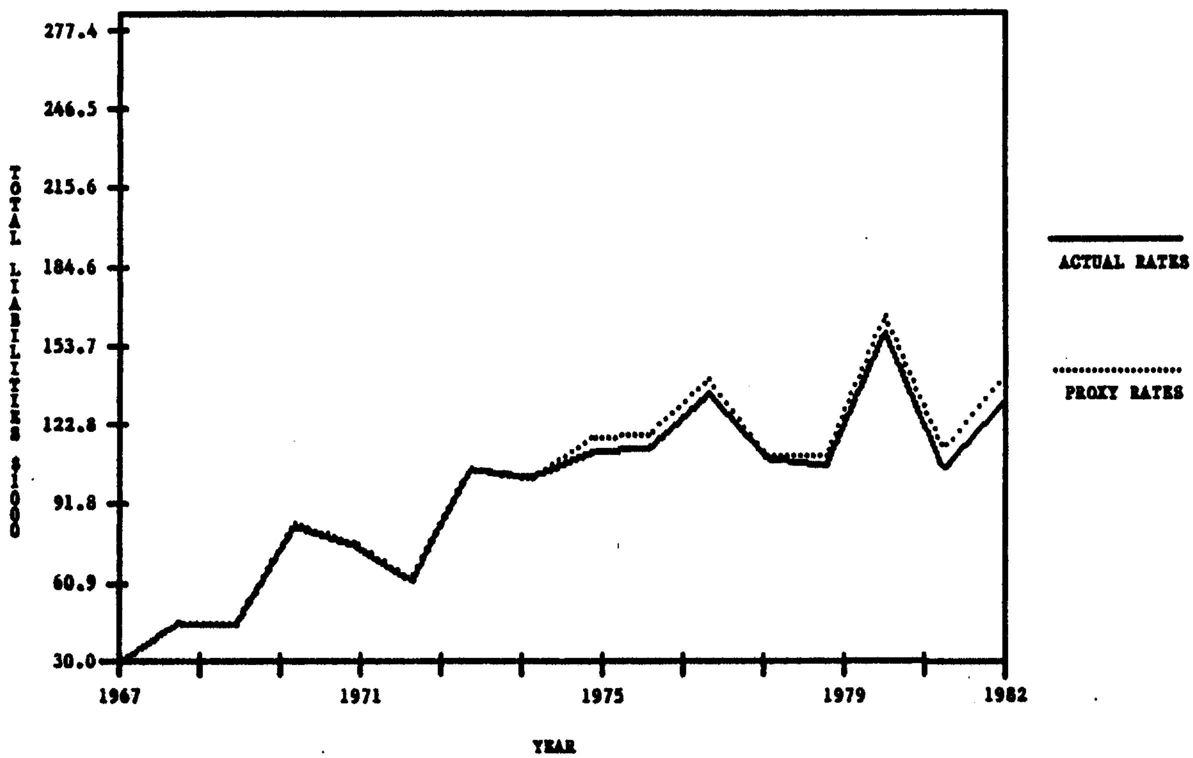


Figure 36: Net Interest Expense: Proxy Variable Rate FCS Financing (Case G) Compared to Actual Variable Rate FCS Financing (Case C)

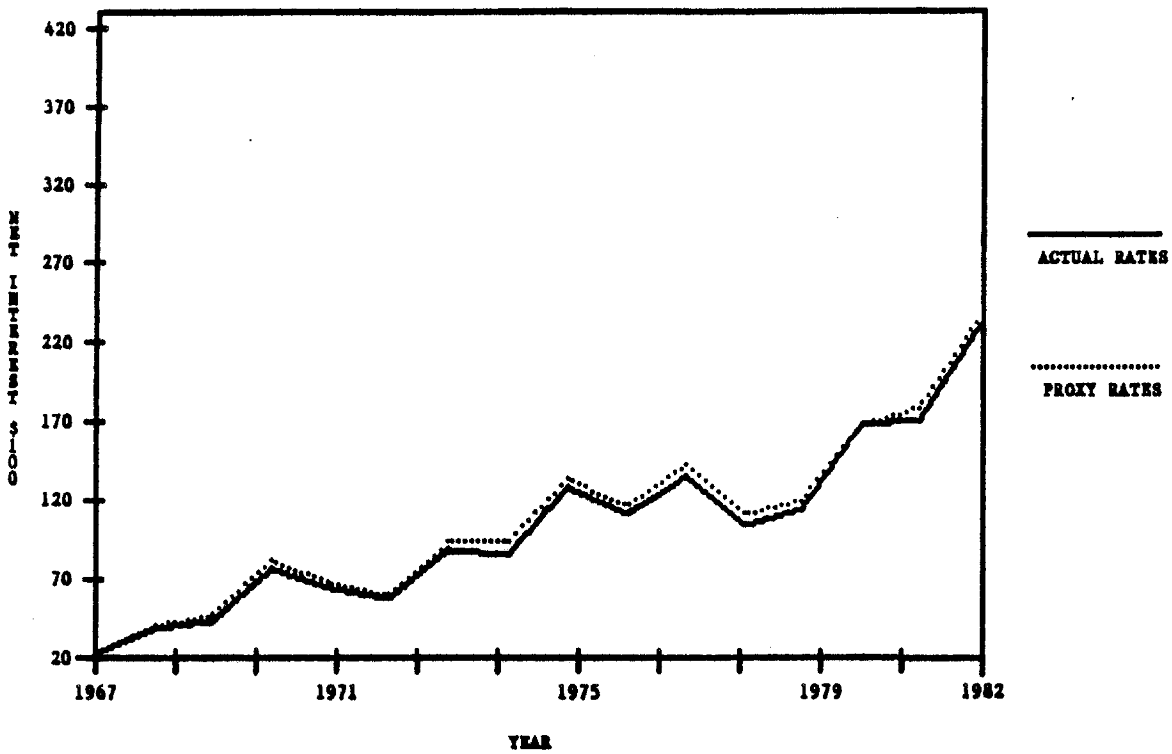
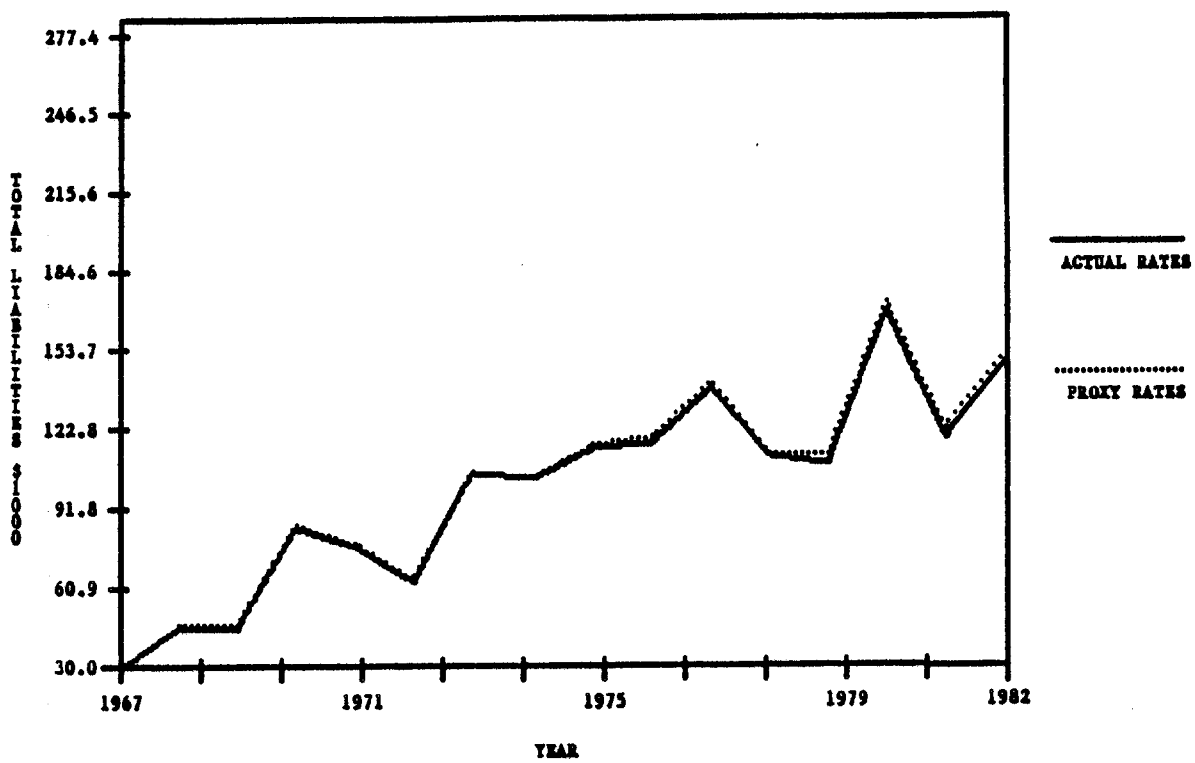


