THE IMPACT OF FINANCIAL POLICY OPTIONS AND GOVERNMENT COMMODITY PROGRAM PAYMENTS ON FARM FINANCIAL SURVIVAL AND PERFORMANCE

By

SA'AD A. NAJIM AL-ABDALI

Bachelor of Science
University of Baghdad
Baghdad, Iraq
1975

Master of Science
University of Ain-Shams
Cairo, Egypt
1980

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
May, 1987

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Thesis Approved:

Harry P. Mapp
Thesis Adviser

Odell L Walker

James R. Russell

Ronald W. McNew

Norman N. Durham
Dean of the Graduate College

1286874

ACKNOWLEDGEMENTS

In the preparation of this study, I am especially grateful to Dr. Harry P. Mapp, my major adviser, for his guidance, understanding and fruitful discussions which, in a substantial measure, greatly improved the quality of this analysis. Dr. Mapp was very helpful and generous with his time throughout our working relationship. Appreciation is also expressed to other members of my advisory committee, Dr. Odell Walker, Dr. James Russell, and Dr. Ronald McNew, for their help in reviewing and making suggestions for this analysis.

Thanks are extended to the Head, faculty and staff of the Department of Agricultural Economics at Oklahoma State University for their hospitality and friendly relationships. Special thanks to the Computer Services group, especially Larry Watkins, for their very valuable assistance and help in compiling and implementing the computer programs used in this study. Special thanks and appreciation to Mrs. Theresa Smith for her patience, flexible scheduling, and meticulous typing of the thesis.

Finally, I would like to express my sincere love and thanks to my brothers Faisal and Moaiad and to my sister Fatima for their support and encouragement throughout my graduate study. Most importantly, I am very grateful for the sacrifice and prayers of my dear mother. Furthermore, I am grateful to the lady I have ever loved and missed for the time we had together! This effort is dedicated to her!

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CHAPTER I

INTRODUCTION

During the 1980's, the U.S. farm sector has experienced a remarkable amount of financial stress. Farm income has been low in both nominal and real terms. Land values have declined, interest rates have been high, and financial leverage has continued to increase. While the effects of these conditions vary considerably among farmers, credit problems, loan delinquencies, foreclosures, and bankruptcies in agriculture have reached significant levels. Moreover, a rippling effect has significantly affected the well-being of many farm lenders, agribusinesses, and rural communities whose financial performance is strongly influenced by economic conditions in agriculture. Due to financial stress, increasing pressure has been brought by farmers, farm groups, lenders, and others to provide public assistance at a time when the high cost of public programs has received close scrutiny from nonfarm groups. Moreover, farmers and their lenders are placing heavy emphasis on managing liquidity and financial restructuring to improve their prospects for farm survival and economic viability (Barry, 1986).

Farm financial stress is rooted in the inflationary decade of the 1970's and adjustments from the excesses of that period to sharply different economic conditions in the 1980's. Throughout the 1970's, farmers faced rapidly expanding exports, accelerating inflation, and low to negative real interest rates. Farmers responded by borrowing heavily to invest in new equipment, and to purchase increasingly expensive farm land. Farm debt rose an average

of more than ten percent a year. Yet land values rose even faster, providing the economic rationale as well as the security for farmers and lenders to expand and increase debt. Debt/asset ratios of farms were stable during the 1970's. By 1980's, the factors that had given rise to the expansion has reversed direction. World-wide recession weakened the international market, the strong dollar further dampened export demands, and inflation was slowed by stringent control of monetary growth. Real and nominal interest rates jumped to unprecedented levels. Farm commodities in foreign and domestic markets were too plentiful to sustain the prices that had prevailed during the 1970's, causing commodity prices and farmers' income to drop significantly. Land values, which depend on both current farm income and prospects for future income growth, also began to decline. The debt levels were no longer sustainable. Many farmers whose solvency depended on continuously rising land values or who pursued an aggressive expansion strategy were pushed toward insolvency. The result has been an increasing number of farm bankruptcies, loan liquidations and delinquent loans, in short, financial stress.

U.S. Department of Agriculture statistics indicate that 320,000 farms, which account for one-fifth of total U.S. farms, are estimated to be experiencing financial stress as reflected by a debt/asset ratio in excess of 40 percent and income shortfalls. An estimated 196,512 farms, 12 percent of the U.S. total, are experiencing high levels of financial stress as reflected by debt to asset ratios from 40 to 70 percent. Also, about 123,700 farms accounting for about 8 percent of total U.S. farms are experiencing very high financial stress as reflected by debt to asset ratios exceeding 70 percent. An estimated 50,600 of these farms which account for 3 percent of U.S. farms are insolvent; that is, they have debt to asset ratios over 100 percent (U. S. Department of Agriculture, 1985). Farms with debt/asset ratios exceeding 70 percent owe

33.4 percent of the total farm operation debt while the farms with debt/asset ratios of 40 to 70 percent owe 32.9 percent. About three-fourths of the debt owed by farmers with debt/asset ratios exceeding 70 percent is owed by farmers with sales of more than $100,000 per year (U.S. Department of Agriculture, 1986a). With the current prices, costs, and productivity relationships in agriculture, these highly leveraged farmers are unable to make interest payments on their indebtedness. Moreover, some of the farmers with leverage ratios of 40 to 70 percent will move to the higher leverage category (debt/asset ratio exceeding 70 percent) and may experience bankruptcy.

The extent to which farmers face financial problems can be gauged by changes in their asset values, debt commitments, and farm income positions. Asset values have declined from $1,003.2 billion in 1980 to $707 billion in 1986, and are expected to decline to $669 billion in 1987. Declining real estate values have contributed most of this decline. Total outstanding farm debt has increased from $170.2 billion in 1980 to $186.2 billion in 1986 resulting in real equity loss of $312 billion over the period. Overall, the debt/asset ratio for the farming sector has increased from 17 percent in 1980 to 26 percent in 1986 and is expected to be the same in 1987 (U. S. Department of Agriculture, 1987). Farmers with significant amounts of debt continue to have cash shortfalls that require them to increase operating debt, refinance, or liquidate some of their assets. With land values continuing to decline, refinancing debt is more difficult. Nominal net farm income has declined from $30 billion in 1981 to $28 billion in 1986 and is expected to be $32 billion in 1987 (U.S. Department of Agriculture, 1986b and 1987).

Financial stress varies by size and type of farm. Large farms often rent more land, and their owned asset base may not fully reflect the strength of the business. Large farms have higher levels of debt relative to the value of their

assets and are, thus, more vulnerable to financial crisis. Furthermore, certain types of farms, such as poultry and egg farms and cattle feedlots, are organized more along industrial lines and may be able to operate with higher debt/asset ratios and suffer less financial stress than more traditionally organized farms, such as cash grain or dairy farms (Huffman and Vandeveer, 1985).

Farmers response to risk by adopting strategies that reduce the likelihood of total risk, transfer risks to other economic units and increase the firm's capacity to bear the consequences of risk. Financial risk management strategies are distinguished from other farm risk management by their emphasis on farm's risk bearing. Their importance in agriculture is expressed by farmers' strong reliance on managing liquidity, leverage, and insurance. These strategies include alternatives which modify the consequences of risk when faced with fixed farm financial commitments. Various financial risk management strategies (policy options) have been suggested by government and non-government institutions to alleviate financial stress including interest rate buy-downs or subsidies, debt moratoriums, debt restructuring, asset restructuring, and recapitalization. Financial risk management strategies need to be flexible to accommodate variations in financial conditions for alternative farm situations and economic assumptions.

Problem Statement

The financial stress in U.S. farm sectors is widely recognized and well documented. Simply stated, the farm financial problem is that for many farms there is more debt than can be repaid from current levels of farm and non-farm income. There is about $50 billion of farm debt, which accounts for 23 percent of total debt held by the agricultural sector, that cannot be repaid with current

farm income. Statistics also indicate that 6.3 percent of family size farms are technically insolvent, 7.4 percent have "extreme" financial stress (debt/asset ratio greater than 70 percent), and 20 percent of farms have "serious" financial stress (debt/asset ratio 40 to 70 percent). These farms owe nearly half of all farm debt (Boehlje, 1985).

In Oklahoma, the financial condition of many farmers and lenders has deteriorated significantly over the past five years. Many farmers have experienced insufficient cash flows, credit problems, forced liquidations, foreclosures and bankruptcies. A recent survey on Oklahoma farms reveals that 14 percent of total farms are under significant financial stress, and six percent are in severe financial stress. In other words, about 20 percent of the farmers and ranchers in the state are carrying debt loads that threaten their financial viability, with perhaps six percent facing financial failure in the immediate future. In this state, different sizes of farms (measured by gross farm income) have different debt/asset ratios and thus have different levels of financial stress and probability of growth and survival. High debt to asset ratios are associated with larger operations and younger operators (Plaxico and Tilley, 1986; and Cochran, Tilley, Knowles, and Plaxico, 1985).

Economists have become increasingly concerned about the downward trends in net return and the apparently increasing number of farm situations experiencing cash flow difficulties or even bankruptcies. Many of the risk management practices available to farmers are not very effective in resolving serious and almost chronic cash flow problems. Protective responses in production and marketing, for example, are short-term options designed to maintain or stabilize production levels or prices within the production year (Barry, 1986). They may not help much in dealing with financial crisis situations. Furthermore, they are often limited by resources, climate, and

accessible markets. As income fluctuations due to business risk increase, financial responses to risk become increasingly important (Sonka and Patrick, 1984). Six financial policy options that are more targeted to the financial stress problems have been identified including 35 percent debt reduction, 35 percent interest rate reduction, two-year debt deferral, 35 percent asset sale with and without lease back, and 35 percent equity infusion. These policy options would improve farm cash flows in the short run and the likelihood of farm financial survival in the long run.

Government commodity programs are other policies that focus directly on farm sector problems. Government deficiency payments have contributed to improve farm cash flows, making it possible for many farmers to make scheduled debt payments. However, economists believe that government commodity programs may not only be extremely costly in terms of financial and human losses, but if improperly implemented might result in long-term dependence on government assistance as well as continued government interference (Boehlje, 1985; Doye and Sanders, 1986; and Tweeten, 1985). Efforts to effectively reduce government program payments would have important impacts on the financial viability of many farm operations. Little is known about the sensitivity of farm financial performance to the level of government payments, however.

Research is needed to evaluate the potential impacts of the financial policy options and government commodity program payments on the long-term financial performance and the probability of financial survival of Oklahoma farms under different economic and financial situations. Such research must include the impact of various beginning leverage positions and economic assumptions on long-run financial performance and probability of financial survival.

Objectives of the Study

The main objective of this study is to evaluate the impacts of various farm financial strategies (policy options) as well as the impact of government commodity program payments on the financial performance and long-run probability of financial survival of Oklahoma farms under different financial situations and economic assumptions. Specific objectives are:

1. Develop a set of whole-farm scenarios in a specified area of Oklahoma and simulate the activities of each farm scenario over time in deterministic and stochastic environments to determine the future financial condition for each farm.
2. Devise financial risk management strategies appropriate for improving the farm financial conditions under alternative farm resource situations.
3. Calculate and evaluate the directional impacts of the alternative farm management strategies on farm profitability, liquidity, risk, and solvency over a specified time period for each of the selected farm situations.
4. Evaluate the potential effects of alternative assumptions regarding beginning debt to asset ratio, participation in government farm programs, and economic outlook on the probability of farm financial survival and economic viability under both deterministic and stochastic crop yields and prices.

Description of the Study Area

The analysis was conducted in Jackson County located in Southwest Oklahoma (Figure 1). Jackson County is typical with respect to the crops

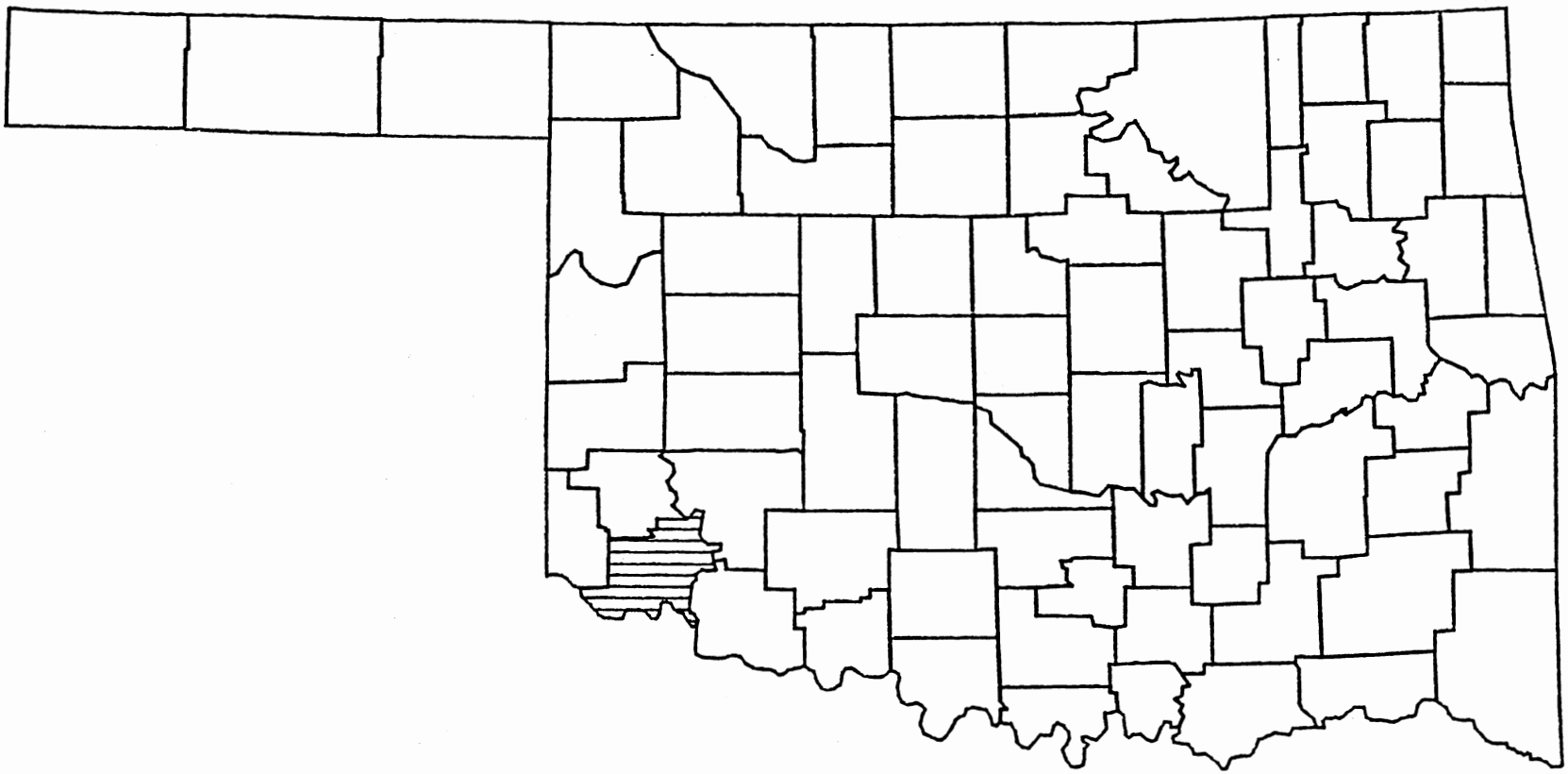


Figure 1. Map of Oklahoma with Shaded Area Indicating the Study Area of Jackson County

grown in the Southern Great Plains, and the weather in this county has substantial influence on crop yields. Jackson County weather has a warm, subhumid climate with an annual precipitation of 27 inches. The months of greatest rainfall are April through October. Dry spells of four to six weeks occur during the summer months when rainfall is erratic (Oklahoma Agricultural Statistics, 1985). These drought periods often result in crop damages to grain sorghum and cotton which are grown in this area.

Jackson County has a total land area of 522,905 acres. Of this total, 85 percent (443,464 acres) is in farmland. Nearly 76 percent of this farm land is devoted to crop enterprises, mostly dryland. About 39,000 acres are irrigated using wells and surface irrigation water from the Altus-Lugert project reservoir in Kiowa County, Oklahoma. Wood land represents only one percent of land area and the remaining 14 percent is devoted to other uses (Oklahoma Census of Agriculture, 1982).

The major crops produced in Jackson County are wheat (dry) and cotton (both dry and irrigated land). About 233,000 acres of hard red winter wheat and 46,000 acres of cotton were planted in 1985. Grain sorghum and hay are the other two crops which are grown and important in this area. About 15,000 acres of grain sorghum and 20,500 acres of hay, mostly alfalfa, were planted in 1985 (Oklahoma Agricultural Statistics, 1985). Cow-calf and stocker cattle enterprises are also common in Jackson County because wheat allows for winter grazing.

Organization of Thesis

The following chapter presents a review of the theoretical development of choice under risk, methods of risk analysis, financial risk management, and the relevant literature. Chapter III contains a complete description of the whole-

farm simulation model used to analyze and evaluate the potential impact of different policy options and strategies on the farm financial viability and the probability of financial survival. It also contains the development of data needed to construct a set of different farm financial situations under deterministic and stochastic environments for yields and prices. Chapter IV presents the implementation, analysis and results of the financial risk management strategies used to improve the financial condition of the simulated farm situations under different economic and financial assumptions. Chapter V summarizes the analysis, draws conclusions, and discusses the implications of the study and the need for future research.

CHAPTER II

THEORETICAL DEVELOPMENT AND LITERATURE REVIEW

Financial Risk Management

Firm Financial Risk

Firm's total risk includes business risk and financial risk. Business risk arises from the market, economic, and social environment facing the firm. It involves the variability of the returns to the firm's risky assets. Financial risk arises from the financial claims on the firm's asset. The greater the financial leverage, the greater the risks are in meeting financial obligations to lender and lessors. As expansion occurs with borrowed capital, the potential loss of equity capital increases, the variation of expected returns to equity increases, and liquidity provided by credit reserves is reduced. These affects are important because, as leverage increases, unfavorable events have greater impact on the firm growth and survival than the favorable events. Financial risks are further increased by unanticipated variations in interest rates, credit availability, and other changes in loan terms, as well as in leasing terms (Barry, Hopkin and Baker, 1983).

Financial risk can be an important component of the farmer's risk environment. Barry and Fraser (1976) predicted that the financial risk would become increasingly important to economic analysis as the agricultural

financial markets become less insulated from world financial conditions. Highly leveraged farms with low liquidity would find it difficult to service debts from their cash flow or credit reserves when the financial markets moved against them. This prediction was fulfilled in the early 1980's as land values and production prices declined and highly leveraged farmers experienced financial stress. Economic analysts have reemphasized the importance of financial considerations in modeling the farm firm as a result of recent financial problems in the farming sector (Barry and Fraser, 1976; Gabriel and Baker, 1980; Barry, 1983; and Wilson and Gundersen, 1985).

The extended portfolio model suggested by Barry (1983) provides an integrated conceptual framework for evaluating the optimal organization of farm asset and liability for risk averse decision makers. Barry showed how business risk is magnified by financial risk to determine the total risk to firm's equity holders in a risk-free cost of borrowing environment. In this approach, the measure of financial leverage serves as a direct indicator of the firm's financial risk. If leverage is zero (100 percent equity capital), then business risk and total risk are the same. As leverage increases, so does the total risk relative to business risk, the degree of increase directly indicates the firm's financial risk.

As Barry (1983) shows, the business risk (BR) and financial risk (FR) are combined in a multiplicative way to determine the total risk (TR) in risk-free cost of borrowing (i.e. fixed interest rate with i_d expected value and zero standard deviation; $\sigma_i = 0$).

$$(TR) = (BR) \bullet (FR) \tag{1}$$

Total risk is expressed by the coefficient of variation for equity holders. The standard deviation of the returns to equity is the weighted standard deviation of the risky assets since the standard deviation of the risk-free cost of borrowing

(interest rate) is zero. The expected rate of returns to equity is the difference between the expected return to the risky assets in the portfolio and the expected cost of borrowing. Thus, total risk is expressed:

$$TR = \frac{\sigma_e}{\bar{r}_e} = \frac{\sigma_a P_a}{\bar{r}_a P_a - i_d P_d} \qquad (2)$$

where

σ_e = the total standard deviation of return to equity

σ_a = standard deviation of return to the risky assets

$\bar{r}_e$ = expected return to equity

$\bar{r}_a$ = expected return to risky assets (In farming these risky assets are expressed as alternatives in production, marketing, and investment.)

P_a = proportion of risky assets in the portfolio

P_d = proportion of risk-free asset (debt) in the portfolio

i_d = risk-free cost of borrowing (i.e. fixed interest rate on borrowing; $\sigma_i = 0$)

Business risk is expressed by the coefficient of variation for risky assets:

$$BR = \frac{\sigma_a P_a}{\bar{r}_a P_a} = \frac{\sigma_a}{\bar{r}_a} \qquad (3)$$

Thus, financial risk is found by dividing total risk in (2) by business risk in (3).

(FR) = (TR)/(BR)

$$= \frac{\sigma_a P_a}{\bar{r}_a P_a - i_d P_d} \Big/ \frac{\sigma_a}{\bar{r}_a}$$

$$= \frac{\bar{r}_a P_a}{\bar{r}_a P_a - i_d P_d} \tag{4}$$

Substituting the expressions for business and financial risk into (1) yields:

$$TR = \left(\frac{\sigma_a}{\bar{r}_a}\right)\left(\frac{\bar{r}_a P_a}{\bar{r}_a P_a - i_d P_d}\right) \tag{5}$$

The first term in equation (5) expresses the business risk and the second term measures financial leverage, which is the index for financial risk.

The important feature of the total risk relationship is that the percentage increases in business risk are expanded by percentage increases in financial risk through increased leverage. Since variability of returns to asset (σ_a) and the index of financial leverage (P_d) are both positively related to the level of total farm risk, a strategic trade-off could occur between financial management strategies and scale adjustments in leverage.

Another approach of the portfolio adjustment for firm's risk was demonstrated by Gabriel and Baker (1980). They derive an additive relationship between business risk and financial risk in determining total risk, which shows the absolute increase in total risk is attributed to debt financing. This approach emphasizes a farmer's trade-off between business risk and financial risk, subject to a maximum risk tolerance. A decline in business risk, perhaps attributed to public policy, may lead to acceptance of greater financial risk, thus offsetting the lower business risk. Their analysis of the aggregate portfolio of farm sector yielded empirical evidence consistent with this phenomenon. Collins (1985) developed a theoretical model that supports Gabriel and Baker's approach. He concluded that a decrease in business risk should produce an increase in financial leverage, ceterus parabus, for a risk-averse expected utility maximizer.

Empirical Analysis of Financial Risk Responses

A firm's risk responses contribute to risk averting goals by reducing the likelihood of business and financial risks, transferring risk to other economic units and increasing the firm's capacity to bear risks. Financial responses to risk are distinguished from those in production and marketing by their emphasis on a firm's risk-bearing capacity. They refer to a firm's capacity to bear risks in production, marketing and financing, and to spread these risks among and between the financial claimants of the firm. Most of farmers' financial responses to risk involve the management of leverage, liquidity, and formal insurance. These actions affect both the farm's assets and liabilities and are interrelated with risk responses in production and marketing. Liquidity management involves methods of generating cash quickly and efficiently in order to meet cash demands. Some of the methods of providing liquidity include: 1) holding assets for sale to meet cash demand; 2) managing the rate of investments and withdrawals; 3) holding liquid credit reserves; and 4) using formal insurance (Barry and Baker, 1984).

The growing importance of credit as a mean of leveraging for firm growth and as contingent sources of liquidity stimulated much study about its role in farmers' liquidity management, how credit appraisals differ among lenders, and how farmers' perceptions of these appraisals influence their business decisions. Farm models based on risk programming and stochastic simulation were developed to evaluate trade-offs between financial gain, risk, liquidity, and survival. Also, linkages between sources of risk and risk responses in production, marketing, and finance were evaluated in terms of their effects on a farm's credit and its capacity to support firm growth and liquidity. Barry and Willmann (1976) tested the relationships between forward contracting and

other financial choices for producers who are subject to external credit rationing by using a borrowing model. Joint contribution of forward contracting to income stability, level of credit, and income growth were evaluated in a multi-period quadratic risk programming model. They found that (E-V) risk efficient growth plans include contracting due to both the favorable effects on credit and the lower price risks. Also, the model's results indicated that when credit is valuable, optimal growth plans include contracting even for farmers with little or no risk aversion and even though expected profits were higher for noncontracted sales.