Table 30: Case G - Farm Simulation Results

Leverage= Low (.3)
Financing- Proxy Farm Credit System
Interest Rate- Variable
Debt Mix LT/IT=EVEN 1/1

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios Current	Leverage	ROR-Equity	Earn/Debt Serv.
1982	234	859	1524	12931	4.7	.11	.05	1.73
1981	179	750	1226	12065	9.0	.09	.05	1.95
1980	168	1226	1720	10667	4.0	.14	.10	2.77
1979	120	68	1122	9012	13.8	.11	-.01	0.23
1978	111	1183	1126	8999	43.9	.12	.12	2.65
1977	142	1023	1415	8086	6.9	.15	.11	2.32
1976	117	862	1200	6643	9.8	.15	.11	1.75
1975	134	364	1171	4764	9.6	.20	.05	1.06
1974	92	950	1036	4156	33.8	.20	.21	3.32
1973	93	1164	1066	2958	30.0	.26	.37	2.93
1972	61	620	649	1967	8.4	.25	.29	2.10
1971	69	187	786	1516	3.4	.34	.08	0.48
1970	83	300	863	1590	3.5	.35	.15	1.08
1969	48	258	463	1515	5.6	.24	.13	0.50
1968	42	275	467	1345	4.9	.26	.17	1.19
1967	25	357	303	1170	6.2	.21	.26	1.84

Figure 37: Total Liabilities: Proxy Variable Rate FCS Financing (Case G) Compared to Actual Variable Rate FCS Financing (Case C)



principal payments will be lower. Figure 38 shows the small difference in net interest expense that exists between the two highly leveraged farms. Toward the end of the period, the farm with greater long term debt experienced a slightly lower net interest expense (see Table 31 versus Table 27) mainly from the lower interest rates applicable to fixed rate, long term debt. A closer look at the peak short term borrowing required during each year revealed a greater difference (See Table 32). The base farm experienced higher peak credit needs during the year due in part to the need to meet relatively larger principal repayment obligations on intermediate term debt, while the long term debt farm produced stronger net-of-debt servicing cash flows due to the lower principal repayment requirements. The cash flow produced by operations, however, enabled the farm to reduce total liabilities to roughly comparable amounts in both cases. And the difference in the earnings to debt servicing is fairly small but the difference that does exist generally favors the farm with greater long term debt (i.e. it has the higher coverage ratio - see Table 31 versus Table 27).

Case I: Interest Rate Hedging. Financial futures contracts developed in a period of rapid inflation, volatile money market interest rates, financial innovations, and deregulation of interest rates. Both lenders and borrowers have come to face uncertain interest income and expenses in that environment. Thus, with variable interest rates a lender wishes to insure that net interest income (the difference between interest earned versus interest paid) remains relatively stable over the period of the loan while the borrower would like to keep finance charges from growing beyond his/her capacity to pay. Thus developed a need to hedge against such uncertainty and to "lock in" an effective interest rate. A major tool which developed to hedge against adverse interest rate changes is the financial futures contract, which is very

Figure 38: Net Interest Expense: Highly Leveraged Greater Long Term Debt, Fixed Rate Bank Financing (Case H) Compared to Low Leverage, Equal Debt Mix (Case A)

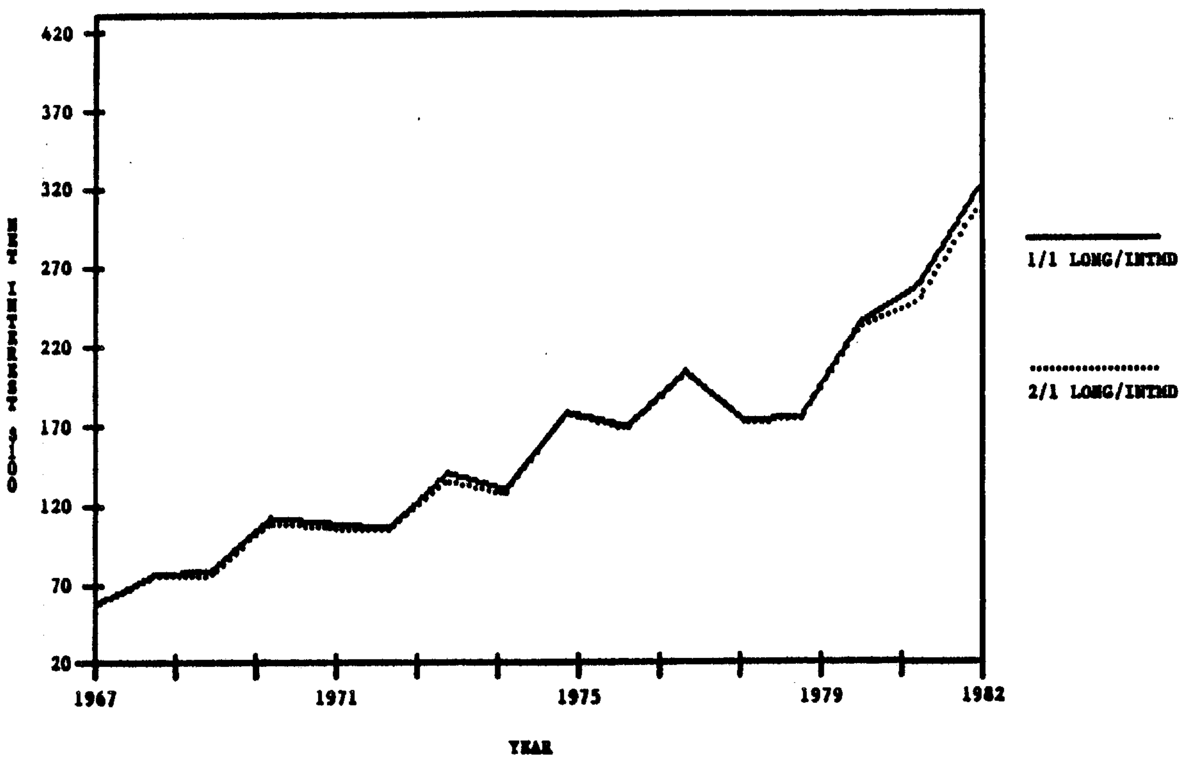


Table 31: Case H - Farm Simulation Results

Leverage= High (.7)
Financing- Bank
Interest Rate- Fixed
Debt Mix LT/IT=UNEVEN 2/1

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios: Current	Ratios: Leverage	Ratios: ROR-Equity	Ratios: Earn/ Debt Serv.
1982	307	788	2449	11904	3.5	.17	.05	1.34
1981	248	681	2116	11103	3.5	.16	.05	1.18
1980	231	1163	2580	9688	2.6	.21	.10	1.84
1979	175	13	1920	8157	2.2	.19	-.02	0.10
1978	171	1126	1740	8162	6.3	.17	.12	1.64
1977	202	963	2180	7238	4.6	.23	.12	1.49
1976	168	811	1938	5840	4.5	.25	.11	1.26
1975	178	319	1882	3992	4.4	.32	.05	0.91
1974	127	915	1555	3415	4.9	.32	.24	1.96
1973	136	1121	1557	2219	7.3	.41	.47	1.81
1972	104	577	1321	1252	4.2	.51	.42	1.44
1971	107	150	1433	812	2.0	.64	.10	0.46
1970	110	273	1488	901	2.3	.62	.23	0.76
1969	78	227	1078	864	3.0	.56	.19	0.44
1968	75	242	1069	706	2.5	.60	.27	0.83
1967	58	325	891	562	3.2	.61	.48	1.09

Table 32: Peak Short Term Debt Levels Case D (1/1) and Gase H (2.1)

Year	Debt Mix LT/IT 1/1 ($100)	Debt Mix LT/IT 2/1 ($100)
1982	563	557
1981	971	911
1980	1002	946
1979	515	514
1978	395	284
1977	366	285
1976	268	256
1975	444	426
1974	581	580
1973	234	234
1972	192	128
1971	202	154
1970	153	135
1969	203	154
1968	176	154
1967	114	103

similar to a commodity futures contract. The financial futures contract is an agreement to make or to take delivery of a standardized amount of a specific (fixed interest rate) financial instrument on a designated date. The most popular financial futures contracts traded are the $100,000 principal value of Treasury Bonds Contract, the contract for $100,000 units of Government National Mortgage Association Pass Through, Mortgage-Backed Certificates (GNMAs) and the contracts for $1 million units of Treasury Bills and Negotiable Certificates of Deposit. The initial price of the contract is determined at the time of contract initiation. For example, consider the Treasury Bond contract based upon $100,000 of Treasury bonds issued at an eight percent coupon interest rate. If the market interest rate is above eight percent at the time of contract initiation, then the face value of the bonds in the `cash´ market and, therefore, the contract price of closer-to-maturity (`nearby´) treasury bond futures contracts is discounted (relative to face value) to compensate for the difference between the market interest rate and the 8% bond coupon interest rate. The discount amount will vary depending upon the difference between the interest rates. The price of financial instruments generally (and of financial futures contracts whose value traces back to and reflects that of the underlying financial instrument in which it is denominated) varies inversely with changes in the market interest rate. Subsequently, as interest rates change, for example as they increase, the price of bonds on the `cash´ or `spot´ market will change - in this case decline - as will the price of the financial futures instrument. At maturity its value must be aligned with the value of bonds being traded on the `spot´ market (if not, there will be opportunities to reap arbitrage profits which will entice arbritraguers to undertake the actions that will restore spot-futures price equality). The futures contract, consequently, allows the price paid or received for an instrument to be "locked in" ahead of an actual transaction.

The strategy used to "lock in" an interest rate when the actual financial instrument being used carries a variable rate, is for the borrower or lender to take an offsetting position with a financial futures contract. For example, a person borrowing at variable interest rates would sell short a financial futures contract (i.e. sell a contract not currently owned) to take an offsetting position. If interest rates rise the price of the futures contract - like that of the underlying financial instrument will fall, producing gains from the futures contract(s) sold short. To harvest the gains, the borrower purchases back an equivalent futures contract to "close out" his/her futures position. Since interest rates rose, the purchase price of the contract would be lower than the previous selling price. These gains can then be used to pay down the amount of loans outstanding which by itself helps to reduce loan payments which, in turn, offsets a portion (or all) of the increase in payments that resulted from the accompanying escalation of the loan′s interest rate. Of course, if interest rates had fallen, the lower level of loan payments resulting from a reduced interest rate would be offset by the losses incurred in the futures market (as prices increased with the decline in interest rates producing a rise in the price of futures contracts and, therefore, a loss on the futures market short sale and subsequent, offsetting contract purchase transactions). This would necessitate additional borrowing and thus drive payment levels back near their original level.

The success of hedging the loan′s variable interest rate risk depends upon the closeness of the correlation between the loan interest rate and the price movements of the financial futures contract utilized. If the correlation is very high and positive - meaning that the borrowers loan rate moves almost exactly "in tandem" with market interest rates on the instruments upon which the futures instrument is based, then a hedge position can be established which will enable the borrower to "fix" (i.e., `lock in´) an interest rate equal to the rate implicit in the futures price - at the time of initiation of the hedge - plus any differential between that rate and the borrowers beginning loan rate. In effect, the borrower could fix the effective loan rate at its beginning level and be `protected´ against changes in payment levels that would result from future changes in the variable interest rate. An important empirical issue is, then, the closeness of the correlation between agricultural loan interest rates and interest rates on the securities upon which financial futures contracts are based.

The following simplified example illustrates the results of one strategy for hedging against adverse interest rate changes. In this example, a producer who has outstanding a $500,000 variable rate loan for twenty-five years from the local Federal Land Bank Association (FLBA) hedges against possible interest rate movements. In order to use all the available futures data, it is assumed that the farmer obtains the loan in May 1977 (shortly following the initiation of trading in GNMA futures contracts) and carries it through until April 1982. This period experienced rapidly rising interest rates and thus provides an ideal opportunity to test empirically the ability to hedge successfully variable interest rate agricultural loans. In a period of more stable interest rates, the advantages of interest rate hedging diminish since there is less risk of an adverse movement in rates. As applied, the hedging strategy collects the gains from the financial futures contract position and applies these to reduce loan principal. For this example the $500,000 FLBA variable rate loan will be hedged by <u>selling short</u> each May one year GNMA futures contracts. The following May offsetting contracts are bought to offset the initial contracts and new futures contracts are sold for the up coming 12 months.