Barry, Baker and Sanint (1981) developed concepts underlying farmers' credit risk to show through an extension of portfolio risk theory how credit risk may influence farmers' debt use and, thus, the farm organization and to evaluate alternative methods for empirically measuring credit risk. These effects are measured by extending the mean-variance portfolio model explicitly to include risk properties for costs of borrowing, and by deriving an expected utility maximizing farm portfolio that accounts for these measures of credit risk. The results showed that the optimum size of credit reserve is positively related to expected return on assets and negatively related to farmer's cost of borrowing, farm income, variance of return, and risk aversion coefficient. The negative correlation indicates that the greater variation in farmers' costs of borrowing from changes in their credit worthiness will add to farmers' total risk through both variance and covariance effects.

Microeconomic and macroeconomic theory suggests a strong relationship between different farm's economic and financial situations, and the probability of farm growth and survival. Farm economic situations include farm size, rate of increase in the cost of agricultural inputs, and rate of increase in farm assets, especially farmland. Farm financial situations include the

beginning equity level, cost of borrowing (interest rate), farmer's choice of lender, sequence and source of borrowing and loan arrangements, financing instrument, and asset structure and enterprise mix of farming operations. Patrick (1979) simulated a representative Indian farm under conditions of price and yield variability to determine the effects of different loan arrangements and debt to equity levels on farm growth and survival. Different debt/asset ratios and loan repayment arrangements were simulated in environment of price and yield variability to determine their effects on the probability of survival and growth, defined as capital investment and net worth accumulation of typical, but hypothetical, farm firms. The result obtained suggests that financial management variation does have considerable implications for risk management. Variation in debt level and loan arrangement do have substantial impacts on the probability of farm firm survival and growth. Further research to determine the guidelines for financial management strategy was suggested in this study.

Mapp, Hardin, Walker, and Persuad (1979) evaluated the effects of alternative assumptions regarding equity level, rate of increase in land value, and rate of increase in cost of agricultural inputs on probability of "success" of risk efficient farm plans for a Southwest Oklahoma farm operation using both MOTAD and simulation models. The analysis simulated the potential effects of reduced rates of increase in land value, increased cost of production, and alternative beginning equity level on the viability of risk efficient farm plans developed on a basis of historical data in a MOTAD framework. The chance of business failure was found to increase substantially when beginning equity is reduced to 45 percent and land value rises at four percent instead of seven percent.

Johnson (1979) used multi-period quadratic programming to integrate short-run production and marketing and long-run investment and financial decisions into a common framework. The model allowed responses to risk through variation in farm size, diversification of crop and livestock production, and adoption of alternative cash selling and hedging options. The results suggested that farmers use scale adjustments, including variations in the levels of investments and credit use, rather than diversification in managing risk. Johnson argued that an integrated analysis of the production, marketing, investment, and financial strategies is essential in risk management.

Held and Helmers (1981) examined the impacts of land expansion strategies and self-imposed borrowing limits upon growth and survival odds of a dryland Nebraska Panhandle wheat farm using simulation analysis over a 15 year period. The result showed a trade-off of enhanced survival at the expense of reduced growth results from more conservative borrowing for land expansion. Compared to land share and rent expansion, purchasing land showed only marginally greater growth at best, with substantially higher odds of firm failure. Also, results showed that providing some financial reserves through unused borrowing capacity improves odds of survival while sacrificing growth and income potential. The marginal value of liquidity (for assisting survival) is relatively high at lower levels of credit reserves.

Richardson and Condra (1981) were the first who developed a model to incorporate the effects of farm size in dynamic, uncertain environments on the farm efficiency, survival, and growth. A dynamic Monte Carlo simulation-programming model was developed and used to analyze the projected survival/success of four alternative farm sizes for the El Paso Valley. The results were tested by simulation of three alternative beginning equity levels and three land tenure situations over a 10 year planning horizon. They

conclude: 1) there is a well-defined, direct relationship between farm size and/or beginning equity level and the chance of survival and success for farms in El Paso Valley; 2) the projected chance of survival and success increases as farm size increases from 160 to 960 acres and/or beginning equity level increases from 25 percent to 100 percent.

Huffman and Vandeveer (1985) evaluated the impacts of size, tenure, leverage and type of farm on financial stress in Louisiana. Fifteen types of farming situations were defined based on tenure, enterprise combination, and geographic area. For each of these types of farming situations, three farm sizes were established with two equity level for each farm size (100 percent and 75 percent). They concluded that it is inappropriate to generalize about the impact of size, enterprise combination and tenure on financial stress among farmers. While, in general, increased size of farm results in larger residual cash balance, there were several situations for which increased size of farm results in greater negative cash balances.

Lines and Zulant (1985) analyzed the relationship between debt-to-asset ratios and selected socioeconomic characteristics obtained from a sample of Ohio farm operators. The analysis was based on polytumous multivariate logit regression. A statistically significant relationship was found between debt-to-asset ratio and operator age, farm size (measured by gross farm sale), and percent of farmland owned by operator. Statistically insignificant relationship was found between debt-to-asset ratios and farm type and off-farm income as a percent of family income.

Perry, Rister, Richardson and Leathem (1985) evaluated the effects of beginning equity level, credit policy (minimum required equity), and capital gain rates for land on the survivability and ending equity position of representative Texas rice and soybean farms. Two farm operations

representing a wholly-leased farm and a part-owner farm were simulated using RICESIM simulation model for the period of 1984-1988. The results showed that beginning equity is the predominant variable in determining the probability of farm survival over the next five years. Credit policy was important to farmers at intermediate beginning equity positions. At low beginning equity, neither type of farm operations will likely survive, no matter how liberal the credit policy. The results also showed that performance of the part-owner versus tenant operations is closely tied to the capital gain rate for land. A high rate causes part-owner operations to perform much better than the tenant operations, even at low beginning equity levels. Ordinary least square regression analysis indicated that the interaction between beginning equity and credit policy (measured by minimum equity ratio) were positive, implying beginning equity became more important to the farm operator as credit policy was tightened. The interaction terms between beginning equity and capital gains were negative, suggesting the value of capital gain to survival of the part-owner diminished as beginning equity increased. Alternatively, beginning equity became less important as capital gains increased.

Most recently, Pederson and Bertelsen (1986) used risk programming and simulation methods to analyze the opportunity to reduce whole-farm risk in a diversified North Dakota cash crop farm through reduced leverage and/or adjustments in rental arrangements. A safety-first, target MOTAD model was developed to identify risk-efficient farm plans. These risk-efficient strategies were simulated over four year planning horizon to monitor farm financial performance within a partially stochastic framework. The simulation model captured the cash flow performance of each strategy. The results showed that these two financial strategies (leverage reduction and adjustment in rental arrangements) extend the ability of the farm operator to manage downside risk

beyond the singular effects of a diversified farm plan. The results also indicated that a trade-off occurs between these strategies, but that reduction of debt has a greater impact on the distributions of net cash flow (before tax) and outstanding term debt.

A major finding of these studies has suggested that financial management of risks holds a prominent position among the methods for managing business and financial risk in agriculture. These financial managements are closely interrelated with other production and marketing responses of farm firms. Moreover, the full range of risk responses has increased in importance as new risks in financing farm businesses have emerged to combine with the traditionally high level of business risks in agriculture. These types of linkages and trade-offs among a firm's assets, liabilities, and risk responses are an inherent part of the portfolio adjustment process. However, identifying and measuring these relationships are challenging tasks.

In analyzing the financial risk management strategies, various methods of risk analysis were used including quadratic programming, MOTAD, target MOTAD, and simulation models. The theory of choice under risk, risk concepts, and methods of risk analysis as well as their advantages and disadvantages will be discussed in the next section.

Theory of Choice Under Risk

Risk and uncertainty are pervasive phenomena in production agriculture. Their importance in production agriculture has received considerable attention in recent years and is well documented. Many factors, such as weather events, disease, technical innovations, general economic conditions, and public and private institutional policies, interact to create a unique decision

making environment for agricultural producers. A farmer's risk comes not only from his assets and income-generating activity (business risk), but also from unanticipated changes in his liabilities and debt servicing requirements (financial risk).

Risk can be widely defined in two ways (Young and Findeis, 1978; and Young, 1984): 1) variability of income as measured by variance or standard deviation, 2) "chance of loss" or probability (α) that random income (π) will fall below some critical or "disaster" level (d). The second definition can be expressed as: $Pr(\pi < d) = \alpha$. The first definition is consistent with quadratic programming model of which maximizing expected utility is assumed while the second definition is more inclined toward "safety-first" models. The safety-first approach assumes that the decision maker is concerned with the ability to prevent total disaster rather than with the possibility of small losses and gains (Robison, Barry, Kliebenstein and Patrick, 1984). It specifies that a decision maker first satisfies a preference for safety, or a risk constraint, in selecting among action choices, and then follows a profit-oriented objective.

Expected Utility Analysis

Prescribing or predicting decision behavior under risk is difficult. It involves choosing from among a number of alternatives for which the consequences are associated with a probability distribution. Maximizing expected utility is predominant theoretical foundation for risk analysis. This concept provides a system whereby consistent choices among risky alternatives are simplified and evaluated. The central theorem of utility analysis, and its function in decision analysis, is known as Bernoulli's Principle, and sometimes called the expected utility theorem. Bernoulli's Principle asserts that the maximization of utility is, by the expected utility

theorem, equivalent to mathematical maximization of expected utility and the optimal behavior of the decision maker is that behavior which maximizes the expected utility when the utility is cardinally measurable (Dillon, 1971). It provides a mechanism for ranking risky prospects in order of preference, the most preferred prospect being the one with the highest utility.

Von Neuman and Morgenstern (1947) showed that the concept of cardinal utility follows logically from a set of simple axioms, and if these axioms are fulfilled, then the utility is measurable up to a positive linear transformation. The set of axioms is summarized as: 1) ordering of choices; 2) transitivity among choices; 3) substitution among choices (independence); and 4) certainty equivalent (CE) among choices (continuity). If a decision maker obeys these axioms, a utility function can be formulated which associates a single real number or utility index with any risky choice faced by the decision maker. These utility indices reflect the decision maker's preferences for outcomes and a subjective probability distribution (degree of belief) that reflects his personal judgment of the choices confronting him.

The Expected Utility Model (EUM) is a perspective tool. It infers that the decision maker who accepts these axioms should choose actions that maximize his expected utility (Robison, 1982; Shoemaker, 1972). It also provides a single-valued index that orders actions according to the preferences or attitudes of the decision maker. To summarize, the components of a decision problem include a set of actions $A_1, A_2, \ldots A_n$, a set of monetary outcomes, X_{ij}, associated with j^{th} action in the i^{th} state of nature, and probability density functions $P(s_i)$ indicating the likelihood of outcomes in the respective state of nature for an action choice. To order these action choices, each monetary outcome X_{ij} is assigned a utility value according to a personalized arbitrarily scaled utility function. The utility value for each

possible outcome of an action choice is weighed by its probability and summed. The resulting expected utility is a preference index for the action choices. Action choices are ranked according to their level of expected utility with the highest value being most preferred. Mathematically, the goal utility function is expressed as:

$$\underset{j}{\text{Max}}\ E\,U(x) = \sum_{i} U(x_{ij})\,P(s_i),\quad j = 1, \ldots n$$

Figure 2 represents three different utility functions, each of which associates a utility value with a risky choice. All three functions are monotonically increasing, i.e. if $\pi_1 > \pi_2$, implying that any function of π_1, say $U(\pi_1)$, is greater than any function of π_2, say $U(\pi_2)$ where π_i is monetary gains. In other words, the first partial derivative of each utility function is positive $[\partial U(\pi_i)/\partial \pi_i > 0]$. However, the magnitude of these derivatives varies among these utility functions. Although the first derivative of these functions is positive $[\partial U(\pi_i)/\partial \pi_i > 0]$, the second derivative may be negative $[\partial^2 U(\pi_i)/\partial \pi_i^2 < 0]$, zero $[\partial^2 U(\pi_i)/\partial \pi_i^2 = 0]$, or positive $[\partial^2 U(\pi_i)/\partial \pi_i^2 > 0]$, which implies the marginal utility of extra income (π_i) is decreasing, constant, or increasing. These utility functions are strictly concave, linear, or strictly convex, and the decision makers with the above utility functions are characterized as risk averter, risk neutral, or risk lover, respectively (Henderson and Quandt, 1980).

The utility of a risky action is smaller than, equal to, or greater than the utility of its expected monetary value when the decision maker is risk averse, risk neutral, or prefers risk, respectively. These relations imply that the certainty equivalent of a risky action will be smaller than, equal to, or greater than its expected monetary value when the decision maker is risk averse, risk neutral, or prefers risk, respectively. Thus, a risk averter would not purchase the risky action at a price equal to its expected monetary value because the

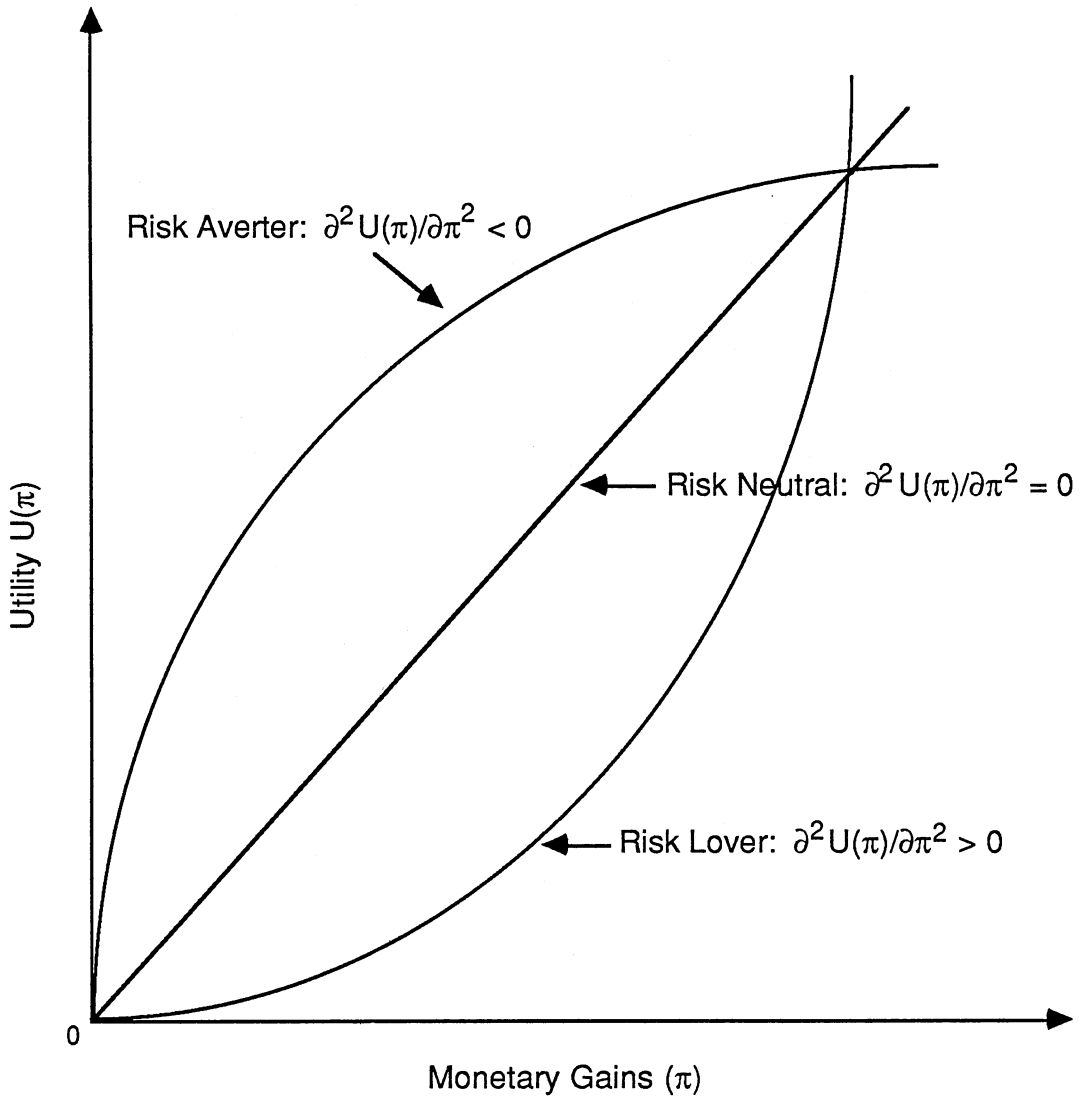


Figure 2. Three Utility Functions

concave utility function would translate the monetary gain into a utility loss (disutility). In other words, a risk averter prefers a certain outcome to an uncertain one with the same expected value. A risk lover, however, will always take a fair bet where the expected value of the gain equals the expected value of the loss.

The difference between the expected monetary value and the certainty equivalent is a risk premium. The risk premium, thus, is another indicator of the decision maker's risk attitudes. It could be positive, zero, or negative indicating that the decision maker is risk averse, risk neutral, or prefers risk, respectively. The risk premium for a risk averse decision maker is determined by the concavity of the utility function, or its bending rate. The greater the bending rate, the greater the risk premium and the more risk averse the decision maker.

Methods of Risk Analysis for Farm Firms

Static economic analysis is based on the simplifying assumptions of certainty about environment and objective of profit maximization. Introduction of risk extends these concepts to include the decision maker's perception of risk and his or her attitude toward risk. A number of approaches have been developed to analyze risk at the firm level; the literature in this area is extensive. These alternative approaches of risk analysis with the appropriate mathematical formulation and their advantages and disadvantages are discussed in this section. In addition, empirical studies that apply these methods to analyzing the production, marketing and financial alternatives of farmers under risky conditions are reviewed.

Quadratic Programming and Mean-Variance Analysis

Quadratic programming (QP) analysis has served as a conceptual framework for many risk analyses in agricultural economics. QP bases the selection of risky prospects on the means and variances of their probability distributions. Markowitz (1959) proposed that a risk averter decision maker selects a portfolio based on a decision rule that minimizes the variance of return (V) for a given level of expected return (E). When the level of expected return is varied, the quadratic programming analysis yields an efficient farm plan having the minimum variance for each expected level of return where the variance is the measure of the risk. Such plans are called efficient (E-V) pairs and defined as an efficient frontier over the set of all feasible farm plans.

Assuming an exponential utility function (Figure 3a), the utility function can be mathematically expressed as:

$$U(M) = a - b\bar{e}^{\lambda M} \tag{6}$$

where

M = the returns and

$b, \lambda > 0$

If M is assumed normally distributed, then it can be shown that

$$E[U(M)] = a - b\bar{e}^{-\lambda E(M) + \frac{\lambda^2}{2} V(M)} \tag{7}$$

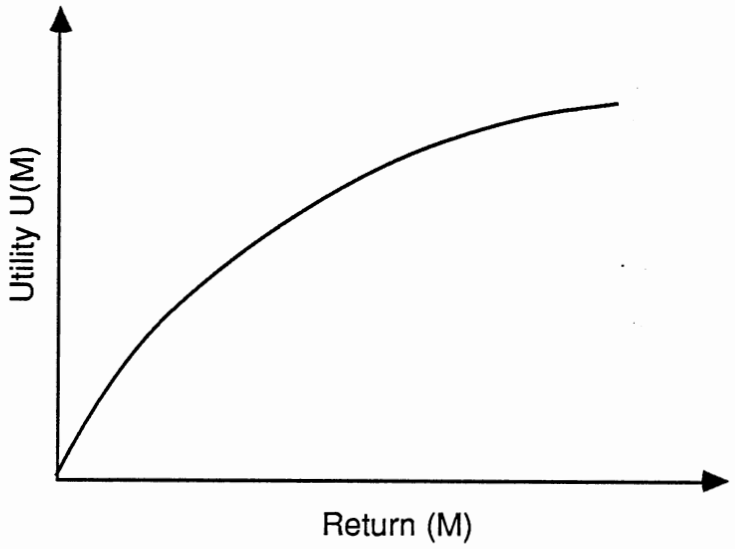
where

V(M) = variance of return (M)

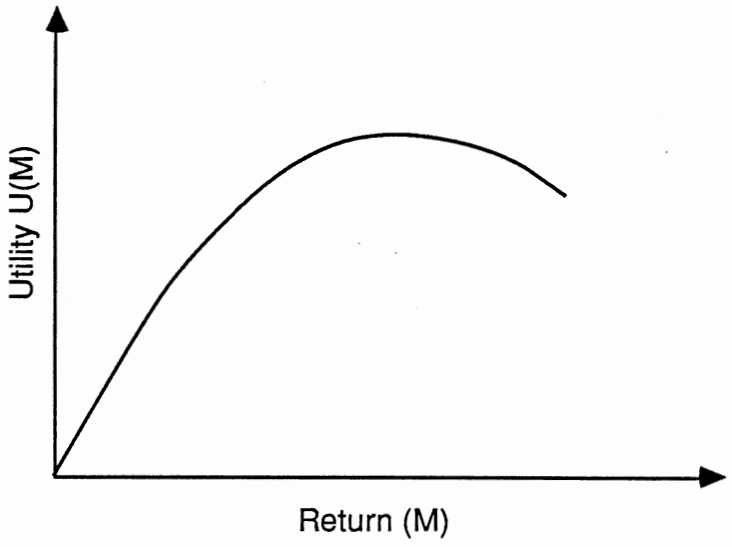
E[M] = expected return

Freund (1956) showed that maximizing equation (7) is equivalent to maximizing

$$E[U(M)] = E[M] - \lambda/2\, V(M) \tag{8}$$



a. Exponential Utility Function



b. Quadratic Utility Function

Figure 3. Exponential and Quadratic Utility Functions

Hence, assuming normality of return (M), the expected utility of decision maker can be fully explained by the mean and variance of the return, i.e. $U = U(E,V)$. The magnitude of λ in equation (8) represents the degree of risk aversion under exponential utility function. The larger is λ, the more penalty is placed on large variances and more risk averse is the individual.

The mean-variance efficient set is also consistent with a quadratic utility function (Figure 3b). To illustrate, consider the quadratic utility function in equation (9).

$$U(M) = M - \lambda M^2, \qquad \lambda > 0 \tag{9}$$

The expected utility E[U(M)]:

$$E[U(M)] = E[M] - \lambda E[M^2] \tag{10}$$

Since

$$V(M) = E[M - E(M)]^2 = E[M^2] - (E[M])^2 \tag{11}$$

then,

$$E[M^2] = V(M) + (E[M])^2 \tag{12}$$

Substitute equation (12) in equation (10) yields

$$E[U(M)] = E[M] - \lambda V(M) - \lambda(E[M])^2 \tag{13}$$

Hence, the expected utility function is also specified by the mean and variance of the return (M) with the quadratic utility function. However, the quadratic function does not increase monotonically. It reaches its maximum at $U' = 1 - 2\lambda M = 0$, where U' is the first derivative of the utility function with respect to the return (M). For a given λ, the maximum monetary value consistent with non-negative marginal utility is $M = 1/2\lambda$. In contrast, the exponential utility function is monotonically increasing, however it requires normally distributed return (M) for mean-variance analysis.

Markowitz (1959) conceived the portfolio selection problem in a quadratic risk programming framework and specified the objective function to

minimize portfolio variance of quadratic utility function for alternative level of expected returns:

$$\text{Minimize } V(Z) = \sum_{i=1}^{n} \sum_{j=1}^{n} q_i \, \sigma_{ij} \, q_j \tag{14}$$

subject to

$$\sum_{i}^{n} q_i \, U_i \geq M \tag{15}$$

$$\sum_{j=1}^{n} a_{kj} \, X_j \leq b_k \qquad \text{(for all } k, k = 1, \ldots m)$$

$$\sum_{i=1}^{n} q_i = 1 \tag{16}$$

$$q_i \geq 0 \qquad \text{(for all } i, i = 1, 2, \ldots n) \tag{17}$$

where

q_i = the proportion of each risky investment i

U_i = the expected return for investment i

σ_{ij} = the variance covariance matrix between the i^{th} and j^{th} activity

M = the expected total return level

b_k = the k^{th} constraint level

m = the number of contraints

The system is solved iteratively through parametric variations in M to define a set of risk efficient (minimum variance) solutions.

Freund (1956) was the first to apply quadratic programming to a farm problem. He demonstrated how to incorporate income variances and covariances in a programming model to determine E-V efficiency. The

problem is to maximize a quadratic objective function subject to a set of linear constraints. The general formulation in matrix notation is:

$$\text{Max } E(U) = \text{Max } U'X - \lambda X'\sigma X \tag{18}$$

subject to

$$AX \leq B \tag{19}$$

$$X \geq 0 \tag{20}$$

where

X = activity level

U = expected return associated with each activity

B = the resource constraints

σ = variance-covariance matrix of the activity return

λ = risk aversion coefficient

The model can be formulated as:

$$\text{Max } (U_1, U_2, \ldots U_n) \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix} - \lambda (X_1, X_2, \ldots X_n) \begin{bmatrix} \sigma_{11}, \sigma_{12} \cdots \sigma_{1n} \\ \sigma_{21}, \sigma_{22} \cdots \sigma_{2n} \\ \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \\ \sigma_{n1}, \sigma_{n2} \cdots \sigma_{nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix}$$

subject to

$$\begin{bmatrix} a_{11}, a_{12} \cdots a_{1n} \\ a_{21}, a_{22} \cdots a_{2n} \\ \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \\ a_{m1}, a_{m2} \cdots a_{mn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix} \leq \begin{bmatrix} b_1 \\ b_2 \\ \cdot \\ \cdot \\ \cdot \\ b_m \end{bmatrix}$$

and $\begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix} \geq 0$

Except for the objective function, the model resembles a linear programming model (LP) with A, X, and B corresponding to their LP counterpart. Data based on either objective or subjective concepts are needed to estimate the variance-covariance matrix. By solving this model we can derive the E-V efficient frontier that has the minimum variance (V) for each expected return level (E) so farmer can choose among feasible farm plans that maximize his utility function as shown in Figure 4.

Quadratic programming, an expected utility approach, is consistent with the existing body of decision theory. It offers considerable potential in farm planning under risk. The decision maker's risk attitude is expressed by the risk aversion parameter (λ). If the decision maker is risk neutral, $\lambda = 0$, the expected return is maximized. As risk becomes increasingly important, the risk aversion coefficient increases and risk efficient plans are identified. Furthermore, Hazell (1971) mentioned that quadratic programming is more flexible in avoiding too rigid a specification of the utility function and perhaps compensates to some extent for situations where return variance is not the best measure of uncertainty. However, quadratic programming has some limitations. Specifying risk aversion coefficient λ is arbitrary, yet critical for determining a risk efficient farm plan (Arrow, 1974). Estimation of the variance-covariance matrix presents numerous methodological pitfalls. Ideally, the variance-covariance relationship should be based on the subjective evaluation of the decision maker, not just historical data. Moreover, the expected utility assumptions underlying E-V analysis, including using quadratic utility function, normality of return distribution, and the approximation of E-V solutions to expected utility solutions, have been criticized (Tsiang, 1972; and Lambert and McCarl, 1985).

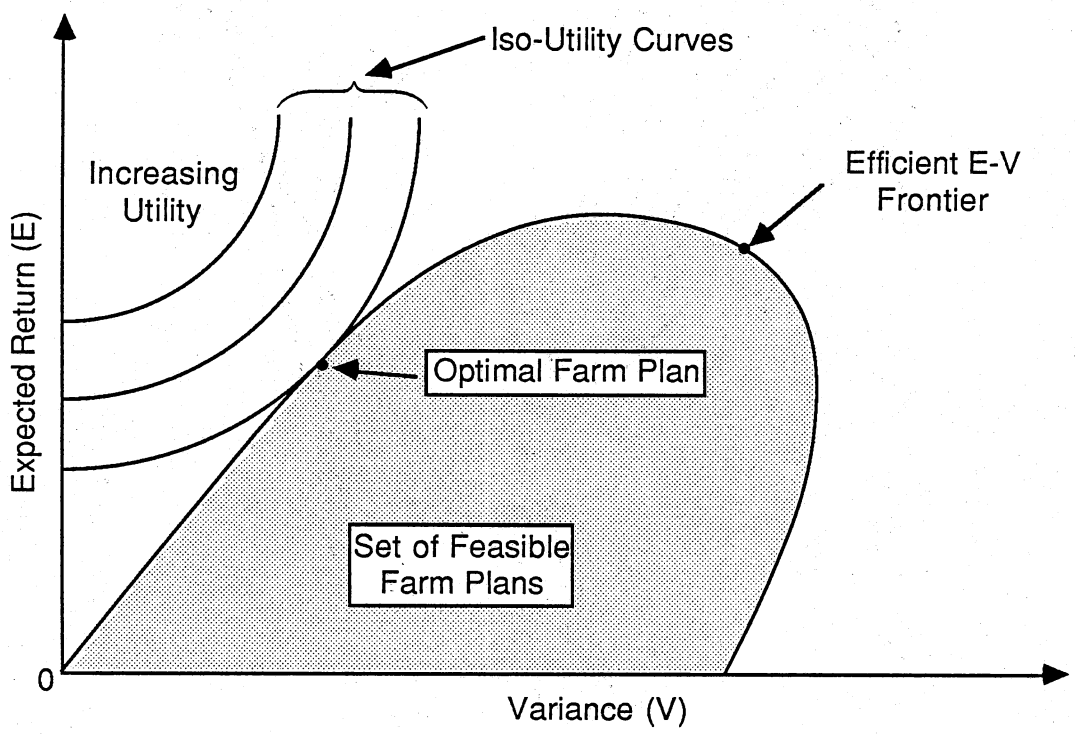


Figure 4. Optimal E-V Farm Plan

Despite its limitations, quadratic risk programming has had numerous applications in empirical analysis. Officer and Halter (1968) provided early examples of using quadratic programming to derive the mean-variance efficient set of alternative feed reserves for a small panel of Australian farmers. The main hypothesis of the study was that farmers' operational decisions are more consistent with a criterion of minimizing expected disutility (maximizing expected utility) than with the criterion of minimizing expected cost (maximizing expected returns). They concluded that the benefits of using utility analysis must be accepted as a guide to the general applicability of utility analysis.

Capstick (1973) and Scott and Baker (1972) utilized quadratic programming to derive a risk efficient set of farm plans for representative farms in Northeastern Arkansas and a Central Illinois cash grain farm respectively. Capstick viewed the efficiency frontier in terms of its elasticity where the elasticity was defined as the percentage change in expected income divided by the percentage change in standard deviation.

Lin, Dean and Moore (1974) used quadratic programming to develop a risk efficient set for a panel of California farms. They tested the hypothesis that farmers' operational decisions are more consistent with utility maximization than with profit maximization by evaluating farm plans under maximization profit, expected utility and lexicographic utility, respectively. They found that the expected utility formulations most accurately predict actual and planned crop patterns followed by the lexicographic formulation and profit maximization.

Whitson, Barry, and Lacewell (1976) modeled a ranch operation with multi-period quadratic programming in order to evaluate the risk return effects of vertically sequenced production and marketing strategies. The results indicated that retention of calf ownership through different finishing stages

either on pasture or by custom feeding in commercial feedlots could significantly influence both the level and variability of income growth.

Musser and Stamoulis (1981) used quadratic programming to model a farm firm in order to analyze the effects on risk efficiency of participating in Food and Agricultural Act of 1977. The basic model included important government commodity programs. The study provided empirical support for the widely held view that the government commodity programs reduce farmers' risk.

Mean Absolute Total Deviation Approach (MOTAD)

Given the same assumptions of quadratic programming, Hazell (1971) developed a linear alternative model to analyze risk at farm level which minimize the total absolute deviation of income from the expected mean (MOTAD). The MOTAD is formulated to derive a set of risk efficient farm plans based on the expected income-mean absolute deviation (E-A) criterion, which approximates the (E-V) criterion derived from quadratic programming. In this approach, variance is replaced by an estimate of income deviation (A) as measure of risk to determine the (E-A) efficient-farm plans that have the property of minimum mean absolute income deviations (A) for a given expected return level of income (E). Hazell argues that using the mean absolute total deviation as a measure of risk, it is reasonable to consider (E) and (V) as crucial parameters in selection of farm plans. He defines the mean absolute income deviation (A) as:

$$A = \frac{1}{s} \sum_{h=1}^{s} \left| \sum_{j=1}^{n} (C_{hj} - g_j) X_j \right| \qquad (21)$$

where

A = an unbiased estimation of population mean absolute income deviations

s = the number of years of sample observations

n = the number of activities

g_j = the sample mean gross margin for the j^{th} activity

C_{hj} = the gross margin (gross returns per acre minus variable costs per acre) for the j^{th} activity on the h^{th} sample observation

X_j = the level of j^{th} activity

In the MOTAD model, the mean absolute total deviations (A) is minimized for a given level of expected income (E). Expected income is varied parametrically over a relevant range using a linear programming algorithm to derive a set of farm plans that are efficient for expected income and mean absolute deviations. Since the sum of absolute values of the negative total deviations from the sample mean is equal to the sum of absolute values of positive total deviations, Hazell suggested an alternative formulation for MOTAD model based on minimizing only the sum of absolute values of the negative total gross margin deviations, ($\sum_{h=1}^{s} Y_h^-$). The mathematical formulation of the MOTAD is as follows:

$$\text{Minimize} \quad \sum_{h=1}^{s} Y_h^- \tag{22}$$

subject to

$$\sum_{j=1}^{n} (C_{hj} - g_j) X_j + Y_h^- \geq 0 \qquad \text{(for all h, h = 1, . . . s)} \tag{23}$$

$$\sum_{j=1}^{n} f_j X_j = \lambda \qquad 0 < \lambda < E_{MAX} \tag{24}$$

$$\sum_{j=1}^{n} a_{ij}X_j \leq b_i \qquad \text{(for all i, i = 1, . . . m)} \tag{25}$$

$$X_j, Y_h^- \geq 0 \qquad \text{(for all h, j)} \tag{26}$$

where

Y_h^- = absolute values of the total negative gross margin deviations

$$\left| \sum_{j=1}^{n} (C_{hj} - g_j) X_j \right|$$

s = the number of years of sample deviations

n = the number of activities in the basic linear programming model

C_{hj} = the gross margin for the j^{th} activity on the h^{th} sample observation

g_j = the sample mean gross margin for the j^{th} activity

X_j = the level of the j^{th} activity

f_j = the expected gross margin of the j^{th} activity

a_{ij} = the requirement of activity j^{th} from resource i

λ = the expected total gross margin which can be specified between zero and maximum expected total gross margin (E_{MAX}) at the basic linear programming solution

Figure 5 depicts the initial tableau of the MOTAD model. By solving this model using a linear programming algorithm, the (E-A) efficient frontier can be derived so the farmer can choose among feasible alternative farm plans that maximize his utility function as shown in Figure 4.

Hazell mentioned that (E-A) criterion has an important advantage over the (E-V) criterion in that it can be formulated by using a parametric linear programming model to derive the efficient (E-A) farm plans. Also, assuming normal distribution, the MOTAD model has been justified as an approximate computational procedure for deriving (E-V) farm plans when a good quadratic programming model is not available. This can be accomplished by

Sources of Restrictions	Decision Variables							Constraints
	X_1	X_2	. . .	X_n	d_1^-	d_2^-	. . . d_t^-	
Objective					1	1	. . . 1	Minimize
Resource 1	a_{11}	a_{12}	. . .	a_{1n}				$\leq B_1$
Resource 2	a_{21}	a_{22}	. . .	a_{2n}				$\leq B_2$
.	.	.		.				.
.	.	.		.				.
.	.	.		.				.
Resource m	a_{m1}	a_{m2}	. . .	a_{mn}				$\leq B_m$
Year 1	D_{11}	D_{12}	. . .	D_{1n}		1		≥ 0
Year 2	D_{21}	D_{22}	. . .	D_{2n}			.	≥ 0
.	.	.		.			.	.
.	.	.		.			.	.
.	.	.		.				.
Year t	D_{t1}	D_{t2}	. . .	D_{tn}			1	≥ 0
Income	C_1	C_2	. . .	C_n				$= \lambda$

Figure 5. Initial Tableau for MOTAD Model

transforming the mean absolute deviation (A) into an estimate of the population standard deviation (σ) using the statistic A $[\pi h/2(h-1)]^{1/2}$ where h is the number of the sample observations, and π = 22/7. Furthermore, the MOTAD model can be modified to use other measures of expectation or risk (Mapp et al., 1979). However, in considering the MOTAD model as a substitute for quadratic programming to develop efficient E-V farm plans, it is well to be prepared for some loss in the reliability of the results.

The MOTAD approach has been used in many empirical analyses of production, marketing and financial risk management. Brink and McCarl (1978) specified a MOTAD model for 38 Corn Belt farmers using individual farm data and negative deviations from expected returns as a measure of risk. A set of farm plans was developed for each farmer by parametrizing the scalor λ. The farmer's risk aversion coefficient was identified as the value of λ that minimized the difference between the risk efficient plan and farmer's present plan. They found that the majority of farmers had risk aversion coefficient (λ) from zero to less than .25.

Persaud and Mapp (1979) used three different approaches to measure variation in net returns using a MOTAD framework and compared their effects on risk-efficient farm plans. Risk was measured as negative deviation of net return from the mean of data series, from equally weighted three-year moving average and from three-year moving average with weights of .5 for most recent years and .3 and .2 for two previous years. They concluded that different measures of variation in net return result in selection of considerably different risk-efficient farm plans for the same data series.

Persaud and Mapp (1980) used the MOTAD model to evaluate a number of more important production, marketing and risk management strategies available to farm operators in Southwestern Oklahoma. The model's

marketing and production activities included forward contracting of wheat sales, wheat storage and subsequent periodic sales on a monthly basis throughout the year, and purchasing crop insurance and government commodity programs. Forward contracting and periodic marketing of wheat appeared in several risk efficient farm plans.

Target MOTAD

Neither mean-variance nor MOTAD model necessarily generates farm plans that meet the second-degree stochastic dominance (SSD). Tauer (1983) cited that if the returns (gross margins) are not normally distributed, then the result derived from mean-variance and MOTAD analyses are not necessarily SSD. He suggested an alternative mathematical programming model that is computationally efficient capable to generate solutions meeting the SSD. The model is a modification of MOTAD and called target MOTAD.

Target MOTAD is a two-attribute risk and return model. Return is measured as the sum of the expected return of activities multiplied by their individual activity level while risk is measured as the expected sum of the negative deviations of the solution results from a target-return level. Target MOTAD maximizes mean income subject to a limit on the total negative deviation measured from a fixed target rather than from the mean. Risk could be varied parametrically by changing the total negative deviations so that a risk-return frontier is traced out. Mathematically, the model is stated as:

$$\text{Max } E(Z) = \sum_{j=1}^{n} C_j X_j \qquad (27)$$

subject to

$$\sum_{j=1}^{n} a_{kj} X_j \leq b_k \qquad \text{for all } k,\ k = 1, \ldots m \qquad (28)$$

$$T - \sum_{j=1}^{n} C_{rj} X_j - Y_r \leq 0 \qquad \text{for all } r,\ r = 1, \ldots s \qquad (29)$$

$$\sum_{r=1}^{s} P_r Y_r = \lambda \qquad \lambda = M \rightarrow 0 \qquad (30)$$

$$X_j, Y_r \geq 0 \qquad (31)$$

where

$E(Z)$ = expected return of the plan

C_j = expected return of activity j

X_j = level of activity j

a_{kj} = technical requirement of activity j for resource k

b_k = level of resource or constraint k

T = target level of return

C_{rj} = return of activity j for state of nature or observation r

Y_r = deviation below T for state of nature or observation r (i.e. the negative deviations)

P_r = probability that state of nature or observation r will occur

λ = constant parameterized from M to 0 where M is large number

s = number of state of nature or observations

m = number of constraints and resource equations

Equation (30) represents the sums of negative deviations after weighting them by their probability of occurring, P_r. Since the target MOTAD has a linear objective function and linear constraints, the model can be solved with a linear programming algorithm.

Tauer (1983) mathematically proved that every plan that is efficient by target MOTAD is also efficient by SSD, except for plans with equal means and deviations. This does not state that all SSD efficient portfolios will be on the target MOTAD efficient frontier. Thus, there may be portfolios not derived by target MOTAD that are acceptable under SSD. Since deviations are not measured from the mean, total negative deviation must not equal to total positive deviations. Therefore, target MOTAD does not restrict (or minimize) positive as well as negative deviations. Furthermore, target MOTAD allows for comparison between using a common risk reference point. Finally, target MOTAD will never choose a dominated plan, regardless of the target selected (Watts, Held and Helmers, 1984). If rational producers do not attach as much disutility to higher income years as they do to lower income years, then the target MOTAD model appears to be a more feasible approach for maximizing risk return trade-off and it is more consistent with recent risk literature.

Simulation Models

An alternative approach to study the effect of risk and uncertainty at firm level has involved firm level simulation models. Simulation has emerged as a practical means of formulating and studying more nearly realistic models of managerial behavior. It may prove to be the most operational method of attacking the problems of decision making under uncertainty (Halter and Dean, 1965). Simulation is an analytical technique that involves setting up a model of real situations and then performing experiments on that model (Dent and Anderson, 1971). In agriculture, simulation analysis is used to model plant and animal growth processes, growth and intergenerational transfers of farm firms, risk and survival prospects, supply and demand relationships, multi-objective decision and many others. Its use in comparing strategies provides

interactions between years not ordinarily available in usual analysis of strategies (Walker and Hardin, 1979). In farm management, simulation can more realistically represent certain aspects of firms (such as uncertain prices and yields, economics of size, use of decision rules which are not simply minimization or maximization rules) than linear programming, budgeting and other models used in farm management work (Clements, Mapp and Eidman, 1971). It offers means of studying decision problems of farming systems in relation to the full complexity and uncertainty of reality.

A simulation model may have many attributes: 1) it may be deterministic or stochastic; 2) it may involve single or multi-period events; 3) it may be programmed to maximize or minimize a linear or nonlinear objective function, search for an optimal solution or be non-optimizing; 4) it may represent part or all of a complex process; and 5) it may be behavioral or mathematical (Mapp and Helmers, 1984). Four steps are involved in constructing the simulation model. These steps are: 1) model formulation in which a problem is identified and research hypotheses are formulated; 2) synthesis in which the model is specified in detail including the stochastic variables, the choice of distribution, collection of data, examination of serial dependence and estimation of covariance; 3) verification/validation which considers the model's technical accuracy and realistic portrayal of stochastic systems; and 4) experimentation.

Flexibility in model design is both an advantage and disadvantage of the simulation. The system and design of the model are determined by the researcher. Simulation models rarely have a pre-existing structure, as occurs with the coefficients, constraints and objective functions of linear and quadratic programming. Each problem is uniquely modeled. Once a firm is simulated, the model can sometimes be adapted to solve or analyze other problems. However, few simulation models in agricultural economics have been

generalized and documented for modification and reuse. In sensitivity analysis, simulation provides a useful framework for evaluating the influence of departure from equalibrium among key variables on the firm's financial performance and decision making.

In agriculture, simulation studies are reported on: 1) expansion by land acquisition; 2) alternative management strategies; 3) effects of beginning equity, farm expansion, and credit limits on farm growth and survival; and 4) the effects of loan arrangements and debt constraints on farm growth and survival (Walker and Helmers, 1984). Halter and Dean (1965) simulated the prices and weather environment, and decision making processes for a large California range-feedlot operation. A comparison among simulated net income is made over the period 1953-1963. They conclude that simulation models are a promising tool of analysis, particularly if uncertainty characterizes the decision making environment and a large number of time related interrelationships among variables exist.

Zusman and Amiad (1965) attempted to apply simulation techniques in solving decision problems of farms located in a region of low and unstable rainfall to indicate possible methodological improvements in existing simulation techniques and to appraise the usefulness of simulation in solving farm management problems. The objective was accomplished by a computer simulator of the decision process. They conclude that simulation techniques are a powerful tool in solving managerial problems arising under conditions of great weather variability and uncertainty.

Mapp et al. (1979) used simulation to evaluate the risk efficient farm plans under different alternatives of economics futures. The simulation procedure complemented the MOTAD model by evaluating the cumulated effects of farm plans derived from MOTAD model over time. The basic of a

linear programming farm plan and two of MOTAD risk management strategies were simulated over a 20 year period under stochastic prices and yields to evaluate the effects of interactions between years which is not possible with the MOTAD model.

Walker and Hardin (1979) simulated firm survivorship and feasibility of land investment in Northcentral Oklahoma. Risk control was measured by the ability of a strategy to reduce the chance of firm failure and/or reduce the standard deviation of some firm economic variables such as ending net worth and net present value. Four strategies were used to control risk associated with farm expansion and operation: crop insurance, diversification, participation in the government programs, and crop share lease arrangements. It appeared that the disaster payment was a very important feature of the then current farm progams.

Mapp and Jeter (1983) developed a whole farm simulation model to analyze the effects of participating in alternative government farm programs and combinations of programs on the economic activity of low equity farm operators in three Oklahoma counties. The production organization specified for each representative farm situation was simulated under conditions of stochastic yields and prices over a 10 year period. Results were analyzed in terms of difference in ending net worth, the chance of firm failure (bankruptcy), and coefficient of variation for ending net worth. It was concluded that program adjustments will be needed in Oklahoma if substantial program participation is to be achieved.

Bailey and Richardson (1985) used a detailed whole-farm simulation model to simulate alternative marketing strategies for Texas high plains cotton farm over a 10 year panning horizon (1983-92). The simulation model was a dynamic Monte Carlo simulation model capable of recursively simulating the

production, farm policy, financial management and growth of farm over time. By incorporating marketing strategies based on daily cash and futures prices, a more realistic economic environment was created for evaluating the impact of alternative marketing strategies on a farm's long-run survival and growth. Stochastic dominance with respect to a function was used to rank the alternative marketing strategies for risk-averse and risk-neutral producers. They found that risk-averse producers would prefer hedge and hold marketing strategies over discretionary hedging strategies. Sellers' call contracting was not highly preferred by either risk-neutral or risk-averse producers.

To evaluate or compare different alternative strategies resulting from applying these risk models, risk efficiency criteria need to be used to select the efficient farm plan or efficient set that maximizes the decision maker utility function or minimizes his disutility function. The common risk efficiency criteria used in agriculture will be discussed in the next section of this chapter.

Risk Efficiency Criteria

Despite the wide acceptance of expected utility hypothesis as a theoretical tool of ordering risky choices, important operational and measurement problems make it difficult to apply in the analysis of actual decisions. A particularly serious problem is that it requires explicit information about the decision maker's preferences. Unfortunately, there are many occasions in agricultural management when analysts, for reasons of cost or expediency, can not obtain appropriately elicited preferences to permit the reliable evaluation of alternative choices. As a result, inaccuracies in an elicited utility function can cause the rejection of the actually preferred choice (type I error), or acceptance (not rejecting) of the unpreferred choice (type II

error) by the decision maker (Anderson, Dillon, and Hardaker, 1977; Cochran, Robison, and Lodwick, 1985; and Robison, 1982).

Imprecision in the measurement of decision maker preferences can be recognized explicitly by using an efficiency criterion rather than a single-valued utility function to order alternatives. An efficiency criterion is a decision rule that provides a partial ordering of the choices for decision makers whose preferences conform to a specified set of conditions. Given specified restrictions on the decision maker's preferences, and, in some cases, on the probability distributions of feasible alternatives, an efficiency criteria divides the decision alternatives into two mutually exclusive sets: an efficient set and an inefficient set. The efficient set contains the preferred choice of every individual whose preferences conform to the restrictions associated with the criterion. No element in the inefficient set is preferred by any of these decision makers. Thus, inefficient alternatives are no longer considered (King and Robison, 1984).

The use of an efficiency criterion to order choices is, in many respects, preferable to the use of a single-valued utility function. No direct quantified preference measurements need be made, and if enough alternatives can be eliminated, a final choice can be made by direct comparison of outcome distributions of those that remain. It is also useful in situations involving several decision makers whose preferences differ yet conform to a specific set of restrictions, and in analyzing policy alternatives, or extension recommendations that affect many diverse individuals. As such, efficiency criteria are valuable tools in risk analysis. However, a major problem with efficiency criteria is the possible trade-off between their discriminatory power and general applicability. Efficiency criteria that place few restrictions on preferences, and so apply for most decision makers, may not eliminate many

choices from consideration. Conversely, criteria that identify small efficient sets usually require more specific information about preferences (King and Robison, 1984). Also, efficiency criteria may impose unrealistic assumptions on probability distributions as in mean-variance criterion where normality of outcome distributions is assumed (King and Robison, 1981a).