Figure 39 shows the inverse relationship between the FLBA interest rate and the price of the financial futures contract for GNMAs. The interest rate graphed is the FLBA rate for long term, farm real estate loans. The financial futures contract is the GNMA futures contract from the Chicago Board of Trade at the month's closing price. The correlation between the interest rate and the GNMA futures contract price is -.93 (recall that prices and yields move in opposite direction - thus the correlation is negative). Perfect correlation would be -1.0. Therefore, it appears feasible that a hedge as outlined above could significantly stabilize (compared to an unhedged variable rate loan position) the producer's effective interest rate paid and, consequently his level of loan payments after application of hedging profits and losses to the outstanding loan balance.

The results for the farmer that hedged a $500,000 principal amount FLBA loan with 5 GNMA financial futures contracts compared to a farmer in an unhedged position is shown in Figure 40. This figure shows the monthly net cash outflows for a loan being amortized over twenty-five years and the net interest cost of the two positions. Initially, the hedged position debt service payments are greater than the unhedged position since the initial margin requirement for the futures contracts sold is borrowed and this increases the outstanding loan amount. The difference grows for several months due to increased borrowing to cover losses on the GNMA futures contracts as interest rates initially decline. Over the entire period, however, the hedged position maintains debt service payments between $3,800 and $4,750 per month. The unhedged position, however, experiences growth in debt service payments from $4,200 to $6,270. An increase of nearly 50% which

Figure 39: Federal Land Bank Interest Rates and GNMA Futures Contract Prices

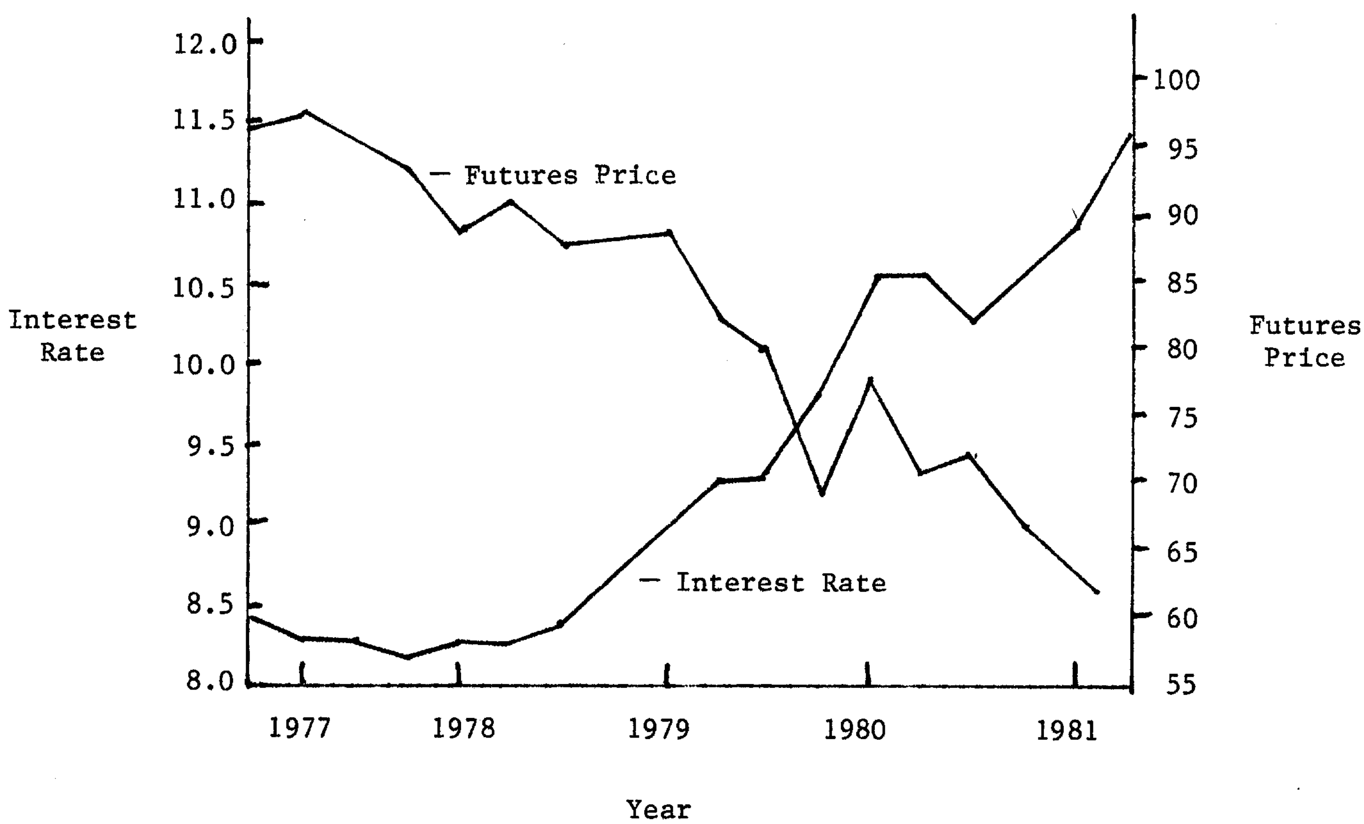
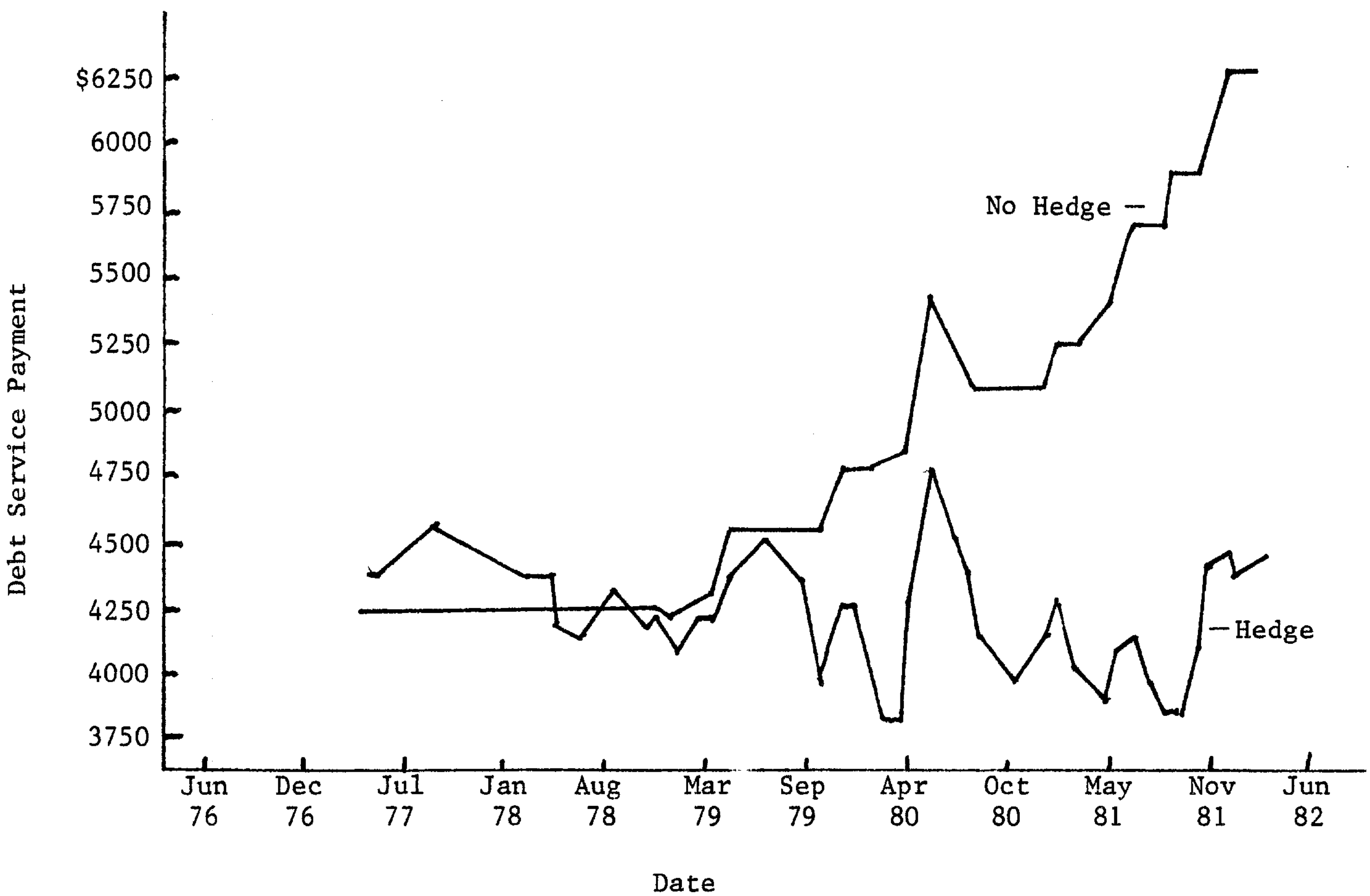