First-degree Stochastic Dominance (FSD)

First-degree stochastic dominance (FSD) is the simplest and most universally applicable efficiency criterion. FSD holds for all decision makers who have a monotonically increasing utility function wherein the first derivative is strictly positive, i.e. $U_1(x) > 0$. In other words, it holds for all decision makers who prefer more to less of the performance measure being considered. Under FSD, an alternative with cumulative distribution function F(y) is preferred to a second alternative with cumulative distribution function G(y) if:

$$F(y) \leq G(y) \tag{32}$$

for all possible values of (y) with at least one strong inequality (Hanoch and Levy, 1969) where:

$$F(y) = P_r(y \leq y^*) = \int_{-\infty}^{y^*} f(y)dy \text{ and}$$

$$G(y) = P_r(y \leq y^*) = \int_{-\infty}^{y^*} g(y)dy$$

This efficiency criterion, like all those to be discussed subsequently, is transitive; if F(y) dominates G(y) and G(y) dominates H(y), F(y) must dominate H(y).

In graphical terms (Figure 6), FSD rule means that the dominant cumulative distribution function curve must be nowhere to the left of the dominated curve. Distributions that are dominated are said to be stochastically

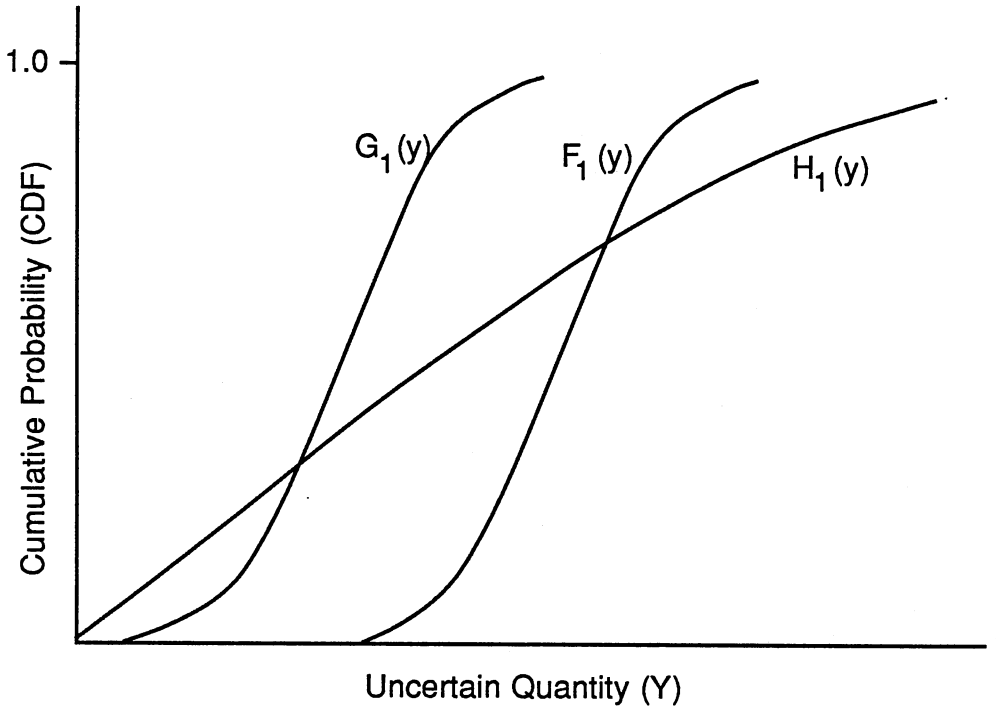


Figure 6. Illustration of FSD

inefficient and, conversely, those that are not dominated are said to be stochastically efficient of first degree. In Figure 6, F(y) dominates G(y), but neither F(y) nor G(y) can be ordered with respect to H(y). The wide generality of FSD, however, limits its usefulness since it eliminates few choices from consideration. Therefore, it is of significant operational advantage to seek more restrictive concepts of efficiency so that smaller efficient sets can be derived.

Second-degree Stochastic Dominance (SSD)

Second-degree stochastic dominance (SSD) is more discriminating than FSD. It assumes that decision maker's utility function is not only monotonically increasing but also strictly concave, i.e. $U'(x) > 0$ and $U''(x) < 0$, where $U'(x)$ and $U''(x)$ are the first and second derivatives of utility function, respectively. These individuals are risk averse. Under SSD, an alternative with the cumulative distribution function $F_1(y)$ is preferred to a second alternative with cumulative distribution function $G_1(y)$ if:

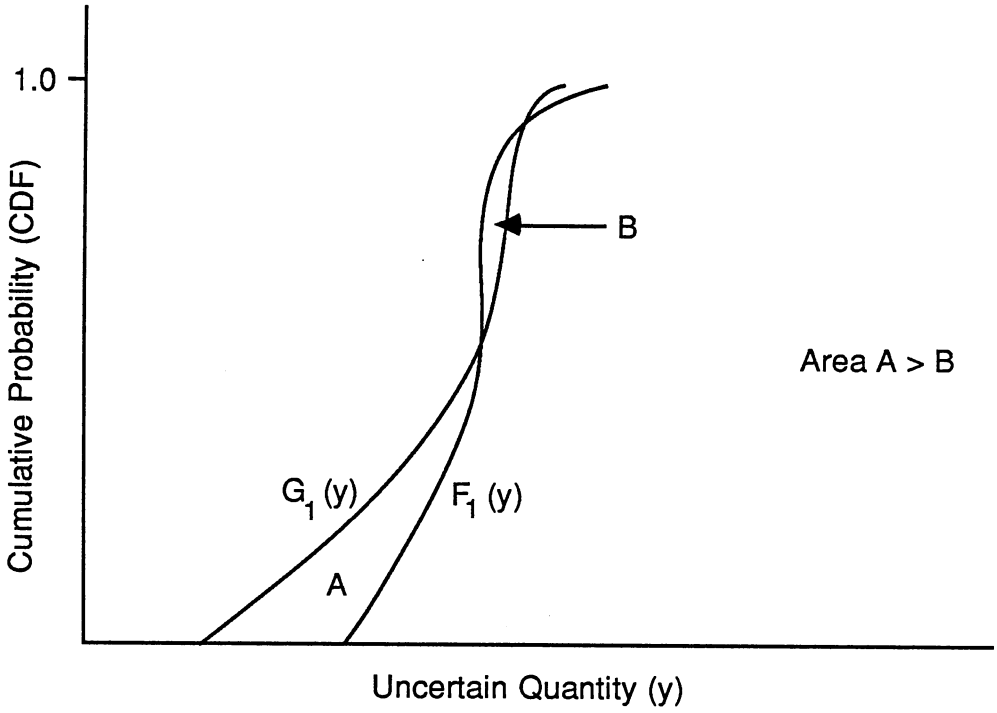
$$F_2(y) \leq G_2(y) \tag{33}$$

for all possible values of (y) with at least one strong inequality (Hanoch and Levy, 1969) where:

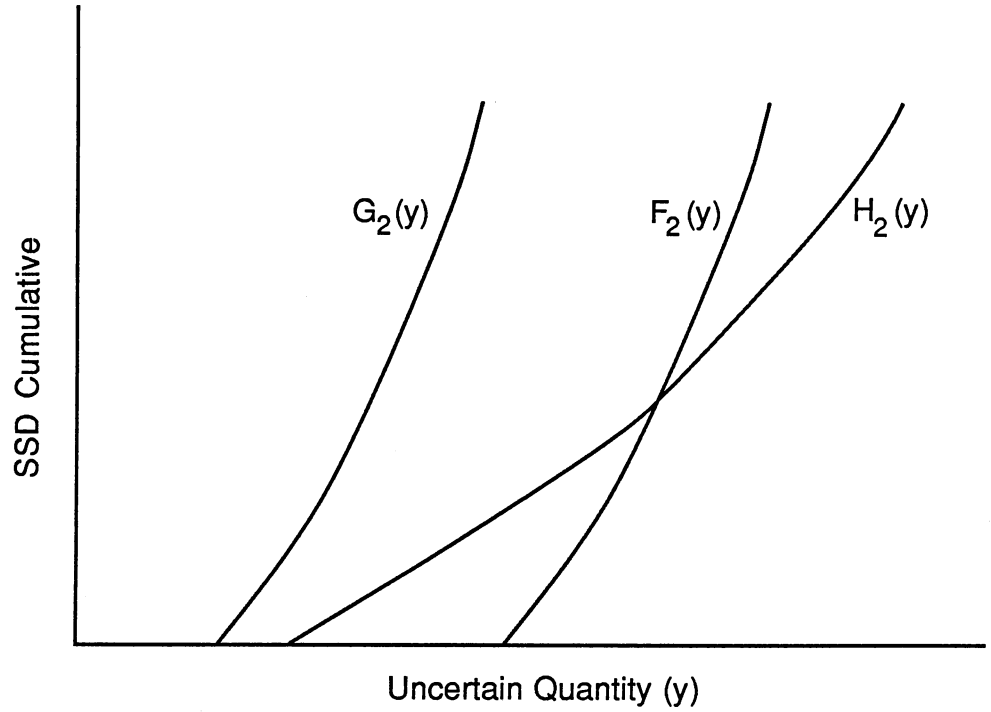
$$F_2(y) = \int_{-\infty}^{y} F_1(y)\, dy \text{ and}$$

$$G_2(y) = \int_{-\infty}^{y} G_1(y)\, dy$$

In other words, a distribution function $F_1(y)$ dominates another distribution function $G_1(y)$ if it lies more to the right in terms of differences in area under the CDF curves cumulated from the lower values of the uncertain quantity. In Figure 7a, the area marked A exceeds the area marked B, thus, $F_1(y)$



a. F(y) Dominates G(y) Since Area A > B



b. F(y) Dominates G(y) Since $F_2(y) \leq G_2(y)$

Figure 7. Illustration of SSD Where CDF's Cross Each Other

dominates $G_1(y)$. Figure 7b depicted the SSD cumulative distribution function for uncertain alternatives $F_1(y)$, $G_1(y)$ and $H_1(y)$. Because $F_2(y)$ always lies below (to the right) of $G_2(y)$, $F_1(y)$ dominates $G_1(y)$. Dominated distributions are revealed as inefficient in that they would never be preferred by risk-averse utility-maximizing decision makers.

SSD is a widely used efficiency criterion. It has more discriminating power than FSD, and risk averse assumption seems reasonable for many situations. However, the assumption of risk aversion does not always hold. Empirical evidence indicates that decision makers do, at times, exhibit preferences for risk (Officer and Halter, 1968, and Conklin, Baquet and Halter, 1977). Also, both FSD and SSD require pair-wise comparison between alternatives, thus, they are not well suited for use in mathematical programming models as in E-V and E-A criteria. Furthermore, although SSD is more discriminating than FSD, it still may not effectively reduce the number of alternatives (King and Robison, 1984). In Figure 7b, when only $F_1(y)$ and $H_1(y)$ are considered, neither dominates the other by SSD since $F_2(y)$ intersects $H_2(y)$.

Mean-Variance Efficiency (E-V)

Mean-variance efficiency (Markowitz, 1959; Freund, 1956) is the most familiar and most widely used criterion. Like SSD, mean-variance (E-V) efficiency requires that the decision maker be risk averse. In addition, E-V efficiency requires that the outcome distribution be normal or that the decision maker's utility function be quadratic where only the mean and variance are relevant concerning the probability distributions of alternative choices. Thus, the E-V efficiency criterion is stated in terms of these two moments. When these restrictions are met, the E-V efficient set is identical to the SSD efficient

set (Hanoch and Levy, 1969; and Lee, Brown, and Lovejoy, 1985). Under E-V efficiency criterion, outcome distribution F, with mean E_F and variance V_F dominates distribution G, with mean E_G and variance V_G, if $E_F \geq E_G$ and $V_F \leq V_G$ and if one of these two inequalities is strict.

E-V efficiency criterion is widely used for several reasons (King and Robison, 1984). The means and variances of probability distributions are easy to work with and familiar to most analysts. In addition, much of the theoretical work on decision making under uncertainty has used the E-V criterion for analytical convenience. Perhaps, the greatest strength of the E-V efficiency criterion is its use of mathematical (quadratic) programming. In the most widely used formulation, the variance of the outcome distribution is minimized subject to the constraint that the distribution's expected value is greater than or equal to some identified value. By varying the expected value constraint parametrically, an E-V efficient set can be identified.

Several problems are also associated with E-V efficiency criterion. As with SSD criterion, the decision maker is assumed to be everywhere risk averse. When this assumption does not hold, the preferred choice may be excluded from the E-V efficient set. Furthermore, like SSD, E-V efficiency often does not effectively reduce the number of decision alternatives. Finally, normality assumption about the distribution outcomes in agricultural situations is not always valid. If so, E-V efficient set will not be accurate and will not be identical with SSD (Tauer, 1983; Anderson et al., 1977; and King and Robison, 1984).

Mean-Absolute Deviation Efficiency (E-A)

The mean-absolute deviation (E-A) criterion is an approximation to E-V efficiency that can be modelled with linear programming (Hazell, 1971).

Linear programming algorithms are more widely available and less difficult to use than are the quadratic programming algorithms required for E-V efficiency criterion. As in E-V analysis, the decision maker in E-A criterion is assumed to be risk averse. When the distributions of outcome being ordered are approximately normal, the E-A efficient set closely resembles the E-V efficient set.

Under E-A (MOTAD) criterion, the mean and the mean-absolute deviation (A) of outcome distributions are used to order alternatives. Outcome distribution F, with mean E_F and mean-absolute deviation A_F, dominates distribution G with mean E_G and mean-absolute deviation A_G, if $E_F \geq E_G$ and $A_F \leq A_G$ and if one of the two inequalities is strict. The mean absolute deviation of the outcome distribution is minimized subject to specified levels of expected return. By varying the expected value of returns parametrically, an E–A efficient set can be derived.

Despite the frequent uses of E-A (MOTAD) criterion in risk programming, several shortcomings are associated with this criterion. When distributions are not normal, the ordering by MOTAD efficiency may poorly approximate the ordering by SSD. Furthermore, like SSD and E-V efficiency, MOTAD efficiency sometimes is limited by its requirement of risk aversion and low discriminating power.

Stochastic Dominance with Respect to Function (SDWRF)

Because of the shortcomings of previous efficiency criteria, there is a need for efficiency criteria which are both more flexible and more discriminating than those described above. King and Robison (1981b) introduced a stochastic dominance with respect to a function (SDWRF)

criterion. The SDWRF is an evaluative criterion which orders uncertain action choices for classes of decision makers defined by specified lower and upper bounds on the absolute risk aversion function. The absolute risk aversion function, R(y), is a Pratt-Arrow absolute risk averse and defined as:

$$R(y) = -U''(y)/U'(y) \tag{34}$$

where U'(y) and U"(y) are the first and second derivative of utility function, respectively. More formally stated, SDWRF is an evaluative criterion which establishes the necessary and sufficient conditions for the cumulative distribution function F(y) to be preferred to the cumulative distribution function G(y) by all individuals whose absolute risk aversion function lies anywhere between lower and upper bounds $r_1(y_1)$ and $r_2(y)$. As developed by Meyer (1977), the solution procedure requires the identification of utility function $U_0(y)$, which minimizes

$$\int_{-\infty}^{\infty} [G(y) - F(y)]\, U'(y)dy \tag{35}$$

Subject to the constraint

$$r_1(y) \leq -U''(y)/U'(y) \leq r_2(y) \quad \text{for all values of } y \tag{36}$$

The expression in (35) accounts for the difference between the expected utilities of outcome distributions F(y) and G(y). If for a given class of decision makers, the minimum of this difference is positive, then F(y) is unanimously preferred to G(y). This condition implies that the expected utility of F(y) is always greater than that of G(y). If the minimum is zero, an individual in the relevant class of decision makers may be indifferent between the two alternatives and they can not be ordered. Should the minimum be negative, F(y) is not unanimously preferred to G(y). In this case the expression

$$\int_{-\infty}^{\infty} [F(y) - G(y)]\, U'(y)dy \tag{37}$$

must be minimized subject to (36) to determine whether G(y) is unanimously preferred to F(y). As with other criteria, a complete ordering is not ensured by SDWRF. The minimum of both (35) and (37) can be negative, which implies that neither distribution is unanimously preferred by the relevant class of decision makers.

SDWRF is a powerful, more discriminating efficiency criterion that allows for greater flexibility in representing decision makers' preferences. Unlike other efficiency criteria, it imposes no restriction on the width or shape of the relevant region of risk aversion interval. The absolute risk aversion functions that define the relevant class decision makers need not be constants; they can be placed anywhere in risk aversion space. Moreover, FSD and SSD are special cases of the more general SDWRF criterion. The requirement for positive marginal utility under FSD places no restriction on decision maker's absolute risk aversion function, so that $r_1(y) = -\infty$ and $r_2(y) = \infty$ for all possible values of y. The requirement under SSD that marginal utility be positive and decreasing implies that $r_1(y) = 0$ and $r_2(y) = \infty$ for all values of y. SDWRF, unlike a single-valued utility function, does not require that an exact representation of the decision makers' preferences be specified. SDWRF has been applied to evaluate various risk management strategies including pest management strategies (Cochran, Robison, and Lodwick, 1985), alternative marketing strategies (Bailey and Richardson, 1985), and water-conserving irrigation strategies (Harris and Mapp, 1986).

SDWRF, however, requires more detailed information on decision makers' preferences. It requires specific information on the lower and upper bounds for a decision maker's absolute risk aversion function. A procedure developed by King and Robison (1981b) uses information revealed through a series of choices between carefully selected distributions to establish these

lower and upper bounds on an individual's absolute risk aversion function. Like FSD and SSD, SDWRF can not be incorporated into a standard mathematical programming model. Furthermore, inaccurate rankings of action choices can be produced with SDWRF when inappropriate rescaling of the outcome variable has been made (Raskin and Cochran, 1986).

The next chapter (Chapter III) focuses on financial performance measures and the simulation model used to analyze the impact of different financial policy options and strategies on the farm financial performance and financial survivability. Development of the input data for three farm situations is also discussed in this chapter.

CHAPTER III

MODEL STRUCTURE AND DATA DEVELOPMENT

Financial Performance Criteria and Model Structure

The purpose of the overall study is to evaluate the financial consequences of various policy options and strategies that farmers might follow in responding to the financial stresses to improve the financial conditions of their farms and increase the probability of financial survival. The analysis focuses on a five year horizon that likely is needed for a reasonable transition from the current adversities toward improved economic and financial conditions in the future. The results of the analysis are intended to provide a comprehensive information base for understanding the effectiveness of alternative farm policies and strategies for responding to financial stress and long-term performance prospects for farm businesses with different beginning financial structures.

Farmers, like other businessmen, place considerable emphasis on financial criteria for measuring farm performance and evaluating their overall well being. Especially important goals are: 1) reasonable level of income and growth in net worth; 2) the ability to meet financial obligations; and 3) security and stability. When translated into financial terms these goals are presented by three major criteria of farm business performance: 1) profitability; 2) liquidity; and 3) risk and solvency. Profitability refers to farmers' returns to the equity capital or net worth after all direct cash costs are covered and

adjustments are made for changes in the values of inventory and capital gains. Thus, growth in net worth is a form of profitability measure. Liquidity measures the ability of the firm to pay obligations as they come due during the year. Financial risk relates to the firm's total structure. It deals primarily with the firm's ability to meet obligations and hence is closely related to solvency. A farm business is insolvent in the final analysis if the sale of all assets fails to generate sufficient cash to pay all liabilities (Barry, Batte, Eidman, and Reid, 1986). Liquidity and solvency criteria are closely related; they are basically distinguished by the length of time involved. Solvency refers to the capacity to meet financial obligations over a longer period of time. Thus, some of the measures clearly represent either liquidity or solvency, while others jointly represent these two criteria.

In selecting measures to reflect the firm's profitability, liquidity and risk, it is important that the measures be meaningful and manageable (Barry, Hopkin, and Baker, 1983). Meaningful refers to how well the measure actually reflects the stipulated goals, while manageable refers to the ease of computations, the ease of comprehension, and the number of measures involved. Several financial measures for profitability, liquidity, and risk and solvency can be developed and used to evaluate the financial condition of the firm's business. In this study, four financial performance measures are used to evaluate the profitability, liquidity, risk, and solvency including average annual net farm income, equity to asset ratio (or debt/asset ratio), present value of ending net worth, and probability of financial survival. Average annual net farm income (ANFI), measured as total cash receipts minus total cash expenses and non-cash adjustment, is an indicator of average profitability over the period of analysis. Equity ratio, calculated as total operator's equity capital divided by value of total firm's assets, measures the operator's claims in each dollar of

firm's assets. In this analysis, the farm is declared technically insolvent when the intermediate- and/or long-term equity ratio is less than 20 percent. Present value of ending net worth (PVNW) measures the financial growth of the firm over the planning horizon period. It is the discounted (6.58 percent discount rate) net worth of the farm in the last year of solvency or at the end of the simulation period. When compared to the beginning net worth, PVNW indicates the relative magnitude of financial growth. Probability of farm's financial survival is the probability that the firm operator will maintain the firm's intermediate- and/or long-term equity (leverage) ratio equal or above (less) the prespecified minimum (maximum) level of equity (leverage). These financial performance measures can be compared over time to identify important patterns or trends and to evaluate the effectiveness of different policy options and strategies designed to improve the farm's financial condition and economic viability.

To accomplish the objectives of this study, a whole-farm level simulation model is needed to simulate different farm situations over years in deterministic and stochastic environments. The model should be designed to ascertain the profitability, chance of survival, solvency and liquidity of a farm firm under different economic and financial conditions. Also, the simulation model needs to be capable of analyzing and evaluating the probable consequences of alternative farm financial policies and strategies designed to improve the firm financial situation over the planning horizon for a typical or representative farm.

The Simulation Model

The Firm Level Income Tax and Farm Policy Simulator (FLIPSIM V) developed by J. W. Richardson and C. J. Nixon of Texas A&M University

(1986) was used for this analysis. The model is a firm level, recursive, simulation model that simulates the annual production, farm policy, marketing, financial management, growth, and income tax aspects of a farm over a multiple-year planning horizon (Figure 8). The model recursively simulates a typical farm by using the ending financial position for one year as a beginning position for the second year, and so on. The model is a Monte Carlo simulation model as opposed to a normative programming model because the purpose of this analysis is to simulate a representative farm for a large number of replications in an uncertain environment. By changing the assumptions regarding beginning equity, debt structure, and government commodity programs, etc., the probable outcomes for alternative policy options and strategies used in farming can be simulated and evaluated in terms of expected value, variance and likelihood of farm financial survival. In this study, three different farm situations representing three beginning levels of leverage ratio are developed and simulated over the 1986-90 planning horizon (inner loop YEARS). The model generates random values for annual prices and yields for the crops grown in these farms using independent empirical probability distributions (STOCH in Figure 8). The five year planning horizon is replicated 50 times, selecting a different set of random prices and yields each year (inner loop ITER). A pseudo-random number generator is used to generate the random values. The same sets of random yields and prices are used for each farm situation and policy option analyzed.

Variable costs of production (VCOSTS in Figure 8) for the farm are calculated for each crop enterprise and summed to obtain total input costs. Harvesting costs are calculated by multiplying production times updated harvesting cost per yield unit. Production and harvesting costs are decreased for landlord participation in costs when a crop share lease arrangement is

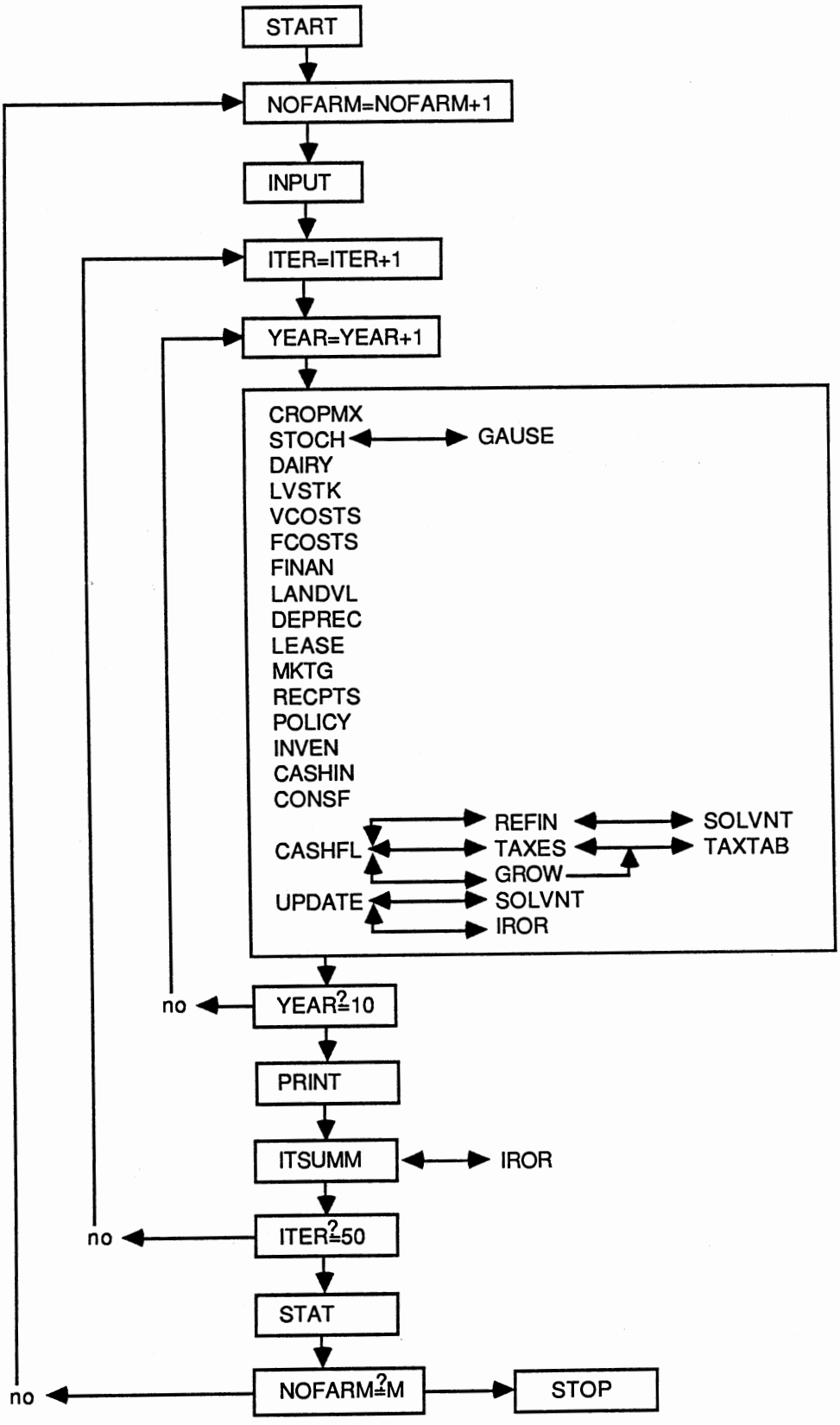


Figure 8. Schematic of the Overall FLIPSIM V Model

specified. Variable costs per head of livestock are multiplied by the number of head and the product is added to the variable costs. Labor cost is the sum of full-time employee salaries (if any) plus the wages paid to part-time employees. The amount of part-time hired labor is the residual labor required each month after fully utilizing full-time employees and unpaid family labor. Labor requirements for each crop are a function of the number of acres planted and the crop's monthly labor requirements per acre. Similarly, monthly labor requirements for livestock enterprises are calculated based on the number of head and monthly labor needs for each head. Annual values for exogenous fixed cost are calculated by inflating their initial values by the appropriate annual percentage changes provided by the analyst. Property taxes are calculated as the product of appropriate property tax rate and the market value of land owned in the previous year (FCOSTS in Figure 8). The property tax rate is expressed as the dollars of property tax paid per dollar of real estate market value.

Existing and new long- and intermediate-term loans are amortized based on their respective loan life, initial amount borrowed, and annual interest rate. All loans are amortized using the remaining balance formula (FINAN in Figure 8). Variable interest rate mortgages are assumed for old and new loans and these rates are provided by the analyst. Interest cost for operating loans are calculated based on the farm's total variable cost of production, the annual interest rate for the operating loan, and the fraction of the year the operating money is used.

The market value of land and farm machinery is updated annually (LAND, UPDATE in Figure 8) using the annual percentage changes provided by the analyst. A zero annual growth rate for cropland and used machinery is assumed over the planning horizon. Depreciation for each item of the

machinery complement and building owned by farm operator is calculated next (DEPREC in Figure 8). In this analysis, for machinery purchased prior to 1981, a straight line depreciation method, seven year depreciation life, no first year expensing and no investment tax credit are selected. For machinery purchased after 1980, a five year cost-recovery and no first year expensing are assumed. The depreciation for each machinery item, building, and other depreciable real estate is summed and treated as a farm expense.

The model calculates the expected machinery replacement expenditures based on the useful lives (economic lives) of the beginning machinery inventory and the current year machinery cost (1986) which is specified by the analyst. During the simulation, when the useful life of a piece of machinery has passed, it is sold and a new like piece of machinery is purchased. The purchasing cost of a new machinery item in a particular year depends on the current year (1986) purchase price of the same machinery item inflated up to year of purchase of the new machinery. A straight line recovery method with no write-off expensing for the first year and five year recovery period are used. Investment tax credit is not allowed on these new machinery purchases. Before a new machine can be purchased, the necessary down payment must be secured. The down payment for each machinery item in each farm situation is consistent with the corresponding beginning debt to asset ratio for that farm situation. There must be a sufficient cash reserve to meet the down payment requirement. If the farm has insufficient cash reserves and/or borrowing capacity to replace the machine when it reaches the end of its economic life, the model allows the farm to defer replacement for only one year. The interest rates and loan life for purchasing new machinery are the same as for the old machinery.

Annual cash receipts are computed based on acres harvested, stochastic yield, and stochastic annual price (adjusted by a seasonal price index for the marketing month). A seasonal price index for each crop allows the operator to take advantage of seasonal price differentials available to producers who store their crops to take advantage of seasonal price differences. It is assumed in this study that 50 percent of wheat and grain sorghum production is stored and sold in the next tax year. Annual cash receipts are calculated for the portion of the crop marketed in the current tax year plus the receipts for selling crops stored from the previous year. Crop cash receipts are adjusted to reflect the share paid to the landlord for share rented cropland. Cash farm income is the sum of cash receipts for crops and livestock, other farm income, and when applicable, deficiency payments. Total cash expenses are subtracted from total cash farm income to arrive at net cash farm income (CASHIN in Figure 8). Total cash expenses include: operating, intermediate- and long-term interest payments; total variable production and harvesting cost for crops and livestock; hired labor costs; value of livestock purchased for resale; property taxes paid; and interest and storage costs. Net farm income is calculated as the sum of net cash farm income and total non-cash adjustments to income (CASHFL in Figure 8). Depreciation and changes in the value of livestock and stored crops are the components of non-cash adjustments to income. Off-farm income is added to net farm income to calculate total net income. The farm is not allowed to grow through purchasing or leasing of cropland over the planning horizon, and the cash surplus is used for early repayment of farm intermediate- and long-term debts.

Cash flow deficits can be covered by (a) granting a loan secured by crops held for sale in next tax year and (b) obtaining a mortgage on equity in farm land and/or intermediate-term assets (REFIN in Figure 8). It is assumed in

this study the operator may not sell cropland to meet the deficits. However, the operator could obtain a mortgage of up to 80 percent of the equity in farmland and/or intermediate assets. If the operator availed himself of these options and still could not remove the deficits, the farm is declared technically insolvent.

Personal income tax and self-employment taxes are calculated annually for the farm operator assuming the operator is married, filing a joint income tax return, and itemizing personal deductions. The regular income tax liability is computed using two methods: (a) income averaging (if qualified) and (b) regular tax tables (TAXES, TAXTAB in Figure 8). The model selects the tax strategy which results in the lower income tax liability. All investment tax credit allowances (if specified) are deducted from regular income tax liability with the result being compared to the income tax liability under the alternative minimum tax. The income tax liability is the greater of the alternative minimum tax or the regular tax liability (regular tax computation or income averaging). The self-employment tax is added to the income tax liability to determine total accrued taxes. It is assumed that the farm operator is subject to the 1985 federal income tax provisions (TFSEGA). The proposed tax schedule of 15, 25, and 35 percent for TFSEGA is used for years 1986 and beyond when this tax provision is selected.

After simulating the growth aspects of the farm, the model computes the farm's end of year balance sheet. The model updates the farm size and prepares to simulate the next year of the planning horizon (UPDATE in Figure 8). The annual process is repeated until the entire planning horizon has been simulated.

Input Data for Farm Situations

This study is concerned with the intermediate-term future of farms and ranches under various economic and financial scenarios. Three typical farm situations in Jackson County of Southwest Oklahoma are developed representing three beginning farm financial positions. The beginning financial positions of these three farms are represented by three different levels of beginning debt to asset ratios including 20 percent (high equity), 40 percent (intermediate equity), and 70 percent (low equity) debt to asset ratio situations. For the purpose of the analysis, the asset structure, crop acreage, management, capital and interest rate, machinery complements, cropping patterns, etc. for each of these three farms are identical. The only difference between these farms is the beginning liability structure (short-, intermediate-, and long-term liability) for each farm which reflects different level of beginning debt to asset ratios. All loans for each farm situation are combined in one short-, intermediate- and long-term loan at the first year of the planning horizon (1986) and amortized using the remaining balance formula. The three farm situations are simulated over five years (1986-1990) under three different scenarios (base, optimistic and pessimistic) regarding future economic conditions.

The base farm simulated in this study is a mixed crop and livestock farm typical of Southwest Oklahoma and contains irrigated and dryland acres, and crop and livestock production activities. Each base farm is an owner-operated unit of 1260 acres, 960 of which are owned and 300 of which are rented on a one-third/two-thirds crop share lease arrangement. The farm production organization includes 480 acres of dryland wheat on owned land, 300 acres of dryland wheat on rented land, 100 acres of irrigated grain sorghum on owned

land, and 380 acres of irrigated cotton on owned land. In addition wheat pasture supports an average of 250 head of stocker steers annually. Stockers are assumed purchased at 400 lbs. in mid-October and sold in mid-March at a weight of 598 lbs.

Land Ownership

The three Jackson County farm situations are assumed to have identical land holding with identical land value at the beginning of the analysis (1986). However, there are differences in the down payment and loan repayment schedule which result in different outstanding principal for each of these three farm situations. These outstanding principals represent 20, 40, and 70 percent beginning debt to asset ratio farm situations. Table I presents land acquisitions and outstanding loan balances for each of these three farm situations. However, for the purpose of the analysis, all real estate outstanding loans are combined in one long-term loan for each farm in the first year of planning horizon which reflects the corresponding debt to asset ratio. In the beginning of the first year of the analysis, the 960 acres of owned land for each farm has a market value of $648,960 using the 1986 per acre price of $557 for dryland and $795 for irrigated land (Financial Letter, Federal Reserve Bank of Kansas City, 1986). Also, each farm has a 1986 market value of farm building of 18,250 which results in market value of fixed asset (land and building) of $667,210. The beginning equity (liability) in land is $533,770 (133,440), 400,330 (266,880), and 199,740 (467,470) representing beginning debt to asset ratio farm situations of 20, 40, and 70 percent, respectively. The outstanding long-term loan for each farm is amortized at the beginning of the planning horizon using the remaining balance formula with a 23 year loan life

TABLE I

SUMMARY OF LAND PURCHASED AND OUTSTANDING LAND LOAN BALANCE FOR ALL JACKSON COUNTY FARM SITUATIONS

Year Purchased	Acres	Purchase Price[1] ($/acre)	Total Purchase Price ($)	1986 Market Value[2] ($)	1986 Outstanding Principal: Farm Situation 1 (D/A = .20) ($)	1986 Outstanding Principal: Farm Situation 2 (D/A = .40) ($)	1986 Outstanding Principal: Farm Situation 3 (D/A = .70) ($)
1975	320	363	116,161	178,240	36,650	73,300	128,393
1978	480	694	333,120	381,600	78,465	156,930	274,881
1981	160	690	110,400	89,120	18,325	36,650	64,196
Total	960		559,681	648,960	133,440	266,880	467,470

[1]The purchase price per acre was taken from Farm Real Estate Market Developments, National Economic Analysis Division, USDA, (1975-1981).

[2]1986 per acre price was taken from Financial Letter, Federal Reserve Bank of Kansas City, 1986.

and a variable interest rate over the planning horizon starting with 12 percent in the first year.

Machinery Complements

The machinery and equipment complements are based on Southwest Oklahoma Crop and Livestock Enterprise Budgets. The purchase prices of the machinery and equipment are consistent with the year in which they were purchased. Current year market values for specific machinery item are calculated by subtracting depreciation accumulated since purchase from the purchase price. Depreciation on machinery and equipment is calculated using a straight line method assuming salvage value of 10 percent of the purchase price. Fifteen items of machinery and equipment are specified for a typical Jackson County farm. Table II presents a detailed description of the machinery, equipment, and building for all three beginning farm situations. These machinery and equipment items are identical for all three farm situations in terms of asset structure. However there are differences in liability structure consistent with the corresponding debt to asset ratio. The total 1986 market value of the machinery and equipment (intermediate asset) on each farm situation is $69,405. Table III presents the outstanding loan balances of machinery, equipment, and building for all beginning farm situations. The intermediate-term debt balance (equity) is approximated as $14,000 ($55,405), $28,000 (41,405), and $49,000 ($20,405) representing beginning debt to asset ratio farm situations of 20, 40, and 70 percent, respectively.

The loan balances for each farm situation are based on their respective beginning loan amount, date of purchases, interest rate, and loan life. Dates of purchase, interest rates, and loan lives are assumed identical for each farm situation. The only difference in these loan balances is their respective

TABLE II

MACHINERY EQUIPMENT AND BUILDING INVENTORY AND MARKET VALUES FOR JACKSON COUNTY FARM SITUATIONS (FARM 1, 2, AND 3)

Inventory	Size	Year Purchased	Purchase Price ($)	Useful Life (years)	1986 Market Value[1] ($)	1986 Purchase Price ($)
Machinery and Equipment						
1. Spring Tooth	24 ft	1977	1800	10	504	3600
2. Electric Fence	2.0 mi	1977	1800	15	936	2070
3. 6-row Cultivator	20 ft	1978	3500	10	980	4700
4. 6-row Planter	20 ft	1978	4700	10	1316	8600
5. Rotary Mower	14 ft	1979	3500	10	1610	6800
6. Offset Disk	18 ft	1979	5600	10	2576	11,000
7. Drill	26.6 ft	1979	6250	10	2875	16,500
8. Tractor	135 HP	1979	25,750	10	11,845	49,900
9. Tractor	155 HP	1982	34,730	10	25,353	56,600
10. Sprayer	20 ft	1982	4500	10	3285	1400
11. M.B. Rollover Blow	5-18 ft	1978	5000	10	1850	11,500
12. 7-R Bar Lister	23.3 ft	1978	1000	10	370	5700
13. Pick-up	.5 ton	1982	9200	8	6095	11,000
14. Chisel	29 ft	1980	9603	10	5282	12,300
15. 2-row Stipper	6.6 ft	1980	10,350	8	4528	25,000
Building						
16. Machine Shed	3500 sq ft	1976	25,000	30	18,250	

[1]The 1986 market values are equal to the purchase price minus the total of yearly depreciation since the item's purchase. Yearly depreciation is calculated by subtracting the 10 percent salvage value from the purchase price and dividing the remainder by the useful life.

Source: Inventory specifications and purchase prices were taken from various years (1977-82) of Oklahoma Crop and Livestock Enterprise Budgets, Southwest Oklahoma.

TABLE III

SUMMARY OF OUTSTANDING LOAN BALANCE FOR MACHINERY, EQUIPMENT AND BUILDING FOR JACKSON COUNTY FARM SCENARIOS (FARM 1, 2, AND 3)

Inventory	Size	Year Purchased	Loan Life (years)	Year Remaining on Note (years)	Loan Interest Rate[1] (percent)	1986 Outstanding Principal		
						Farm Situation 1 (D/A = .20)[2] ($)	Farm Situation 2 (D/A = .40)[3] ($)	Farm Situation 3 (D/A = .70)[4] ($)
Machinery and Equipment								
1. Tractor	135 HP	1979	8	2	10	2074	4146	7260
2. Tractor	155 HP	1982	8	5	14	6364	12,729	22,275
3. Rotary Mower	14 ft	1979	7	1	10	162	323	568
4. Offset Disk	18 ft	1979	8	2	10	451	903	1580
5. Sprayer	20 ft	1982	8	5	14	1017	2034	3559
6. Chisel	29 ft	1980	6	1	11	917	1834	3210
7. 7-R Bar Lister	23.3 ft	1978	8	1	9	41	82	143
8. 6-row Cultivator	20 ft	1978	8	1	9	143	287	502
9. 6-row Planter	20 ft	1978	8	1	9	193	386	675
10. M.B. Rollover Blow	5-18 ft	1978	8	1	9	206	411	719
11. Pick-up	.5 ton	1982	5	2	14	1879	3757	6575
12. Drill	26.6 ft	1979	8	2	10	553	1106	1936
13. Machinery Shed	25,000 sq ft	1976	10	1	9	766	1533	2682

[1]The interest rates were FmHA farm loans and were taken from Agricultural Finance Statistics, 1960-83, USDA Statistic Bulletin No. 706.

[2]The operator was required to make 80 percent down payment on all machinery, equipment, and building purchases.

[3]The operator was required to make 60 percent down payment on all machinery, equipment, and building purchases.

[4]The operator was required to make 30 percent down payment on all machinery, equipment, and building purchases.

beginning amount of loan which is based on the corresponding down payment required for each farm situation. The down payment required for each farm situation is consistent with the corresponding beginning debt to asset ratio. As with the long-term loans, all intermediate-term loans are combined in one intermediate-term loan for each farm situation at the beginning of planning horizon (1986) and amortized using the remaining balance formula. A five year intermediate-term loan life with variable interest rate starting with 12.2 percent in the first year (1986) is assumed. A straight line depreciation method for machinery and equipment with seven year depreciation life for those purchased prior to 1981 and five year for those purchased after 1980 is specified.

Overall, total assets have a beginning value of nearly $870,500 for all farm situations, total liability has beginning value of nearly $183,000, $349,000 and $609,000 for farm situations with beginning debt/asset ratio of 20, 40, and 70 percent, respectively. The beginning net worth is nearly $688,000, $521,000, and $261,500 representing 79, 60, and 30 percent equity ratios for beginning debt/asset ratio farm situations of 20, 40, and 70 percent, respectively. Initial balance sheet information is presented in Table IV.

Enterprises

As mentioned earlier, all three farm situations have the same enterprise patterns and the same acreage (or head) of each enterprise. These enterprises are dryland wheat, irrigated grain sorghum, irrigated cotton, and stocker steers. Seven hundred eighty acres of dryland wheat are produced at an operating cost per acre of $53.48. Three hundred acres of dryland wheat are rented on a one-third/two-thirds crop share lease arrangement. The per acre operating costs for the enterprises are based on Oklahoma Crop and

TABLE IV

BEGINNING BALANCE SHEETS: THREE SOUTHWEST OKLAHOMA FARM SITUATIONS

Beginning Balance Sheet	Farm 1 20% D/A	Farm 2 40% D/A	Farm 3 70% D/A
ASSETS			
Current Assets			
Cash in Hand	5,000	5,000	5,000
Inventories: Crops	27,385	27,385	27,385
Livestock	74,250	74,250	74,250
Inventories in Growing Crops	27,003	27,003	27,003
Total Current Assets	133,638	133,638	133,638
Intermediate Assets			
Machinery and Equipment	69,405	69,405	69,405
Other	0	0	0
Total Intermediate Assets	69,405	69,405	69,405
Fixed Assets			
Cropland	648,960	648,960	648,960
Building	18,250	18,250	18,250
Other	0	0	0
Total Fixed Assets	667,210	667,210	667,210
TOTAL ASSETS	870,253	870,253	870,253
LIABILITIES			
Current Liabilities			
Current Loans	26,400	52,799	92,397
Accrued Federal and Self-employment Tax	8,798	1,528	0.0
Total Current Liabilities	35,198	54,327	92,396
Intermediate Liabilities			
Intermediate Loan	14,000	28,000	49,000
Other	0	0	0
Total Intermediate Liabilities	14,000	28,000	49,000
Long-term Liabilities			
Long-term Loan	133,440	266,880	467,470
Other	0	0	0
Total Long-term Loan	133,440	266,880	467,470
TOTAL LIABILITIES	182,638	349,207	608,867
Net Worth Without Contingencies	687,615	521,046	261,380
Percent Equity	79.0	59.9	30.0
Leverage Ratio (D/E)	.266	.670	2.329

Livestock Enterprise Budgets of 1986 and include charges for seed, fertilizer, chemicals, fuel and lubricants, repairs and custom harvesting. Labor and interest on annual operating capital are calculated by the model separately. Harvesting costs are calculated on a dollar per unit of production. Fixed charges such as depreciation on machinery are excluded from the per acre cost of production and calculated by the model. Wheat pasture supports an average of 250 head of stocker steers annually. This number was derived depending on the AUM units of pasture provided by wheat acreage and the number of units needed for a head. Stocker are assumed purchased at 400 lbs. in mid-October and sold in mid-March at a weight of 598 lbs. per head. The production cost of the stocker steers including the purchase price of the steer is $312 per head, $30 of which is attributed to cost of starter feed, salt, mineral, trucking, utilities and medication and $282 of which is the cost of the steer assuming a purchasing price of $.705 per lb. (Oklahoma Crop and Livestock Enterprise Budgets, 1986). Also, all three farm situations produce 100 acres of irrigated grain sorghum and 380 acres of irrigated cotton at a per acre cost of $105.39 and $209.34, respectively. The farm operator is assumed to use flood irrigation from the Atlus-Lugert project to irrigate both grain sorghum and cotton. Table V presents detail on units produced and per unit cost of production for all three farms.

The operator participates in government commodity programs. Wheat, grain sorghum, and cotton are all government program commodities. Participation in the wheat and feed grain program reduces the wheat acreage base by 25 percent, grain sorghum acreage base by 20 percent, and cotton acreage base by 25 percent. For wheat, a target price of $4.38 per bushel and a loan rate of $2.40 per bushel were used, for sorghum a target price of $5.14 per cwt and a loan rate of $3.25 per cwt were used, and for cotton a target

TABLE V

ACRES PRODUCED AND PER ACRE YIELD AND OPERATING COST FOR ALL FARM SITUATIONS, JACKSON COUNTY OF SOUTHWEST OKLAHOMA IN 1986

	Unit Per Acre	Units Produced (acre)	Seed ($/acre)	Fertilizer and Lime ($/acre)	Chemical ($/acre)	Fuel Lubricants ($/acre)	Repair ($/acre)	Other ($/acre)	Harvest Cost ($/yield unit)	Total Operating Cost ($/acre)
Dry Wheat	26 bu	780	4.1	18.02	4.00	11.52	0.0	12.72	.12	53.48
Irrigated Grain Sorghum	50 cwt	100	5.2	19.00	15.00	16.64	22.25	17.25	.20	105.39
Irrigated Cotton	650 lb	380	12.5	18.75	69.75	19.11	11.11	18.48	.075	209.34

Source: Oklahoma State University Crop and Livestock Enterprise Budget, 1986.

price of $.81 per lb. and a loan rate of $.44 per lb. were used (Womack and Young, III, 1985). Government program calculation for 1986 resulted in an expected deficiency payment of $1.98 per bushel for wheat, $2.50 per cwt for sorghum, and $.26 per lb. for cotton (Sanders, 1986). Participation in the three commodity programs individually would result in government payment during 1986 for wheat in excess of $25,000, for grain sorghum in excess of $5,000, and for cotton in excess of $50,000. Participation in all three commodity programs would result in government payments in excess of the $50,000 government program payment limit. Thus, government payment income is restricted to $50,000 per year for the five years of the analysis. Deficiency payments are paid if a crop's average market price in the first five months of the marketing year is less than its target price. The deficiency payment is the product of the crop's payment rate (lesser of target price minus average price or target price minus loan rate), national allocation factor, farm program yield, and harvested acreage.

Additional Input Data

For completely specifying the input data to simulate the farm situations over the five year planning horizon, other input data and growth rate projections for many variables are needed. The above farm situations are defined as family farm operations with the farm operator being both manager and laborer. The level of management is assumed to be above average. The total annual family labor available is 2200 hours. Additional labor hours are assumed available at $4.50 per hour. The consumption function for the Southern Plains region which relates the family living expenses to income is selected for the farm operator. This consumption function is estimated using the SRS-USDA "Farm Operator Family Living Expenditures Survey for 1973"

(USDA). The minimum and maximum values for annual family living expenses are set to $14,000 and $20,000 respectively and are annually adjusted for percentage changes in the CPI, so the purchasing power of minimum and maximum withdrawals is maintained over time. A 40-year of age married farm operator with four personal income tax exemptions is specified for the farms.