Figure 40: Debt Service Payments with No Hedge and with a GNMA Hedge



indicates the magnitude of interest rate risk exposure faced by a borrower with a floating rate loan in this period. Figure 41 shows the effect of the interest rate hedge upon the principal balance of the loan. The lower level of loan payments at the later stages of the period for the hedged position resulted, of course, from applying futures positions profits to pay off the loan balance. The interest rate applied to the outstanding loan balance was the same - at any point in time - for the hedged and the unhedged loan.

In the final simulation scenario, a similar GNMA futures contract hedge was used by the simulated farm. The farm used Farm Credit System financing and began 1967 with a 0.7 debt to asset ratio (Scenario E). A single, $100,000 GNMA contract, representing 80.9% of the farm's long term, real estate debt or 43.3% of its total debt at that point in time was employed in the later years of the simulation period. Thus this scenario involved only partial (fractional) hedging of the farm's variable rate debt. A more fully hedged position would need to take account of not only the dollar amount of liabilities but also their remaining maturities and payment patterns versus those of the instruments upon which the futures instrument is based and any differential responsiveness of yields on the futures instrument versus those on the farm loans to changes in market interest rates. The GNMA futures contract was initiated in 1977 as outlined in the example above (no hedge was in place during the first ten years of the period because no financial futures markets were in operation then). Figure 42 shows the reduction of net interest expense of 9.4% by 1982 (see Tables 33 versus 28). Figure 43 displays the reduction in total liabilities of 8.9% due to application of hedging profits to reduce outstanding loan principal. These results are not as dramatic as those for the $500,000 FLB loan considered in isolation above. When the fractional nature of the hedge position is considered, however, they

Figure 41: Outstanding Principal Balances with No Hedge and with a GNMA Hedge

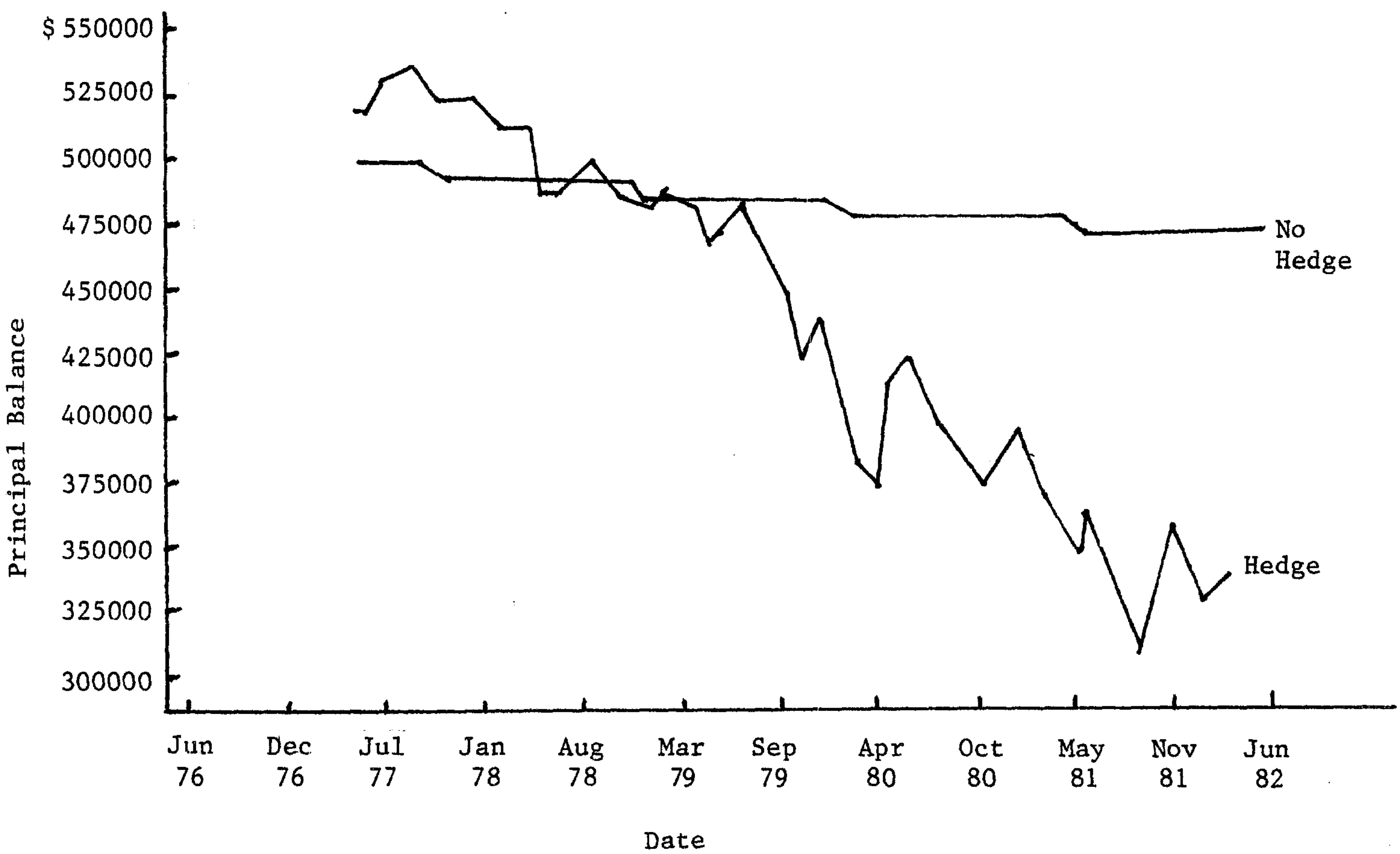


Figure 42; Net Interest Expense: Interest Rate Hedge (Case I) Compared to High Leverage Variable Rate FCS Financing (Case E)

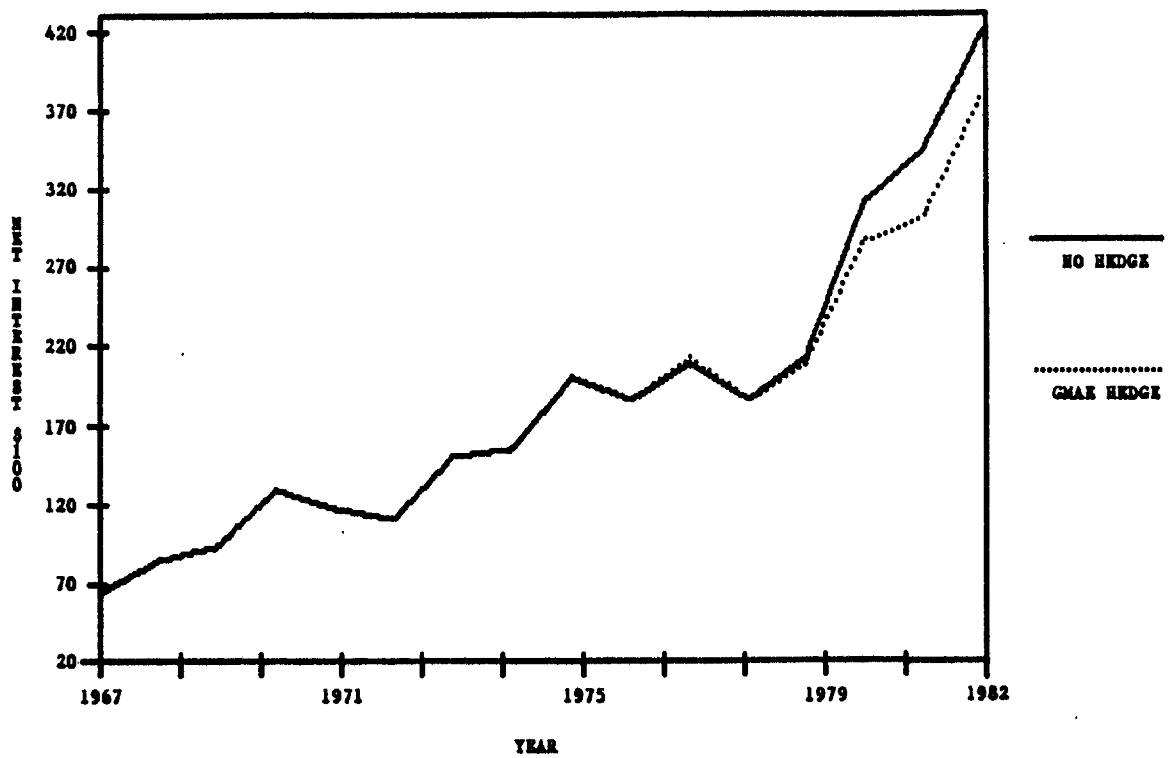
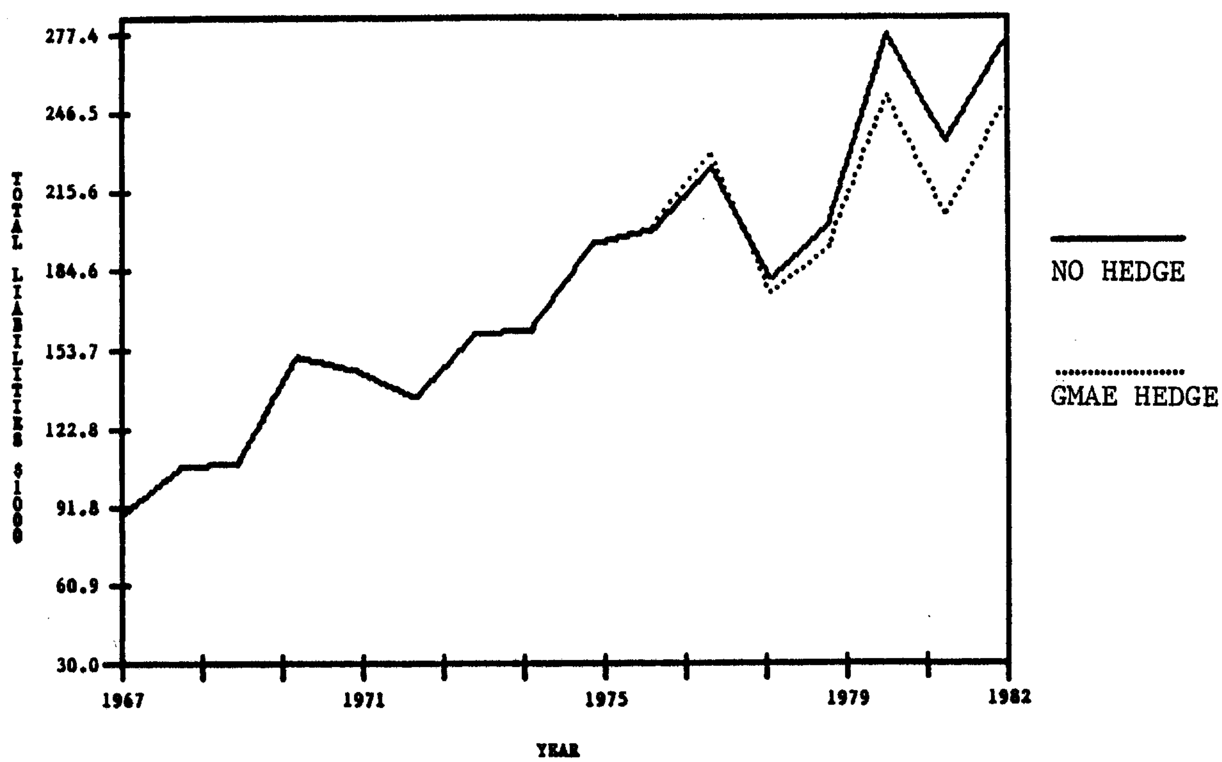


Table 33: Case I - Farm Simulation Results With GNMA Hedge

Leverage= High (.7)
Financing- Farm Credit System
Interest Rate- Variable
Debt Mix LT/IT=EVEN 1/1

Year	Income Statement Net Interest ($100)	Net Farm Inc. ($100)	Balance Sheet Total Liab. ($100)	Net Worth ($100)	Ratios: Current	Leverage	ROR-Equity	Earn/Debt Serv.
1982	378	708	2498	12047	3.4	.17	.05	1.52
1981	300	734	2056	11309	3.2	.15	.05	9.37
1980	286	1234	2529	9930	2.7	.20	.11	1.64
1979	209	61	1940	8268	2.3	.19	-.01	0.12
1978	186	1186	1768	8246	6.4	.17	.13	1.53
1977	212	898	2311	7270	4.3	.24	.11	1.57
1976	186	793	2016	5899	4.0	.25	.11	1.03
1975	201	297	1954	4049	3.4	.32	.05	0.81
1974	156	887	1623	3447	3.9	.32	.23	1.67
1973	151	1107	1606	2266	5.9	.42	.46	1.60
1972	111	570	1361	1315	3.1	.51	.39	1.21
1971	119	138	1471	887	1.5	.62	.08	0.54
1970	131	253	1524	982	1.9	.61	.19	0.85
1969	94	212	1102	928	2.1	.54	.16	0.49
1968	86	231	1083	777	2.0	.58	.23	0.74
1967	66	316	900	620	2.6	.59	.42	0.88

Figure 43: Total Liabilities: Interest Rate Hedge (Case I) Compared to High Leverage Variable Rate FCS Financing (Case E)



become more impressive. And, of course, these results are obtained over a period of rapidly rising interest rates. If interest rates were falling the hedge would have maintained or perhaps slightly increased net interest expense relative to initial levels and would have increased it versus the unhedged case in later years.