The minimum equity ratio for solvency for both intermediate- and long-term equity is set to be 20 percent. The farm is declared technically insolvent if the intermediate- and/or long-term equity ratio drops below its prespecified minimum level of 20 percent. Farmer cash reserve is $5000 for the beginning year (1986) and $2000 for the remaining years of the planning horizon. A $10,000 annual off-farm income is assumed and is inflated over the years using the CPI. An after-tax discount rate of 6.58 percent is specified and used to calculate the net worth present value for the simulated farm situations.

The annual percentage changes for selected variables over the planning horizon (1986-1990) are presented in Table VI. These growth rates were developed using the October 1985 median macroeconomic projections of Wharton Econometric Associates and the 1985 House Farm Bill (Womack and Young, III, 1985). Stocker steer purchase price and other inputs for livestock are adjusted to reflect expected changes in stocker selling price rather than expected changes in overall production expenses. For the stochastic run, 50 iterations are selected to generate cumulative distribution functions and develop statistical analysis for selected key economic variables.

TABLE VI

PROJECTED ANNUAL CHANGES IN SELECTED VARIABLES USED IN SIMULATING ALL FARM SITUATIONS OVER THE PLANNING HORIZON (1986-1990)

Item	Percentage Change (%) Year Ago				
	1986	1987	1988	1989	1990
New Farm Machinery	3.6	5.8	2.4	4.8	5.0
Fixed Cost and Insurance	3.6	0.8	1.6	3.7	4.7
Seed Costs	-0.5	-8.5	1.7	5.9	7.2
Fertilizer and Lime	6.5	5.1	5.6	5.5	6.6
Chemical Costs	2.2	2.4	3.3	3.1	3.4
Fuel and Lube Costs	1.3	6.6	7.4	6.5	5.4
Other Production Costs	2.9	1.4	3.3	4.5	5.8
Hired Labor Costs	6.9	5.1	4.9	5.9	7.2
Inputs for Livestock	6.2	1.6	-3.2	-4.9	-3.4
Off Farm Storage Costs	5.3	5.4	3.6	3.7	4.0
Interest Rates	-4.6	-3.3	4.5	3.3	6.8
Family Living - CPI	3.7	4.1	5.3	4.7	5.0
Wheat Price	-11.0	-6.2	3.9	6.3	3.5
Grain Sorghum Price	-11.8	-7.6	5.3	2.3	2.2
Cotton Price	-21.0	-2.4	-2.4	10.0	4.6
Stocker Selling Price	6.2	1.6	-3.2	-4.9	-3.4

Source: Womack, A. W. and R. E. Young, III. "An Analysis of U.S. House of Representatives 1985 Farm Bill." FAPRI Staff Report #10-85, December 1985.

Stochastically Generated Prices and Yields

Yields and Prices

A major share of the income variability associated with agricultural production is due to the high level of variability in agricultural prices and yields. Not all prices and yield variations produce adverse effects on firm growth and net farm income. Positive variations in prices or yields will produce favorable, above average net farm income and hence will allow above average firm growth. The reverse holds true for low prices and low yields. When prices or yields are low, net farm income and farm growth will be adversely affected.

To simulate variability realistically, historical price and yield data are needed for the farm situations analyzed. Because actual farm level data are not available, county average yields per harvested acre from 1977-1986 for Jackson County, Southwest Oklahoma are utilized. The yield per harvested acre of dryland wheat, irrigated grain sorghum and irrigated cotton are presented in Table VII. The yield per harvested acre from 1977-1985 was taken from Oklahoma Agricultural Statistics while the yield per harvested acre for 1986 was taken from Oklahoma Crop and Livestock Enterprise Budgets of 1986. Also, because of unavailability of commodity prices for Jackson County, season average prices for Oklahoma for the same period (1977-86) are used in the analysis. These seasonal average prices were deflated using the GNP implicit deflator with 1985 as a base year and are presented in Table VIII.

Correlated Yields and Prices

The yields of the farm commodities produced are not independent at the farm level. Drought condition during the summer will likely affect cotton and grain sorghum yields adversely. Wheat yields are related with summer crop

TABLE VII

YIELD SERIES USED TO TEST TIME TREND FOR ALL JACKSON COUNTY FARM SITUATIONS, OKLAHOMA YIELD SERIES

Year	Dry Wheat Yield (bu/acre)	Irrigated Grain Sorghum Yield (cwt/acre)	Irrigated Cotton Yield (lbs/acre)
1977	22.0	30.24	627
1978	21.0	31.75	544
1979	32.0	25.20	795
1980	25.8	16.52	607
1981	22.8	36.96	482
1982	30.8	38.64	498
1983	32.1	28.00	508
1984	26.1	50.40	413
1985	26.0	50.00	650
1986*	26.0	50.00	650

*Oklahoma Crop and Livestock Enterprise Budgets for 1986 were used since Oklahoma Agriculture Statistics for 1986 are not available.

Source: Oklahoma Agriculture Statistics, 1977-85, and Oklahoma Crop and Livestock Enterprise Budgets of 1986.

TABLE VIII

ADJUSTED PRICE SERIES TO TEST TIME TREND FOR ALL JACKSON COUNTY FARM SITUATIONS, OKLAHOMA SEASONAL PRICES

Year	Wheat Price ($/bu)	Grain Sorghum Price ($/cwt)	Cotton Price ($/lb)
1977	3.74	5.35	1.01
1978	4.43	5.35	.79
1979	5.19	5.72	.79
1980	5.09	6.14	.88
1981	4.64	5.74	.74
1982	3.99	4.80	.48
1983	3.73	5.42	.58
1984	3.52	5.01	.62
1985	3.04	4.08	.47
1986	2.65	3.53	.37

Source: Oklahoma Crop and Livestock Enterprise Budgets (1977-86). GNP implicit deflator was used to adjust the prices (1985 = 100).

yields since lack of summer rains may mean poor soil moisture to produce an adequate stand of wheat at planting time. Prices are also assumed to be correlated in some manner, however, the logic of this relationship may not be as clear as the yield relationships. Correlation between yields and prices is built into the model based on the ten-year historical yield and deflated price series developed earlier. Yields and prices are assumed independent on the farm level.

Many probability distributions can be used to stochastically generate prices and yields. The stochastically generated prices and yields should possess the appropriate correlation relationships so that they will more nearly reflect realistic income variations. In this analysis, independent empirical probability distributions are used to simulate yield and price variability. Using empirical distributions is justified since the exact probability distributions for these yields and prices are not known. To generate empirically distributed random values for yields and prices, yearly independent normal deviates and a factored correlation matrix for the yields and prices should be provided as input in the model. The deviates are multiplied by the factored correlation matrix and the product is transformed to the unit scale (0.0 to 1.0) using the error function (ERFF). These transformed values are used in the inverse transformation formula to calculate empirically distributed random values for crop yields and prices (Law and Kelton, 1982; and Larson, 1982). The matrix of correlation coefficients must be positive definite and symmetrical about its main diagonal so it can be factored into unique upper and lower triangular matrix to generate the empirically distributed and appropriately correlated prices and yields (Clements et al., 1971). Only the upper right triangular correlation matrices are actually needed.

A test using Statistical Analysis System (SAS) was conducted for a significant time trend for Jackson County yields per harvested acre and prices for crops analyzed in this study and a significant trend was indicated for most yields and prices for the period 1977-86. To adjust for the trend, the residual values for each crop yield and deflated price equation were used to develop the yields and prices correlation matrix. The yield and deflated price residuals are presented in Table IX. Separate correlation coefficient matrices are constructed for the yield and deflated price series to portray an independent relationship between prices and yields at the farm level. These correlation coefficient matrices are presented in Table X. Each correlation matrix has its own unique upper right triangular matrix. The yield and deflated price upper right triangular correlation matrices are presented in Table XI. The upper right triangular correlation matrices are used as input in the simulation model to generate the independent empirically distributed values for prices and yields for each year of the planning horizon when stochastic run is used.

TABLE IX

RESIDUALS USED TO DERIVE THE YIELDS AND PRICES CORRELATION MATRICES

Observation	Yields			Prices		
	Wheat	Grain Sorghum	Cotton	Wheat	Grain Sorghum	Cotton
1	-2.5945	7.225	15.730	-1.1462	-0.6346	0.0640
2	-4.0091	5.900	-59.750	-0.2590	-0.4411	-0.0953
3	5.5764	-3.484	98.780	0.6891	0.1224	-0.0347
4	-0.0382	-14.999	18.310	0.7553	0.7358	0.1160
5	-3.4527	2.606	-99.160	0.5424	0.5293	0.0367
6	4.1327	1.452	-75.640	0.0896	-0.2173	-0.1627
7	5.0182	-12.025	-58.110	0.0267	0.5962	-0.0020
8	-1.3964	7.542	-145.580	0.0139	0.3796	0.0987
9	-1.9109	4.308	98.950	-0.2690	-0.3569	0.0093
10	-2.3255	1.473	105.470	-0.4618	-0.7135	-0.0300

TABLE X

THE CORRELATION COEFFICIENT MATRICES FOR EMPIRICALLY DISTRIBUTED YIELDS AND DEFLATED PRICES, SOUTHWEST OKLAHOMA FARM SITUATIONS

	Yields			Prices		
	Wheat	Grain Sorghum	Cotton	Wheat	Grain Sorghum	Cotton
Wheat Yield	1.0	-.5567	.2722	0.0	0.0	0.0
Grain Sorghum Yield	-.5567	1.0	-.1822	0.0	0.0	0.0
Cotton Yield	.2722	-.1822	1.0	0.0	0.0	0.0
Wheat Price	0.0	0.0	0.0	1.0	.7812	.0754
Grain Sorghum Price	0.0	0.0	0.0	.7812	1.0	.4598
Cotton Price	0.0	0.0	0.0	.0754	.4598	1.0

TABLE XI

THE UPPER RIGHT TRIANGULAR CORRELATION MATRICES FOR YIELD AND DEFLATED PRICES, SOUTHWEST OKLAHOMA FARM SITUATIONS

	Yields			Prices		
	Wheat	Grain Sorghum	Cotton	Wheat	Grain Sorghum	Cotton
Wheat Yield	.8124	-.5157	.2722	0.0	0.0	0.0
Grain Sorghum Yield	0.0	.9833	-.1822	0.0	0.0	0.0
Cotton Yield	0.0	0.0	1.0	0.0	0.0	0.0
Wheat Price	0.0	0.0	0.0	.5362	.8407	.0754
Grain Sorghum Price	0.0	0.0	0.0	0.0	.8880	.4598
Cotton Price	0.0	0.0	0.0	0.0	0.0	1.0

CHAPTER IV

ANALYSIS AND RESULTS OF THE FINANCIAL RISK MANAGEMENT ALTERNATIVES

The main objective of this study is to evaluate the impact of various farm management strategies under different farm economic and financial situations on selected Southwest Oklahoma farms that could increase the long-run farm growth and probability of farm survival. To achieve this goal, a number of combinations of economic forecasts, beginning leverage positions, and policies designed to relieve financial stress were analyzed. Three economic outlooks were considered, including a most likely or base scenario, an optimistic scenario, and a pessimistic scenario. In addition, three leverage positions representing three farm financial situations were investigated including a beginning 70 percent debt to asset ratio situation, a 40 percent debt to asset ratio situation, and a 20 percent debt to asset ratio situation. Six financial policy options designed to reduce the level of financial stress were evaluated. Also, an attempt was made to evaluate the potential impact of government commodity program payments on the economic viability and survival of farm situations being analyzed.

All farm situations were simulated over the 1986-90 planning horizon in deterministic and stochastic environments for crop yields and prices with 50 iterations (replications) for each year of the stochastic analysis. The results

were analyzed in terms of the impact of various economic and policy alternatives on profitability, liquidity, solvency, and risk.

Economic Scenarios

The original farm situations were evaluated under three economic scenarios representing possible future conditions of the economy. The input data described earlier for the Southwest Oklahoma farm is consistent with the base economic scenario. The farm's operator was assumed to receive $50,000 in government commodity program payments and $10,000 in off-farm income. Land value was assumed constant over the planning horizon in this scenario. The optimistic economic scenario reflects a 5 percent increase in farm returns each year of the five year planning horizon and a 2 percent annual increase in land value starting in the second year. The increase in returns could be comprised of changes in both prices for products and costs of inputs or could even reflect improved productivity in the input-output ratio. For the pessimistic economic scenario, the maximum government commodity program payment was reduced to $30,000 instead of $50,000 to reflect the government policy trend of shifting risk responsibility from public sector to the private sector. Also, a 2 percent annual reduction in land value starting in the second year of planning horizon was assumed in the pessimistic economic scenario.

Financial Policy Options and Input Adjustments

In addition to analysis of the farm financial situations under the original plan and three different economic scenarios, the study also evaluates the six financial policy options for each farm situation. Several of these options, such as debt reduction, interest rate reductions, and debt deferral have been

discussed by government and non-government financial institutions as possible means to alleviate farm financial problems. Other financial policy options, such as partial asset sales and equity infusions, are also being considered by farm operators and do not necessarily require assistance from outside lending institutions. These financial policy options are discussed in more detail below.

Reduction in Indebtedness

The intention of the reduction in indebtedness policy option is to decrease the farm's initial indebtedness by 35 percent across all liability types. The total beginning debt levels for each beginning debt to asset ratio situation are $608,867, $349,207, and $182,638, and the 35 percent reduction in these liabilities are $213,103, $122,222 and $63,923 for the 70, 40, and 20 percent debt to asset ratio situation, respectively. For each debt to asset ratio situation, all debt forgiveness is treated as taxable farm income in the first year of the planning horizon.

Reduction in Interest Rates

Interest rates on all debt outstanding are reduced by 35 percent. Original interest rates used for operating loans, old intermediate-term loans and old long-term loans are reduced by 35 percent over the five year planning horizon. The interest rates for new or refinance long- and intermediate-term loans are not reduced over the five-year period. The original and the reduced operating, intermediate- and long-term interest rates used in this analysis are presented in Table XII.

TABLE XII

BEGINNING INTEREST RATES AND RATES AFTER 35 PERCENT REDUCTION FOR OPERATING, INTERMEDIATE- AND LONG-TERM LIABILITY[1]

Interest Rate	Year				
	Year 1 1986	Year 2 1987	Year 3 1988	Year 4 1989	Year 5 1990
Original Operating Loan Rates	11.80	11.40	12.00	12.30	13.20
Reduced Rates (35% less)	7.67	7.41	7.80	7.80	8.58
Original Intermediate Loan Rates	12.20	11.80	12.40	12.80	13.60
Reduced Rates (35% less)	7.93	7.67	8.06	8.32	8.84
Original Long-term Loan Rates	12.00	11.60	12.10	12.50	13.40
Reduced Rates (35% less)	7.80	7.54	7.87	8.13	8.71

[1]The original interest rates for the first year were taken from USDA, ERS, Agricultural Finance Outlook and Situation Report, AFO-26, March 1986. These interest rates were inflated over the five-year period using the growth rates specified for interest rates in Table VI in this thesis.

Deferral of Debt Obligations

All scheduled payments of principal and interest for old intermediate- and long-term debt are deferred for two years with this strategy. In the interim, there is no accrual of interest. All payments commence in the third year at the original payment schedule. A zero interest rate is used for years 1 and 2 for intermediate- and long-term debt. Payments on short-term debt are not deferred.

Asset Sale - No Lease Back

Thirty-five percent of the farm assets are to be sold with this asset restructuring option. The proceeds are used to reduce intermediate- and long-term debt proportionately. In this analysis, 463 acres of dryland wheat are assumed sold for $257,891 and wheat acres in the production plan are reduced accordingly. The original purchase price of the land sold is $220,389 which results in $37,502 in capital gains. Since substantial acres of crops remain in the production plan, machinery assets are not assumed sold. For each debt to asset ratio situation, the land sale value is used to reduce the original long-term debt proportionately. Sixty percent of capital gains and the remaining cash after paying back the original loan is treated as non-taxable income while the remaining 40 percent of capital gains is treated as taxable farm income. The number of stocker steers is reduced from 250 to 116. Unallocated costs are reduced by 21 percent. Real estate taxes are reduced by the simulation model accordingly to reflect the 35 percent reduction in farm assets.

Asset Sale - Lease Back

The asset sale - lease back option involves selling 35 percent of farm assets and leasing back the assets that are sold. This option is implemented by selling 463 dryland wheat acres and leasing the land back on a one-third/two-thirds crop share lease typical for wheat in Southwest Oklahoma. No machinery sales are assumed. The long-term debt is reduced and the capital gains are treated the same way as in asset sale - no lease back option. Real estate taxes are reduced accordingly to reflect the 35 percent reduction in farm assets.

Equity Infusion

The final financial policy option involves a direct infusion of capital to reduce existing indebtedness. This strategy is implemented by injecting new equity in the amount of 35 percent of the farm's total indebtedness. The proceeds from the infusion are used to directly reduce operating, intermediate- and long-term debt. The equity infusion for long-term liabilities is $163,615, $93,408, and $46,705 and the equity infusion for intermediate-term liability is $17,150, $9800, and $4900 for debt to asset ratio situation of 70, 40, and 20 percent, respectively. The equity infusion for the operating loan is implemented by reducing the interest rate for the operating loan by 35 percent in the first year.

Analysis and Results

To provide a basis for comparison of the different economic and financial scenarios, an original plan is analyzed with beginning debt to asset ratio of 20 percent, 40 percent, and 70 percent under base, optimistic, and pessimistic

economic scenarios. Then each of the financial policy options is evaluated to determine its merit for improving the firm's profitability, liquidity, and solvency. The following discussion highlights the results for each of the economic assumptions across financial situations. The original plan is assumed to receive $50,000 in government commodity program payments and the family earns $10,000 in off-farm income.

Original Plan - Base Economic Scenario

Selected financial performance measures representing profitability, liquidity, risk, and solvency under both stochastic and deterministic environments for the farm being analyzed under the base economic condition are presented in Tables XIII and XIV. Under base economic assumptions and a 20 percent beginning debt to asset ratio, the original plan ends up in better financial condition at the end of the five year period with a 100 percent probability of financial survival. The probability of survival is the probability that the farm's intermediate- and/or long-term equity ratio will remain equal or above its prespecified minimum level (20 percent). Table XIII shows that the average annual net farm income is above $20,000 with a coefficient of variation (CV) of 34 percent. The coefficient of variation of any variable measures the relative variability and is calculated as the standard deviation of that variable divided by its mean and the result is multiplied by 100. The equity to asset ratio is 80.1 percent and the present value of ending net worth is nearly $517,000, and both measures have very low CV of 2.8 percent. These statements are generally true for the 40 percent debt to asset ratio situation. The original plan for the 40 percent debt to asset ratio situation ends up with probability of financial survival of 100 percent, average net farm income of

TABLE XIII

MEAN AND COEFFICIENTS OF VARIATION FOR SELECTED FINANCIAL MEASURES, DIFFERENT GOVERNMENT COMMODITY PROGRAM PAYMENT LIMITS AND DIFFERENT BEGINNING D/A, STOCHASTIC RUN, BASE ECONOMIC SCENARIO

Beginning Financial Situation	Government Payment Limitation	Present Value of Ending Net Worth		Equity to Asset at End of Last Solvent Year, All Iterations		Average Annual Net Farm Income for Years Simulated		Probability of Financial Survival for the Last Year[1]
	($)	Mean	CV	Mean	CV	Mean	CV	
70% D/A	50,000	157,145	39.03	.252	37.68	-27,881	-29.17	82
	40,000	81,881	77.50	.135[2]	72.51	-39,053	-17.77	34
	30,000	31,329	90.44	.055[3]	85.09	-49,211	-13.13	2
	20,000	19,140	131.21	.033[4]	134.37	-58,663	-12.26	0
	10,000	24,476	104.06	.042[5]	106.32	-67,049	-9.90	0
	0.0	15,524	150.53	.026[6]	158.20	-76,463	-8.97	0
40% D/A	50,000	387,408	4.54	.618	4.38	1810	411.69	100
	40,000	369,506	5.54	.590	5.61	-9202	-83.35	100
	30,000	342,177	8.31	.545	8.14	-20,775	-38.11	100
	20,000	312,680	10.17	.498	9.95	-32,248	-24.97	100
	10,000	274,364	11.75	.437	11.56	-44,364	-18.59	100
	0.0	230,698	15.64	.367	15.44	-56,909	-15.04	100
20% D/A	50,000	516,602	2.82	.801	2.81	20,039	34.91	100
	40,000	504,114	3.60	.790	3.05	9518	74.94	100
	30,000	486,242	3.67	.772	3.50	-1197	-611.86	100
	20,000	462,990	4.54	.739	4.54	-12,169	-61.57	100
	10,000	436,253	6.53	.695	6.31	-23,634	-33.37	100
	0.0	407,116	7.36	.648	7.14	-35,023	-22.68	100

[1]The probability of financial survival is the probability of the farm's intermediate and/or long-term equity will remain equal or above 20 percent. It is computed as the number of technically solvent iterations divided by the total number of iterations, 50.

[2]The farm was declared technically insolvent in 1990.

[3]The farm was declared technically insolvent in 1989.

[4,5]The farm was declared technically insolvent in 1988.

[6]The farm was declared technically insolvent in 1987.

TABLE XIV

SELECTED FINANCIAL MEASURES FOR 70 PERCENT DEBT/ASSET FOR DIFFERENT GOVERNMENT COMMODITY PROGRAM PAYMENT LIMITS OVER YEAR OF PLANNING HORIZON, DETERMINISTIC RUN, BASE ECONOMIC SCENARIO

Government Payment Limit ($)	Net Worth Adjusted for Unrealized Capital Gains, Depreciation and Contingent Liability					Percentage Change in Adjusted Net Worth (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
50,000	264,556	269,064	268,195	267,547	253,157	17.51	1.70	-.32	-.24	-5.38
40,000	254,356	247,485	233,813	218,676	62,552	12.97	-2.70	-5.52	-6.47	-71.40
30,000	244,156	225,602	199,431	49,064	NA	8.44	-7.48	-11.72	-75.40	NA
20,000	233,978	204,742	48,932	NA	NA	3.92	-12.50	-76.10	NA	NA
10,000	223,756	182,749	-4585	NA	NA	-.62	-18.33	-102.51	NA	NA
0.0	213,556	40,300	NA	NA	NA	-5.15	-81.13	NA	NA	NA

Government Payment Limit ($)	Debt to Asset Ratio					Probability of Financial Survival (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
50,000	.656	.649	.651	.676	.707	100	100	100	98	82
40,000	.669	.678	.696	.735	.918	100	100	98	62	34
30,000	.683	.706	.741	.933	NA	100	100	70	24	2
20,000	.695	.732	.927	NA	NA	100	90	32	2	0
10,000	.709	.762	1.007	NA	NA	100	48	6	0	0
0.0	.722	.940	NA	NA	NA	100	20	0	0	0

NA = Figures are not available because the farm was declared technically insolvent. The farm is declared technically insolvent when equity to asset ratio is less than 20 percent.

about $2000, equity ratio of 62 percent, and present value of net worth of $387,000.

When the beginning debt to asset ratio is 70 percent, the financial condition of the original plan deteriorates over the five year period and the probability of financial survival is only 82 percent. The average annual net farm income is -$28,000, the equity to asset ratio is 25 percent, and the present value of ending net worth is $157,000. Both equity ratio and present value of ending net worth have relatively high CV of 39 percent. Table XIV presents selected financial measures over the five year period for the 70 percent debt to asset ratio situation under a deterministic environment for crop yields and prices. The financial condition of the original plan deteriorates over the planning horizon using all performance measures. The debt to asset ratio (equity ratio) is 66 (34), 65 (35), 65 (35), 68 (32), and 71 (29) percent for year 1, 2, 3, 4, and 5 of the planning horizon respectively. Net worth adjusted for unrealized capital gains, depreciations, and contingencies declines from about $265,000 in the first year to $253,000 in the last (fifth) year of the planning horizon. Despite the deterioration in financial condition, even at the 70 percent beginning debt to asset ratio, the farm survives beyond the five year period of analysis.

Impact of Government Program Participation

The substantial commodity program income is extremely important in maintaining the viability of the farm unit. Farm operators in Southwest Oklahoma who are eligible to participate in the government commodity programs would likely do so in the current environment. However, to evaluate the potential impact of government commodity program payments on the economic viability of the farm being analyzed, a series of sensitivity analyses

are conducted. The original plan is analyzed under base economic conditions, $10,000 of off-farm income, and different limits of government program payment. These limits are $50,000 (original plan), $40,000, $30,000, $20,000, $10,000 and $0.0 government payment limit and are called level 5, level 4, level 3, level 2, level 1, and level 0, respectively. Analyses are conducted for the original plan with beginning debt to asset ratio of 20, 40, and 70 percent.

Financial performance measures for the farm situations being analyzed under different levels of government payment are presented in Tables XIII and XIV. The results are quite different for each government payment level compared to the original plan (level 5) across all beginning debt to asset ratio situations, particularly the 70 percent debt to asset ratio situation. The financial condition for all farm situations deteriorates over the years of the planning horizon as the government program payments decrease. As government program payment limit decreases, the coefficient of variation (CV) associated with both present value of ending net worth and equity ratio increase while the CV associated with average net farm income decreases. Also, the CVs associated with present value of net worth and equity ratio decrease as the beginning D/A ratio decreases across all levels of government program payment.

For the 20 percent debt to asset ratio situation, average annual net farm income is $20,000, $9500, -$1000, –$12,000, -$24,000, and -$35,000 for government payment levels 5, 4, 3, 2, 1, and 0, respectively. Equity to asset ratio is 80, 79, 77, 74, 70, and 65 for government program payment levels 5, 4, 3, 2, 1, and 0, respectively. Present value of ending net worth declines from about $517,000 with a 2.8 percent CV for the level 5 government program payment limit to $407,000 with a CV of 7.4 percent for level 0 government

program payment. Despite the deterioration of financial condition, the farm situation has a probability of financial survival of 100 percent for all government program payment levels. These statements are generally true with 40 percent debt to asset ratio situation. The magnitude of changes, however, is different. With no government program payments (level 0) for the 40 percent debt to asset ratio situation, the average annual net farm income is -$57,000, the equity to asset ratio is 37 percent, and the present value of net worth is $231,000.

When the beginning debt to asset ratio is 70 percent, the farm financial condition dramatically deteriorates over the five year period. The probability of financial survival at the end of planning horizon declines to 34 percent for level 4, 2 percent for level 3, and 0 percent for levels 2, 1, and 0 compared to 82 percent for level 5 of government program payment (original plan). Average annual net farm income decreases from -$28,000 for the original plan (level 5) to -$76,500 for the original plan with no government program payment (level 0). Equity to asset ratio at the end of planning horizon becomes 13.5 percent for level 4, 5.5 percent for level 3, 3.3 percent for level 2, 4.2 percent for level 1, and 2.6 percent for level 0 of government program payments (Table XIII). Present value of ending net worth decreases from $157,000 with 39 percent CV for the original plan to only $15,500 with high CV of 150 percent for the original plan with no government commodity program payment (level 0).

Table XIV presents selected performance measures for the 70 percent debt to asset ratio situation over years of the planning horizon. The rate of financial deterioration for the 70 percent debt to asset ratio situation increases as the government commodity program payment decreases. While the original plan (government payment level 5) remains technically solvent at the end of the five year period, it was declared technically insolvent in year 5 (1990) for

level 4, in year 4 (1989) for level 3, in year 3 (1988) for level 2 and 1, and in year 2 (1987) for level 0 of government commodity program payment. Also, for any government program payment level, the adjusted net worth decreases at an increasing rate over the years of planning horizon. For the level 4 ($40,000) government program payment, for example, the percentage change in adjusted net worth is 13, -3, -6, -7, and -71 for year 1, 2, 3, 4, and 5, respectively.

Impact of Financial Policy Options

For each of the beginning debt to asset ratio situations, policy options including debt reduction, interest rate reduction, debt deferral, asset sale with and without lease back, and equity infusion are evaluated. For the base economic scenario, results from stochastic and deterministic environment simulations are presented in Tables XV and XVI, respectively. The policy options have differential impacts on profitability, risk, and solvency across the beginning debt to asset ratio situations. Some options such as equity infusion result in relatively low average net farm income but large increases in net worth over the five years. Other options such as asset sale with and without lease back result in relatively high average net income and equity ratios but small increases or even decreases in net worth over the five years. Overall, the impact of these policy options, however, is to improve the financial conditions and probability of farm financial survival and to reduce the relative variability as measured by the coefficients of variation compared to the original plans across all debt to asset ratio situations. All farm situations end the five year planning horizon with 100 percent probability of survival even though the financial condition for these farms is deteriorating over the years of the

TABLE XV

MEAN AND COEFFICIENTS OF VARIATION FOR SELECTED FINANCIAL MEASURES, DIFFERENT POLICY OPTIONS, AND DIFFERENT BEGINNING D/A, STOCHASTIC RUN, BASE ECONOMIC SCENARIO

Beginning Financial Situation	Policy Option	Present Value of Ending Net Worth		Equity to Asset Ratio at End of Last Solvent Year, All Iterations		Average Annual Net Farm Income for Years Simulated		Probability of Financial Survival[1]
		Mean	CV	Mean	CV	Mean	CV	
70% D/A	Original plan	157,145	39.03	.252	37.58	-27,881	-29.16	82
	Debt reduction	264,965	7.44	.406	7.10	20,778	34.04	100
	Interest reduction	244,872	5.84	.392	5.70	4332	176.21	100
	Debt deferral	210,988	11.86	.325	11.56	-1845	-390.43	100
	Asset sale - no lease	224,089	8.11	.508	8.02	7095	94.88	100
	Asset sale - lease	236,089	9.76	.526	9.54	940	790.95	100
	Equity infusion	396,527	6.48	.631	6.26	1592	487.58	100
40% D/A	Original plan	387,408	4.53	.618	4.38	1810	411.69	100
	Debt reduction	427,353	3.77	.670	2.54	28,368	24.74	100
	Interest reduction	416,661	3.52	.656	2.83	22,017	32.35	100
	Debt deferral	408,394	4.26	.627	4.07	15,672	45.57	100
	Asset sale - no lease	408,476	1.73	.850	1.06	25,446	23.52	100
	Asset sale - lease	408,061	2.99	.842	2.81	19,396	34.15	100
	Equity infusion	506,121	3.08	.808	3.12	18,752	38.58	100
20% D/A	Original plan	516,602	2.82	.801	2.81	20,039	34.90	100
	Debt reduction	536,625	2.88	.824	2.85	33,242	20.30	100
	Interest reduction	539,267	2.60	.819	2.40	33,528	20.50	100
	Debt deferral	530,217	2.54	.804	2.51	26,536	25.80	100
	Asset sale - no lease	520,059	2.84	.927	.55	34,749	17.03	100
	Asset sale - lease	512,823	3.17	.929	.60	28,733	22.74	100
	Equity infusion	577,649	2.43	.890	2.70	28,971	23.90	100

[1]The probability of financial survival is the probability of the farm's intermediate and/or long-term equity will remain equal or above 20 percent. It is computed as the number of technically solvent iterations divided by the total number of iterations, 50.

TABLE XVI

SELECTED FINANCIAL MEASURES FOR 70 PERCENT DEBT TO ASSET RATIO, DIFFERENT POLICY OPTIONS OVER YEARS OF PLANNING HORIZON, DETERMINISTIC RUN, BASE ECONOMIC SCENARIO

Policy Option	Net Worth Adjusted for Unrealized Capital Gains, Depreciation and Contingent Liability					Percentage Change in Adjusted Net Worth (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
Original plan	264,556	269,064	268,195	267,547	253,157	17.51	1.71	-.32	-.24	-5.38
Debt reduction	388,656	382,487	362,613	366,190	361,382	72.63	-1.59	-5.20	.98	-1.31
Interest reduction	264,939	270,914	299,213	328,747	354,772	17.68	2.26	10.45	9.87	7.92
Debt deferral	283,226	304,936	308,984	306,447	292,955	25.80	7.67	1.33	-.82	-4.40
Asset sale - no lease	261,828	269,630	283,821	299,648	313,892	87.22	2.98	5.26	5.58	4.75
Asset sale - lease	263,333	267,678	286,748	306,277	325,216	88.29	1.65	7.12	6.81	6.18
Equity infusion	445,669	473,350	497,662	525,215	545,410	9.80	6.21	5.14	5.54	3.85

Policy Option	Debt to Asset Ratio					Probability of Financial Survival (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
Original plan	.656	.649	.651	.676	.707	100	100	100	100	82
Debt reduction	.571	.542	.561	.571	.600	100	100	100	100	100
Interest reduction	.652	.634	.611	.602	.589	100	100	100	100	100
Debt deferral	.632	.610	.625	.642	.677	100	100	100	100	100
Asset sale - no lease	.528	.522	.501	.474	.484	100	100	100	100	100
Asset sale - lease	.524	.523	.504	.472	.472	100	100	100	100	100
Equity infusion	.399	.383	.353	.364	.368	100	100	100	100	100

planning horizon under some of these policy options. The results of each of the financial policy options are discussed in detail below.

Debt Reduction

Thirty-five percent debt reduction is a very attractive policy option for all debt to asset ratio situations. It results in relatively high average net farm income and present value of ending net worth across all debt to asset ratio situations. Equity ratio is somewhat improved by this option. For the 70 percent debt to asset ratio situation, the present value of ending net worth is nearly $265,000, average net farm income is almost $21,000, and the equity ratio is nearly 41 percent (Table XV). Similarly, for the 40 percent and 20 percent beginning debt to asset ratio situations, the debt reduction option improves all the financial measures relative to the original plan. Thus, the direction and nature of debt reduction impact is independent of the beginning debt to asset ratio situations. Table XVI depicts the financial measures for the 70 percent debt to asset ratio situation over the five-year planning horizon. Even though the 70 percent debt to asset ratio situation has a 100 percent probability of financial survival over the five years, the financial condition of this farm situation is deteriorating over the years. Ending debt to asset ratio increases from 57 percent in the first year to 60 percent in the last (fifth) year and net worth decreases from nearly $389,000 in the first year to $361,000 in the last (fifth) year of the planning horizon.

Reduction in Interest Rate

The interest reduction option improves all performance measures relative to the original plan across all debt to asset ratio situations. It results in relatively high present value of ending net worth and average net farm income.

For the 70 percent debt to asset ratio situation, present value of ending net worth is nearly $245,000, the equity ratio is 39 percent, and average net farm income is more than $4000. Table XVI shows that the financial condition of this farm situation is improving over the five-year planning horizon. The net worth is $265,000, $271,000, $299,000, $329,000, and $355,000 for years 1, 2, 3, 4, and 5 of the planning horizon. For the 40 and 20 percent debt to asset ratio situations, the impact of the interest rate reduction option is in the same direction as with the 70 percent debt to asset ratio situation. All performance measures for these two farm situations are improved at the end of five years. For all debt to asset ratio situations, the coefficients of variation are relatively low for the present value of net worth and equity ratio and relatively high for the average net farm income.

Debt Deferral

Debt deferral for two years appears an unattractive option for all debt to asset ratio situations. It ranks very low in all financial measures with very high coefficients of variation. Compared to the original plan, the debt deferral option slightly improves the financial condition across all beginning debt/asset ratio situations. For example, the present values of ending net worth are $211,000, $408,000, and $530,000 for 70, 40, and 20 percent debt to asset ratio situations compared to $157,000, $387,000, and $517,000, respectively, under the original plan. Because principal and interest payment are deferred for two years, the financial condition is improved and surplus cash flow is attained for the first two years. However, once debt payments commence, the financial condition deteriorates rapidly in the following years across all debt to asset ratio situations. Table XVI shows the financial condition over the planning horizon for the 70 percent debt to asset ratio situation. The debt to

asset ratio is 63 percent in the first year, decreases to 61 percent in the second year, and then increases to 63, 64, and 68 percent for the third, fourth, and fifth year of the planning horizon, respectively. Similarly, percentage changes in net worth are 26, 8, 1, -1, and -4 for years 1, 2, 3, 4, and 5 of the planning horizon, respectively.

Asset Sale - No Lease Back

The asset sale without lease back option dramatically improves the financial condition for all debt to asset ratio situations. It provides early cash flow and immediately reduces the interest and principal payments for short-, intermediate-, and long-term debt. The asset sale - no lease back option results in relatively high average net farm income and equity ratio for all debt to asset ratio situations. The land sold, which is dryland wheat, is not profitable without government program payments. With cotton production maintained, government program payments still equal $50,000 and unprofitable wheat production is reduced, resulting in higher net income for all farm situations. However, this option results in relatively small increases in net worth present value across all debt to asset ratio situations, which is expected since implementation of this option includes selling 35 percent (463 acres of dryland wheat) of total farm assets. Average net farm income is $7000 for the 70 percent D/A, $25,000 for the 40 percent D/A, and $34,000 for the 20 percent D/A ratio situations (Table XV). The equity ratio is 51, 85, and 93 percent and present value of ending net worth is $224,000, $408,000, and $520,000 for the 70, 40, and 20 debt to asset ratio situations, respectively. The coefficients of variation associated with most of these financial measures are relatively low compared to the other policy options and the original plan. The financial condition for the 70 percent debt to asset ratio situation is improving over the

five-year planning horizon. For example, net worth increases from $262,000 in the first year to almost $314,000 in the last (fifth) year of planning horizon, while the debt to asset ratio decreases from 53 percent in the first year to 48 percent in the last year of the planning horizon (Table XVI).

Overall, asset sale - no lease back is a very attractive option across all debt/asset ratio situations. Even though the implementation of the asset sale without lease back option results in a substantial reduction in wheat acreage, the government payment income remains at its maximum level of $50,000. Because cotton and grain sorghum acreage and production are maintained the same over the five-year period, yearly government program payments for all three crops grown in these farms are still at $50,000 for all years of the planning horizon.

Asset Sale - Lease Back

As with the asset sale - no lease back option, the asset sale - lease back option improves early cash flow and immediately reduces the interest and principal payments, providing a continued stream of income from the existing farm. However, this option results in average net farm income less favorable than the asset sale - no lease back option across all beginning debt/asset ratio situations. For the 40 and 20 percent debt/asset ratio situations, this option also results in lower present value of ending net worth than with the asset sale – no lease back. Because the land sold, which is dryland wheat, is not profitable, leasing it back on a one-third/two-thirds crop share lease results in less favorable financial condition for the asset sale lease back option compared to asset sale - no lease back option. As with the asset sale - no lease back option, this option results in a wide variation in average net farm income across the beginning D/A ratio situations. Average net farm income is

$940 for the 70 percent D/A ratio, $19,000 for the 40 percent D/A ratio, and $29,000 for the 20 percent D/A ratio situation (Table XV). For the 70 percent D/A ratio situation, the financial condition is improving over the planning horizon. The debt to asset ratio decreases from 52 percent in year 1 to 47 percent in year 5 and adjusted net worth increases from $263,000 in year 1 to $325,000 in year 5 (Table XVI). The coefficients of variation associated with both average net farm income and present value of ending net worth are relatively high and are always higher than the corresponding values associated with asset sale - no lease back option.

Equity Infusion

The equity infusion option immediately reduces the debt and increases the equity capital of the firm. This option ranks very high across all debt to asset ratio situations for assuring the solvency and survivability of the firm as measured by the equity ratio and present value of net worth. However, it ranks relatively low in terms of profitability as measured by average net farm income. Since the equity infusion option is implemented by injecting new equity in the amount of 35 percent of farm's original liability across debt to asset ratio situations, the impacts of this option on financial measures vary among the beginning debt to asset ratio situations. Compared to the original plan, present value of ending net worth increases by $239,000 for the 70 percent debt to asset ratio situation, by $119,000 for the 40 percent debt to asset ratio situation and only by $61,000 for the 20 percent debt to asset ratio situation. The average net farm income is $1500, $19,000 and $29,000 for 70, 40, and 20 percent debt to asset ratio situations, respectively. The coefficients of variation associated with present value of ending net worth are relatively low while those associated with average net farm income are relatively high. For

the beginning debt to asset ratio situation of 70 percent, equity infusion appears to be very attractive since it results in the highest present value of ending net worth and equity ratio, the financial survival measures. For this D/A ratio situation, the equity ratio increases to 63 percent compared to 25 percent under the original plan. Also, the financial condition is improving over the years of the planning horizon for this D/A ratio situation.

As a rough measure of the overall attractiveness of the options, all six strategies with the original plan are ranked for each measure and the unweighted ranks are summed for each strategy. The results are compared across debt to asset ratio situations and presented in Table XVII. For the 20 percent D/A ratio situation, asset sale - no lease back and equity infusion rank first and interest rate reduction ranks second. For the 40 percent D/A situation, both debt reduction and asset sale - no lease back rank first while equity infusion ranks second. For the 70 percent D/A situation, equity infusion ranks first, debt reduction ranks second and asset sale - no lease back ranks third. Debt deferral ranks the lowest compared to other policy options across all D/A situations. If farm operators weigh the different performance criteria equally, these ranks give fair indication of the attractiveness of their options.

Stochastic Dominance Analysis

First- and second-degree stochastic dominance and stochastic dominance wtih respect to function (SDWRF) criteria were used to order all government payment levels and financial policy options for the 70 percent debt/asset ratio situations. Figures 9 and 10 depict the cumulative distribution function (CDF) for the present value of ending net worth and average annual net farm income for 70 percent debt to asset ratio situation with different levels of government payment, respectively. Using the first- and second-degree

TABLE XVII

RANK OF POLICY OPTIONS FOR THE BASE ECONOMIC SCENARIO BY DEBT/ASSET SITUATION, BASE ECONOMIC SCENARIO

Policy Options	Beginning Debt to Asset Ratio Situation					
	20 Percent		40 Percent		70 Percent	
	Sum of Ranks	Overall Rank	Sum of Ranks	Overall Rank	Sum of Ranks	Overall Rank
Debt reduction	11	3	8	1	8	2
Interest reduction	10	2	12	3	12	4
Debt deferral	17	5	18	5	19	5
Asset sale - no lease back	9	1	8	1	11	3
Asset sale - lease back	14	4	13	4	12	4
Equity infusion	9	1	10	2	7	1
Original plan	21	6	22	6	23	6

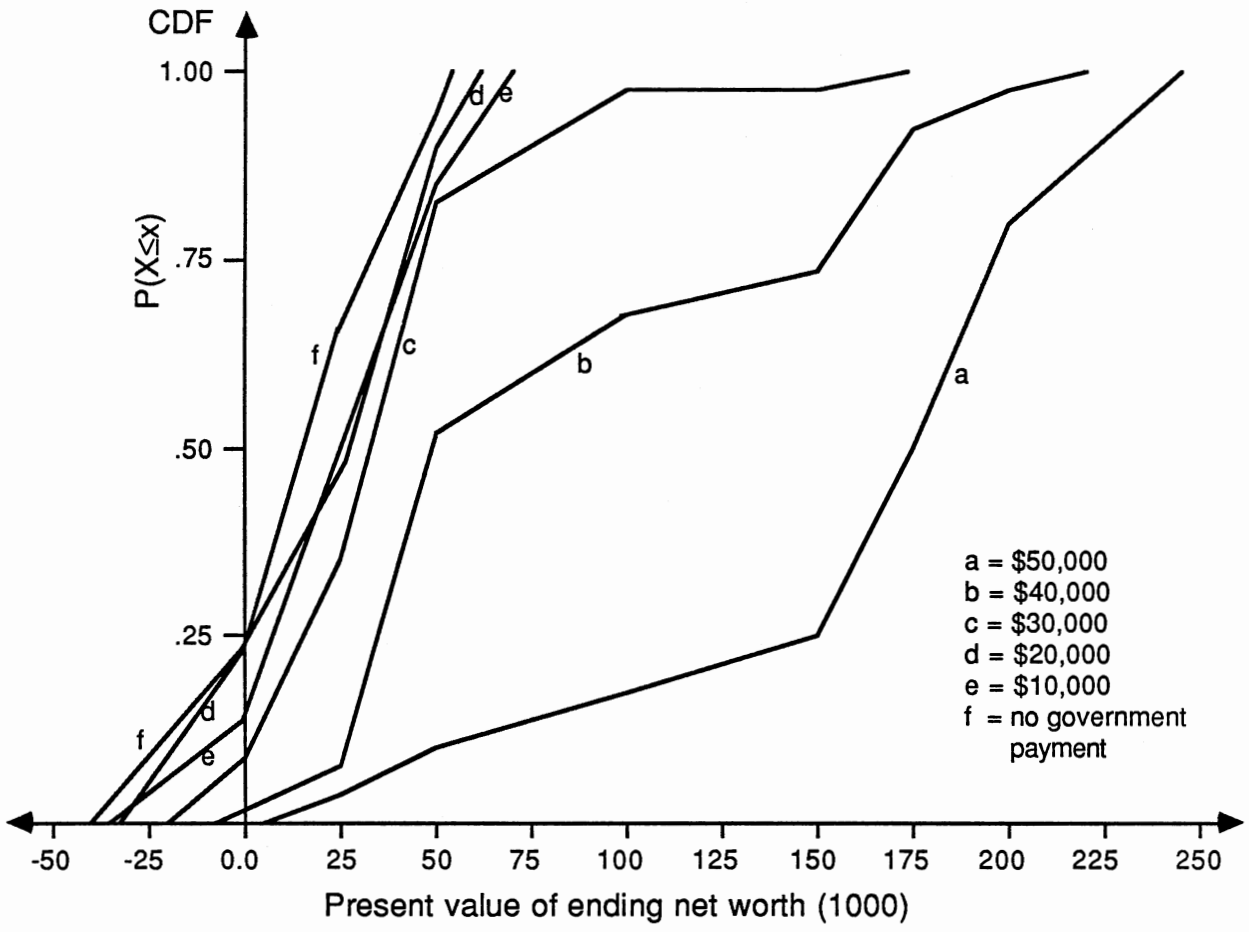


Figure 9. CDF of Net Worth Present Value at the End of Last Solvent Year, Different Government Payment Limits for the 70 Percent D/A Ratio Situation

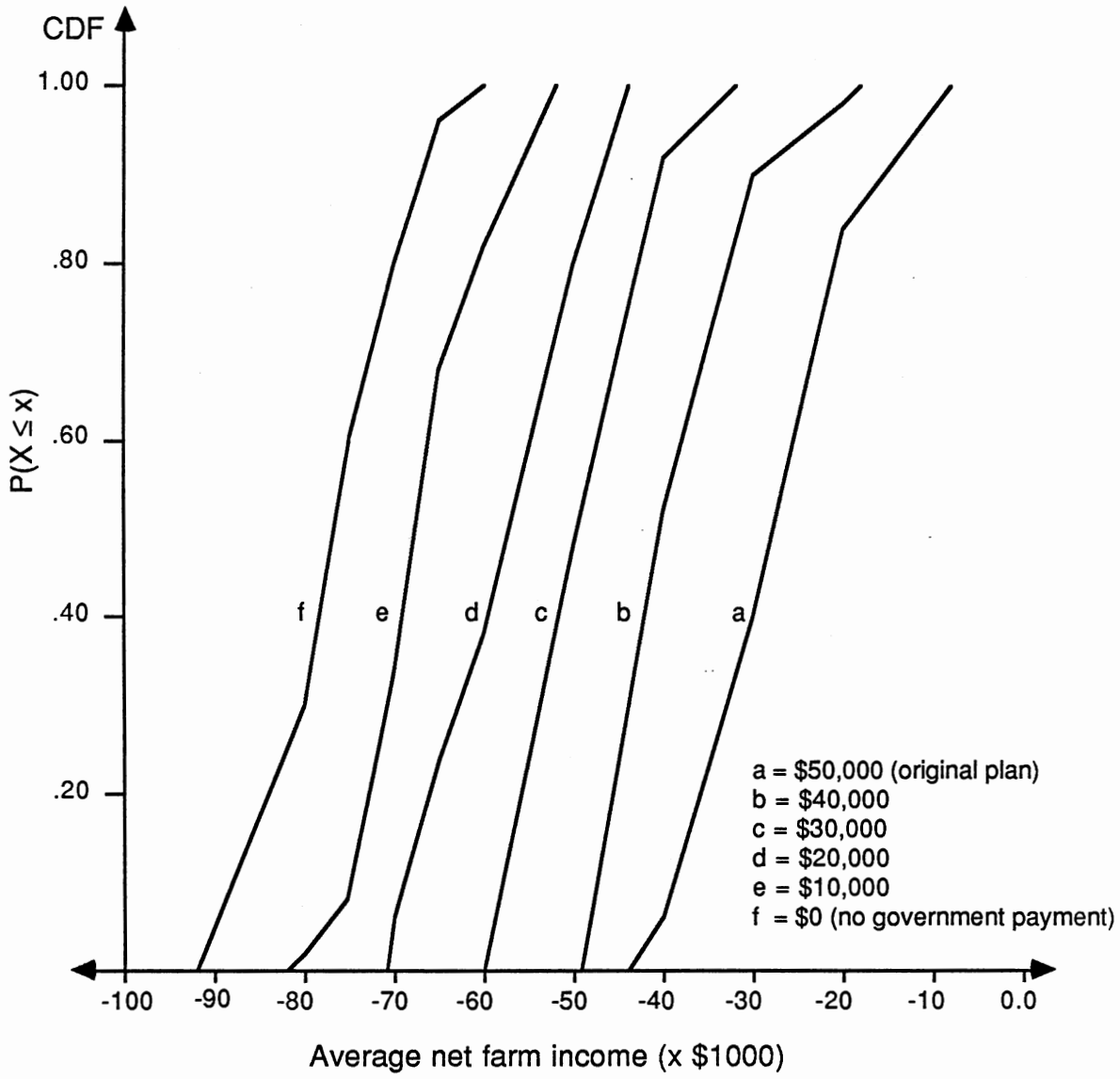


Figure 10. CDF of Average Net Farm Income, Different Government Program Payment Limits for the 70 Percent D/A Ratio Situation

stochastic dominance criteria, the original plan with $50,000 government commodity program payment limit (level 5) dominates the original plan with all other government commodity program payment limits (levels 4, 3, 2, 1, and 0). The probability that present value of ending net worth or average annual net farm income is equal to or less than specified value with level 5 government program payment ($50,000) is always less than the corresponding probability associated with other government program payment levels. All government program payment levels can be ordered by FSD and SSD criteria using average net farm income. However, some levels including level 2 and level 1 ($20,000 and $10,000 government program payment limit, respectively) cannot be ordered by these two criteria using present value of ending net worth since the CDFs of the present value of ending net worth for these two levels intersect over their relative ranges.