From the above results, the use of financial futures contracts by farmers appears to be a realistic tool for stabilizing debt servicing charges. The correlation between the Federal Land Bank Association's interest rate and the GNMA futures contracts' prices is quite high. Therefore, it should be possible to determine the amount required to fully offset agricultural interest rate changes for such loans. Tests on other variable rate loans await further research.

The specific hedging strategy employed here used a systematic (or 'mechanical') profit withdrawal and yearly contract turnover scheme. Other strategies might include a discretionary profit withdrawal and contract turnover. This discretionary use of the financial futures markets, however, turns the hedger into a speculator. A very good working knowledge of financial futures markets and the ability to consistently forecast interest rate changes correctly is necessary before a discretionary strategy should be attempted.

In the example above, the agricultural interest rate rise of approximately six percent moved the futures contract price significantly lower thus producing gains for the hedger who has a 'short' position in futures instruments. Thus, the interest rate hedge worked quite well. In a period of stable interest rates, the use of the hedge is not as necessary to control interest expense. However, the unpredictability of credit markets demonstrates that interest rates may be impossible to forecast over any relatively long time period.

Presently, the institutional structure in financial futures markets is not conducive for most farmers to employ financial futures contracts. The major problem is indivisibility of contracts making it difficult for many farmers to establish the exact dollar position in futures contracts that is needed. Farmers, however, could use these financial futures contracts to stabilize their net interest expense - and payment levels - if the structure changes to (or new institutions emerge that) enable the use of more fractional positions. If so, farmers will be able to employ financial futures to control interest expense, just as some now use commodity futures to control other uncertain variables such as commodity prices. To reduce their overall risk farmers must strive to control as many uncertain variables as possible.

Summary

This section has applied the techniques of dynamic simulation in a historic context to data compiled for a representative southern Minnesota corn-soybean hog farm. The simulation period covered the years 1967 to 1982. Marketing strategies for the representative farm consisted of cash sale of slaughter hogs and cash sale of grain held for sale in the seasonally high priced months. Crop yield and hog feed-gain ratios reflect actual experience of the unit from which the production data was drawn and thus reflect production variability actually encountered. Since marketing strategies, production results, and nonfinancial operating expenses were held constant in all runs, the differences in simulation results for the nine alternative runs (scenarios) reflect the impact of variations in financial strategies.

The various simulation runs allow comparisons of the impact of high versus low beginning leverage positions (70% beginning debt-to-asset ratio versus 30%), alternative sources of credit supply (commercial bank versus Farm

Credit System), and alternative loan pricing arrangements (variable rate versus fixed rate). Also examined were the effects of variations in the mix of long term versus intermediate term debt. Additional items examined were the effects of employing one type of financial futures contract (the GNMA contract) to partially hedge interest rate risk arising on variable rate loan arrangements, and the effect of any changes in credit pricing relationships that might be emerging as a consequence of changes in the financial market place - particularly those associated with financial system deregulation.

Table 34 presents in nominal dollars the average yearly net income for the nine simulation runs, and the ending net worth and leverage ratios. The baseline farm (Case A) with the low debt level, and fixed rate commercial bank debt is, not surprisingly, the most favorable configuration with the highest average income and largest ending net worth. The worst configuration is Case E, the high debt level with variable Farm Credit System financing, which shows the lowest average net income, lowest net worth and highest ending leverage ratio. Case I, which is a variant of Case E modified to incorporate an interest rate hedge, shows improved income and higher net worth.

COMPARISON OF FINANCIAL RISK TO PRICE AND PRODUCTION RISK

The differences in the methods used in the analysis of financial risk and the analysis of business risk makes any comparison very general in nature. The use of the mean (contribution margin)-variance optimization model for business risk analysis explicitly assumes a two period static model while the simulation model used to examine financial risk was dynamic. Also, the mean-variance analysis was in constant 1977 dollars and the simulation analysis in nominal dollars. Any comparison must be made in terms of constant purchasing power dollars. Finally, the financial risk simulation model of necessity examined earnings <u>after</u> interest expense and overhead charges were

Table 34: Yearly Average Net Farm Income, Ending Net Worth and Leverage Ratio, for Scenario A - I, Nominal Dollars

Simulation Scenario	Average Net Farm Income (Nominal Dollars) 1967-1982	1982 Ending Net Worth	Leverage 1982 (Total Liabilities ÷ Total Assets)
A	$67,520	$1,302,300	.09
B	64,970	1,278,400	.11
C	65,760	1,296,300	.10
D	60,270	1,186,800	.17
E	57,430	1,182,700	.19
F	66,960	1,293,800	.10
G	65,290	1,293,100	.11
H	60,590	1,190,400	.17
I	60,160	1,204,700	.17

deducted. The contribution margin measure employed in the business risk analysis did not have these charges deducted from it.

Table 35 gives the estimated standard deviation associated with each risk level in Model 1 and Model 2. Model 1, with an estimated standard deviation of returns of $9,292.10, has an expected contribution margin of $63,315, yielding a coefficient of variation of 14.68%. The coefficient of variation, which shows the percent that standard deviation is of expected return, increases from a low of 14.68% for the low risk level to a high of 28.65% for the high risk level. For the model with the crop rotation constraint imposed, the coefficient of variation ranges from 17.33% for the low risk level to 28.84% for the high risk level. Thus variations in marketing plans that are included in the efficient set involve a high risk-high return alternative that has a variability of contribution margin associated with it that is nearly twice the level of the low risk-low return strategy.

The 16 yearly net farm income estimates for each simulation run specified in the financial risk analysis were converted to 1977 dollars using the gross national product implicit price deflator. The yearly average net income after interest expense for each scenario is presented in Table 36. The relative profitability (or) ranking of Cases B through I compared to the baseline farm (Case A) is the same in real dollars as it is in nominal dollars. Case A has the largest average net farm income of $73,360 and Case E, with the high debt level and variable FCS financing, has the lowest average net farm income of $63,280. Cases B, C, F and G, all with a low (.3) debt-to-asset ratio, have average net farm income levels in excess of $70,000 when measured in constant (1977) dollars. The high debt (.7) level cases; D, H and I have average net farm income values within $3,000 of the lowest net return case, Case E. The standard deviations of the nine cases are very similar, Case A has the lowest

Table 35: Standard Deviation, Expected Contribution Margin and Coefficient of Variation for Model 1 and Model 2 in Constant 1977 Dollars

Model 1

Standard Deviation	Expected Net Return	Coefficient of Variation
$ 9,292	$ 63,315	14.68%
13,938	93,315	14.94
18,584	113,112	16.43
23,230	121,846	19.07
27,876	122,797	22.70
32,522	123,529	26.33
35,393	123,529	28.65

Model 2

$ 9,292	$ 53,609	17.33%
13,938	80,109	17.40
18,584	105,515	17.61
23,230	119,599	19.42
27,876	122,733	22.71
32,522	123,449	26.63
35,656	123,614	28.84

Table 36: Standard Deviation, Average Net Farm Income After Taxes and Coefficient of Variation for Simulation Scenarios in Constant 1977 Dollars.

Case	Standard Deviation	Average Net Farm Income	Coefficient of Variation
A	$38,450	73,360	52.41%
B	38,710	71,220	54.35
C	38,670	71,810	53.85
D	38,470	65,780	58.48
E	38,850	63,120	61.56
F	38,560	72,750	53.00
G	38,630	71,280	54.19
H	38,470	66,090	58.20
I	38,460	65,200	58.98

with $38,450 and Case E the highest with $38,850. It follows then that Case A, with the highest average net farm income and lowest standard deviation has the most favorable coefficient of variation, 52.41%, while Case E, with low average income and high standard deviation has the highest coefficient of variation, 61.56%.[18]

Table 36 does suggest that the level of financial leverage is one of the most powerful determinants of financial risk - a finding that is not surprising. The coefficients of variation (CVs) for the four high leverage simulations (D, E, H, I) are all well above those for the five lower leverage simulations (A, B, C, F, G). At the lower leverage levels there is not a

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[18] These coefficients of variation are not directly comparable to those for the production risk optimization model. First, the measure of earnings is different. In the production risk model the earnings measure utilized is the contribution margin which does not have fixed operating expenses and interest expense deducted from it. For the financial simulation model these items are deducted to arrive at a net earnings measure that is correspondingly smaller. This in turn implies that the expected earnings measure used in the denominator of the coefficient of variation for the financial risk simulation model is smaller than the expected value of the earnings measure employed in calculating coefficients of variation for the price and production risk optimization model. This alone will tend to make the coefficient of variation measure larger for the financial risk simulation model. Secondly, the earnings numbers for the financial risk simulation model reflect both business risk (production and marketing sources of income variability) and financial risk combined. The level of business risk reflects the representative farm's actual production experiences and the operation of a specific marketing strategy: cash sale of slaughter hogs combined with cash sale of grain in the seasonally high price months. In contrast, the optimization model employed to analyze business risk did not reflect the additional variability of net earnings that result from financial leverage effects. Those leverage effects are in some years earnings enhancing and in other years they serve to diminish the net returns to producer-borrowers. And, of course those financial leverage effects serve to make net returns more variable. For both reasons, therefore, the financial risk measures will reflect relatively more variability, per dollar of expected return, than will be the case for the business risk measures employed.

great increase in the CV as the firm shifts from fixed rate bank credit (simulation A) to variable rate FCS credit (simulation C). There is a slightly greater increase in relative income variability, as measured by the CV, in moving from fixed rate bank credit to variable rate bank credit (simulation A versus B). This is also not too surprising; the average cost of funds based pricing employed by the FCS does serve to `level' or reduce some of the `shock' to the farm's interest expense bill that results from the gyrations of financial market rates. This `buffering' effect is not present to the same degree in the more marginal cost of funds based pricing approach that is more common in commercial banking. However, the difference in CVs for variable rate bank credit versus variable rate FCS credit is less than half the difference between the CVs for variable rate FCS credit versus fixed rate bank credit.

At the higher leverage levels, the impact of a shift from fixed rate bank financing to variable rate FCS credit on the level of relative income variability is more pronounced (simulation D versus E). Indeed, by 1980 and for the two subsequent years, the difference in interest expense level - which was about one-third greater for simulation E (FCS variable rate) versus D (commercial bank fixed rate) - becomes quite large - approaching $100,000 in 1982. This suggests that choice of funds source and method of loan pricing may become a more important issue as the farm unit becomes more heavily leveraged.

Tilting the debt mix more heavily toward long term debt - given that fixed rate bank credit is employed - has a fairly slight impact in terms of reducing relative income variability (simulation H versus D). However, employing a financial futures hedge position, even on a fractional - or partial - basis as was the case in simulation I, does lower the CV to a notably degree given that the farm is operating at the high leverage level with variable rate FCS credit (simulation I versus E). Indeed it lowers the CV for the case to such a degree that it is not much larger than the corresponding CV for fixed rate bank financing (simulation I versus D). Finally, at least at low leverage levels, any recent changes in agricultural loan markets that may have been associated with the advent of financial innovations and deregulation do not appear - <u>in and of themselves</u> to have a major effect on relative farm income variability. When the proxy rate series are substituted for the actual rate series, only moderate increases in the CV (and the cost of credit) are observed for the fixed rate, commercial bank financial scenario (simulation F versus A) and the variable rate FCS scenario (simulation G versus C). The increase would almost certainly have been greater at the high leverage level but given the comparatively small changes at the low leverage level, it is unlikely that the increase would be great. This does <u>not</u> suggest that agricultural credit markets have not become a larger source of risk for farm borrowers in recent years. What it does imply is that the volatility in agricultural credit markets is more the result of the increase in the volatility of basic financial market rates generally than it is a result of changes in the way in which credit is priced. Farmers, like all other borrowers, confront more risk as the nation's money and bond markets become more chaotic.

But even with fairly drastic changes in the case farm's leverage level (.30 versus .70), source of finance and nature of instrument (fixed rate versus floating rate), large differences (e.g. doubling) in the relative variability of net income fail to emerge. While there are several important qualifications, these results mildly suggest that the greatest potential for risk reduction lies in the area of marketing strategy selection. Again, it must be noted that, for all scenarios, leverage levels in relative terms had declined greatly from initial levels by the later years of the simulation period when interest rates escalated sharply. This tends to mute the effects of the interest rate movements that did occur over this period. Had the case farm carried its beginning leverage levels throughout the period, by making larger asset purchases that would have necessitated greater amounts of borrowing, then the impact of the loan rate increases that occurred late in the simulation period would have been more dramatic and the differences in income variability associated with alternative financing scenarios would likely have been more marked. Also, the simulation period ends at a point in time where interest rates in both nominal and real terms (the market rate minus the inflation rate) remain (and continue to be) quite high relative to their values through most of the simulation period. The cumulative impact of several consecutive years of high interest rates for debt loads greater than those carried by the representative farm at the end of the simulation period would have produced greater income variability and, in all likelihood, greater differences between the alternative financing strategies examined.

Finally, it must be noted that the farm operator must be concerned with the combined total of business risk and financial risk. If the sum is too great, it does not particularly matter which particular source was well controlled and which source grew excessively large; an excess in either one can lead to the financial failure of the farm firm.

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