Stochastic dominance with respect to function criteria were used to order the six distributions of government program payment levels and the result is presented in Table XVIII. The symbol 1 indicates that the first distribution name is preferred to the second; -1 indicates that the second name is preferred to the first; and 0, if any, indicates that the two distributions cannot be ordered by SDWRF criteria for the class of decision makers whose risk aversion functions lie within the specified bounds. Lower bound of .001 and upper bound of .01 for the risk aversion coefficient function were specified. This risk aversion coefficient interval represents risk averse decision makers. Raskin and Cochran (1986) reviewed the previous empirical studies that elicited the risk aversion coefficient intervals for the decision makers. A lower bound of .00004 and upper bound of ∞ for risk averse decision makers was found. Thus, the risk aversion coefficient interval specified for this study falls within these ranges.

TABLE XVIII

ORDERING THE GOVERNMENT PROGRAM PAYMENT LEVELS FOR 70 PERCENT D/A AND BASE ECONOMIC SCENARIO USING SDWRF CRITERIA

Government Payment Level		Name	NWPV	ANFI
Level 5 ($50,000)	versus	level 4	1	1
		level 3	1	1
		level 2	1	1
		level 1	1	1
		level 0	1	1
Level 4 ($40,000)	versus	level 5	-1	-1
		level 3	1	1
		level 2	1	1
		level 1	1	1
		level 0	1	1
Level 3 ($30,000)	versus	level 5	-1	-1
		level 4	-1	-1
		level 2	1	1
		level 1	1	1
		level 0	1	1
Level 2 ($20,000)	versus	level 5	-1	-1
		level 4	-1	-1
		level 3	-1	-1
		level 1	-1	1
		level 0	1	1
Level 1 ($10,000)	versus	level 5	-1	-1
		level 4	-1	-1
		level 3	-1	-1
		level 2	1	-1
		level 0	1	1
Level 0 ($0.0)	versus	level 5	-1	-1
		level 4	-1	-1
		level 3	-1	-1
		level 2	-1	-1
		level 1	-1	-1

Table XVIII shows that level 5 government program payment is the only level that dominates all other government program payment levels using both present value of ending net worth (NWPV) and average net farm income (ANFI). In other words, the efficient set is comprised of only level 5, the only distribution that is not dominated. Also, level 1 ($10,000) of government program payment dominates level 2 ($20,000) by SDWRF criteria using PVNW. While the farm was declared technically insolvent in the same year (third year) of the five-year period for both levels (level 2 and 1), the chance that the farm remained technically solvent with level 2 government program payment is higher than that with level 1, giving more time for the farm with level 2 to lose more equity capital. The average period the farm remained in operation is 3.2 years for level 2 government payment and 2.5 years for level 1. As expected, the original farm plan without government program payment is dominated by all other government program payment levels using both present value of ending net worth and average net farm income.

As with government program payment levels, the six financial policy options were ranked using stochastic dominance criteria. Figures 11 and 12 depict the cumulative distribution function (CDF) of the present value of ending net worth and average annual net farm income, respectively, for the 70 percent D/A situation. Using first- and second-degree stochastic dominance criteria (FSD and SSD), the equity infusion option (option 6) dominates all other policy options using present value of ending net worth (PVNW), while the debt reduction option (option 1) dominates all other options using average net farm income (ANFI). The debt reduction option (option 1) ranks second using PVNW while asset sale - no lease back (option 4) ranks second using ANFI performance measure. Debt deferral option (option 3) is dominated by all other policy options using both PVNW and ANFI. The original farm plan is

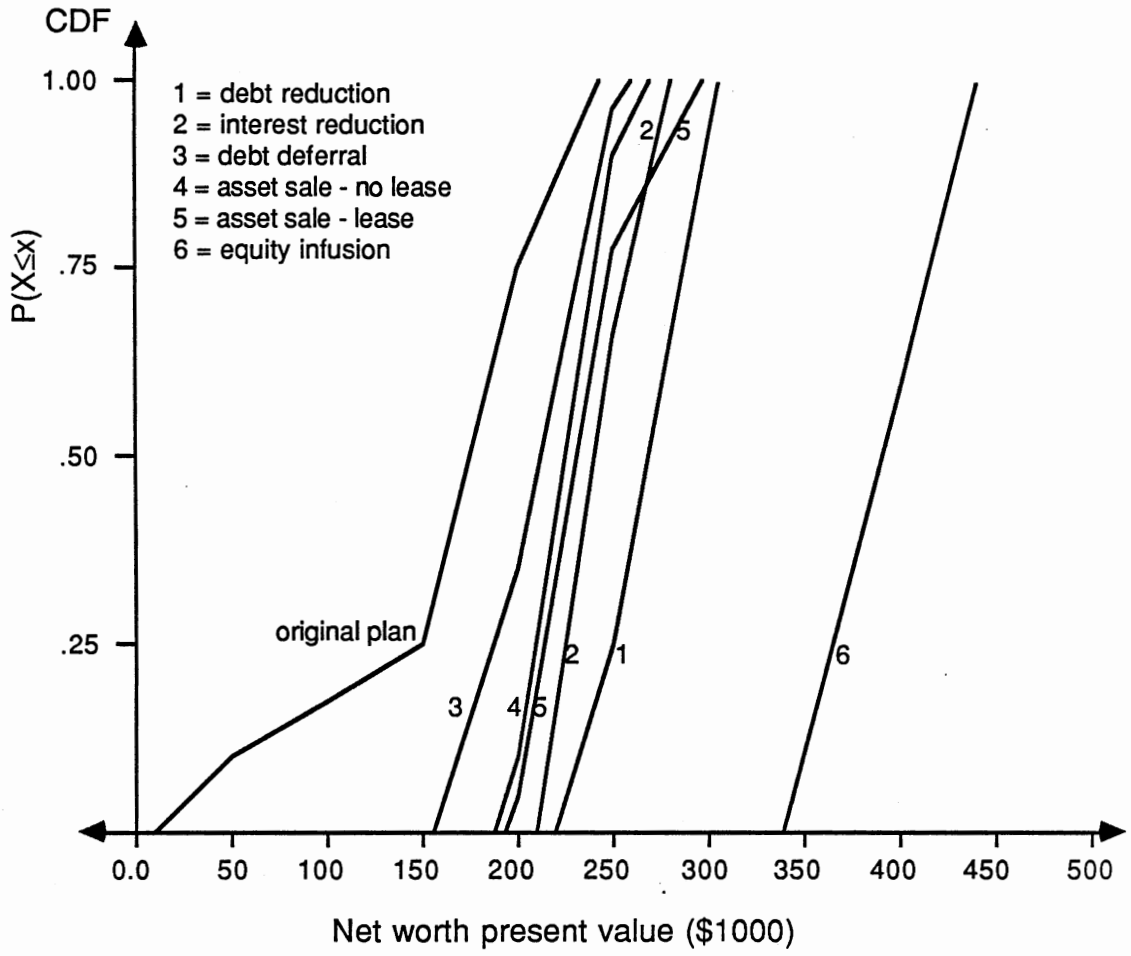


Figure 11. CDF for Net Worth Present Value at the End of Last Solvent Year, Different Policy Options for the 70 Percent D/A Ratio Situation

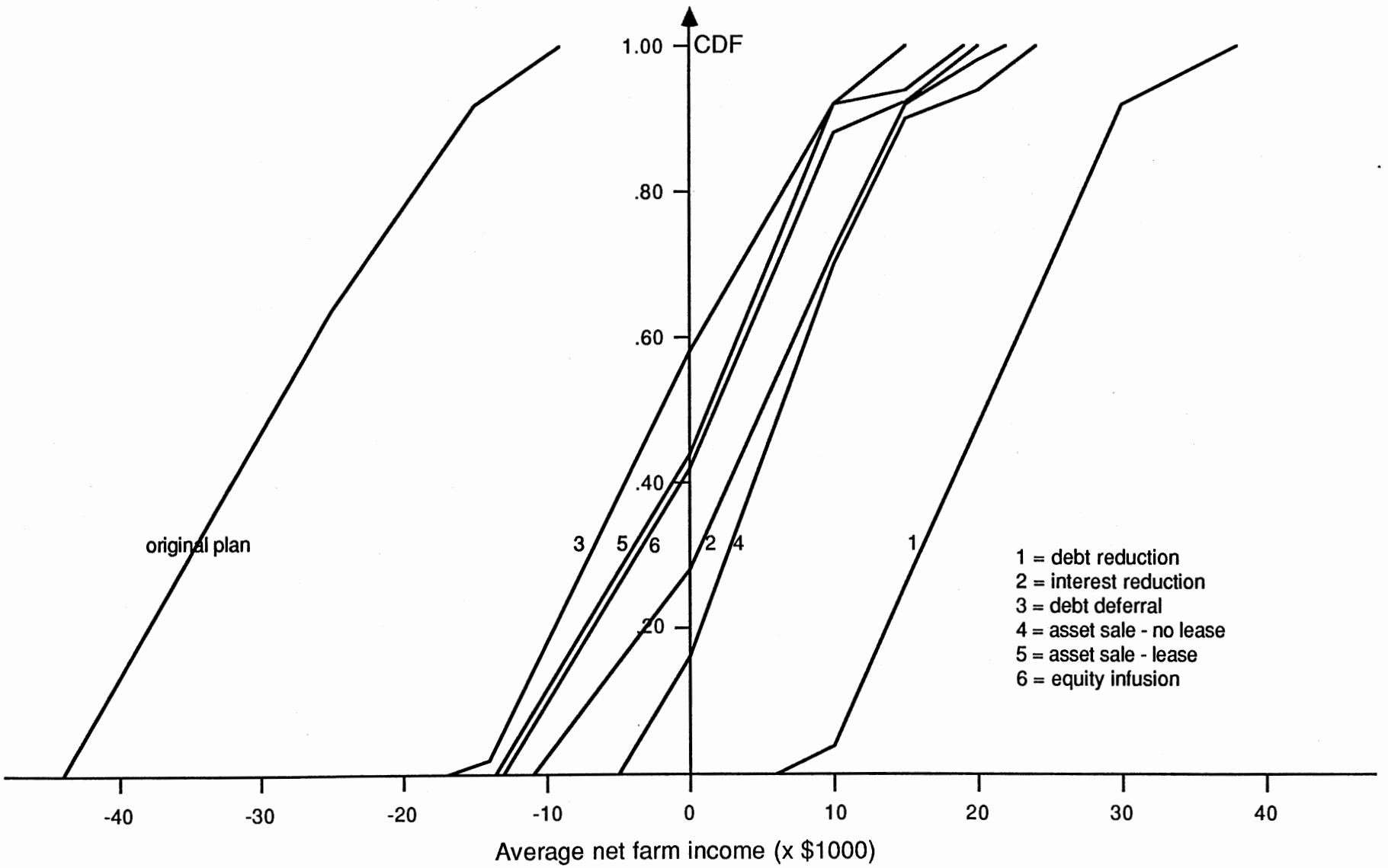


Figure 12. CDF for Average Net Farm Income, Different Policy Options for the 70 Percent D/A Ratio Situation

dominated by all policy options in both performance measures (PVNW and ANFI). Some policy options including asset sale - lease back (option 5) and interest reduction (option 2) options cannot be ordered using these two criteria since their CDF intersects over the ranges of their present value of ending net worth.

Stochastic dominance with respect to function (SDWRF) was used to rank the six distributions of the financial policy options as well as the original plan. As with the analysis of government program payment limitations, a lower bound of .001 and an upper bound of .01 for the risk aversion coefficient function were specified and the results for both PVNW and ANFI are presented in Table XIX. The rank of policy options using SDWRF is the same as with FSD and SSD. The equity infusion option (option 6) is the only efficient set using PVNW, and the debt reduction option (option 1) is the only efficient set using ANFI. Both are the only distributions that are not dominated by any other policy options. By using SDWRF, both the interest reduction and asset sale - lease back options are ordered. The interest reduction option dominates the asset sale - lease back option using both PVNW and ANFI. Again, the debt deferral policy option (option 3) is dominated by all other policy options while the original plan is dominated by all options in both PVNW and ANFI.

Various intervals for the risk aversion coefficient function were specified to rank the government program payment levels and the financial policy options. The results of ranking these alternatives, however, remain unchanged among these intervals. This is not very surprising in this analysis since the difference between these alternatives in terms of NWPV and ANFI is so big that it makes ranking of these six levels invariant with respect to risk aversion coefficient.

TABLE XIX

ORDERING THE POLICY OPTIONS FOR 70 PERCENT D/A AND BASE ECONOMIC SCENARIO USING SDWRF CRITERIA

Policy Option		Name	NWPV	ANFI
Original plan	versus	option 1	-1	-1
		option 2	-1	-1
		option 3	-1	-1
		option 4	-1	-1
		option 5	-1	-1
		option 6	-1	-1
Debt reduction (option 1)	versus	original plan	1	1
		option 2	1	1
		option 3	1	1
		option 4	1	1
		option 5	1	1
		option 6	-1	1
Interest reduction (option 2)	versus	original plan	1	1
		option 1	-1	-1
		option 3	1	1
		option 4	1	-1
		option 5	1	1
		option 6	-1	1
Debt deferral (option 3)	versus	original plan	1	1
		option 1	-1	-1
		option 2	-1	-1
		option 4	-1	-1
		option 5	-1	-1
		option 6	-1	-1
Asset sale - no lease (option 4)	versus	original plan	1	1
		option 1	-1	-1
		option 2	-1	1
		option 3	1	1
		option 5	-1	1
		option 6	-1	1
Asset sale - lease back (option 5)	versus	original plan	1	1
		option 1	-1	-1
		option 2	-1	-1
		option 3	1	1
		option 4	1	-1
		option 6	-1	-1
Equity infusion (option 6)	versus	original plan	1	1
		option 1	1	-1
		option 2	1	-1
		option 3	1	1
		option 4	1	-1
		option 5	1	1

Original Plan - Optimistic Economic Scenario

As explained earlier, the optimistic economic scenario reflects a 5 percent improvement in farm gross returns in each year of the planning horizon and a 2 percent annual growth in land value over years of planning horizon starting in the second year. The increase in returns is implemented by increasing the prices of crop and livestock enterprises by 5 percent each year. The farm is still assumed to receive $50,000 in government program payment and $10,000 in off-farm income.

Tables XX and XXI depict the financial performance for the original farm plan and the policy options under the optimistic economic scenario. As one would expect, optimistic economic assumptions lead to results that are considerably more favorable than under base economic assumptions across all beginning debt to asset ratio situations. Under this economic scenario, even the farm situation with 70 percent beginning debt to asset ratio ends up in better financial condition at the end of five-year period. For example, the original plan with a beginning debt to asset ratio of 70 percent has 100 percent probability of financial survival at the end of the five-year period compared with only 82 percent probability of financial survival under the base economic scenario. The 70 percent debt/asset ratio situation has average net farm income of -$15,000, equity to asset ratio of 36 percent, and present value of ending net worth of $242,000 (Table XX). All these financial measure values are more favorable than the correspondent values under the base economic scenario. Moreover, the financial condition for the 70 percent debt to asset ratio situation is improving over the five-year period. Table XXI shows that adjusted net worth increases from $250,000 in year 1 to $278,000, $301,000,

TABLE XX

MEAN AND COEFFICIENTS OF VARIATION FOR SELECTED FINANCIAL MEASURES, DIFFERENT POLICY OPTIONS, AND DIFFERENT BEGINNING D/A, STOCHASTIC RUN, OPTIMISTIC ECONOMIC SCENARIO

Beginning Financial Situation	Policy Option	Present Value of Ending Net Worth		Equity to Asset Ratio at End of Last Solvent Year, All Iterations		Average Annual Net Farm Income for Years Simulated		Probability of Financial Survival[1]
		Mean	CV	Mean	CV	Mean	CV	
70% D/A	Original plan	241,878	11.64	.362	11.29	-15,425	-53.98	100
	Debt reduction	323,111	5.33	.461	5.06	31,785	23.44	100
	Interest reduction	294,290	4.92	.444	4.41	16,184	48.61	100
	Debt deferral	302,834	6.09	.432	5.71	10,864	69.31	100
	Asset sale - no lease	268,284	7.03	.573	6.82	15,530	46.93	100
	Asset sale - lease	284,551	7.21	.599	6.82	12,869	61.20	100
	Equity infusion	454,287	5.07	.680	4.93	13,130	62.49	100
40% D/A	Original plan	440,376	3.43	.657	2.64	13,514	56.32	100
	Debt reduction	483,156	3.10	.697	2.29	39,205	18.32	100
	Interest reduction	469,657	3.22	.680	2.42	33,182	22.21	100
	Debt deferral	475,273	2.94	.681	2.72	27,195	26.88	100
	Asset sale - no lease	440,373	2.46	.856	.70	32,788	19.26	100
	Asset sale - lease	443,403	2.67	.857	.75	29,983	23.14	100
	Equity infusion	556,283	2.65	.827	2.37	29,733	25.20	100
20% D/A	Original plan	571,851	2.55	.817	2.33	31,013	23.38	100
	Debt reduction	587,867	1.82	.839	1.47	43,802	16.33	100
	Interest reduction	586,894	1.91	.837	1.48	44,350	16.34	100
	Debt deferral	584,661	1.86	.835	1.47	37,382	19.16	100
	Asset sale - no lease	560,378	2.88	.923	.51	42,032	15.02	100
	Asset sale - lease	560,996	3.22	.924	.55	39,227	17.69	100
	Equity infusion	625,968	2.25	.900	2.15	39,501	18.22	100

[1]The probability of financial survival is the probability of the farm's intermediate and/or long-term equity will remain equal or above 20 percent. It is computed as the number of technically solvent iterations divided by the total number of iterations, 50.

TABLE XXI

SELECTED FINANCIAL MEASURES FOR 70 PERCENT DEBT TO ASSET RATIO, DIFFERENT POLICY OPTIONS OVER YEARS OF PLANNING HORIZON, DETERMINISTIC RUN, OPTIMISTIC ECONOMIC SCENARIO

Policy Option	Net Worth Adjusted for Unrealized Capital Gains, Depreciation and Contingencies					Percentage Change in Adjusted Net Worth (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
Original plan	250,107	278,490	301,094	325,800	338,750	11.09	11.35	8.12	8.20	3.98
Debt reduction	397,060	407,229	409,741	409,256	430,756	76.36	2.56	.62	-.12	5.25
Interest reduction	274,236	299,515	349,100	373,033	421,549	21.80	9.22	16.56	6.86	13.00
Debt deferral	314,307	381,226	382,782	408,767	429,217	39.60	21.29	.41	6.79	5.00
Asset sale - no lease	268,530	282,820	311,019	341,465	371,344	92.01	5.32	9.97	9.79	8.75
Asset sale - lease	272,527	292,108	329,183	369,679	410,409	94.87	7.19	12.69	12.30	11.02
Equity infusion	454,443	502,935	521,737	572,612	617,280	11.96	10.67	3.74	9.75	7.80

Policy Option	Debt to Asset Ratio					Probability of Financial Survival (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
Original plan	.665	.644	.622	.624	.631	100	100	100	100	100
Debt reduction	.567	.527	.532	.535	.558	100	100	100	100	100
Interest reduction	.644	.612	.562	.568	.548	100	100	100	100	100
Debt deferral	.605	.559	.558	.543	.552	100	100	100	100	100
Asset sale - no lease	.524	.510	.470	.427	.420	100	100	100	100	100
Asset sale - lease	.518	.502	.448	.390	.369	100	100	100	100	100
Equity infusion	.397	.357	.320	.340	.327	100	100	100	100	100

$326,000, and $339,000 in years 2, 3, 4, and 5, respectively. Debt/asset ratio decreases from 67 percent in year 1 to 63 percent in year 5.

Farm situations with beginning debt to asset ratios of 40 and 20 percent end up in considerably improved financial condition over five-year period. The farm with a beginning debt to asset ratio of 40 percent has average net farm income of about $14,000, equity ratio of 66 percent, and present value of ending net worth in excess of $440,000. The 20 percent debt to asset ratio situation has average net farm income of $31,000, equity ratio of 82 percent, and present value of ending net worth nearly $582,000. The coefficients of variation associated with equity ratio and present value of ending net worth under the optimistic economic scenario are much lower than the correspondent ones under the base economic scenario for all beginning debt/asset ratio situations.

Impact of Financial Policy Options

The impacts of the six policy options evaluated under the optimistic economic assumptions are about as they were under the basic economic assumptions. All policy options result in 100 percent probability of financial survival and improved financial condition over five-year period for all beginning debt/asset ratio situations. Tables XX and XXI depict the financial performance for the debt/asset ratio situation under the optimistic economic scenario. For the 70 percent D/A ratio situation, all six policy options result in positive average net farm income. The average net farm income has a range from $11,000 with debt deferral option to $32,000 with debt reduction. The coefficients of variation associated with the policy options, in general, are always lower than the CVs associated with the original plan across all D/A ratio situations.

The six policy options, while they improve the financial conditions across all debt/asset ratio situations, have differencial impacts on the performance measures. The equity infusion consistently results in highest present value of ending net worth, relatively high equity ratio, and relatively low average net farm income across all debt/asset ratio situations. The present value of ending net worth is $452,000 for the 70 percent D/A ratio, $556,000 for the 40 percent D/A ratio, and $626,000 for the 20 percent D/A ratio situation. Average net farm income is about $13,000, $30,000, and $40,000 for the 70, 40, and 20 percent D/A ratio situations, respectively (Table XX). The coefficients of variation (CV) associated with this option are always less than the corresponding values of the original plan. Table XXI shows that the financial condition for the 70 percent D/A situation is improving over the years of the planning horizon.

Debt reduction option results in the highest average net farm income for both 70 and 40 percent debt to asset situations and next to the highest for the 20 percent debt/asset ratio situation. This option also results in relatively high present value of ending net worth and equity ratio across all debt/asset farm situations. Average net farm income associated with this option is about $32,000 for the 70 percent D/A situation, $39,000 for the 40 percent D/A situation, and about $44,000 for the 20 percent D/A situation. As with equity infusion option, the coefficient of variation associated with this option across all debt/asset ratio situations is always less than the corresponding values under the original plan. The equity ratio is 46, 70, and 84 percent for the 70, 40, and 20 percent D/A ratio situations, respectively. The financial condition for the 70 percent debt/asset situation is improving over the years of the planning horizon. For example, adjusted net worth increases from $397,000 in year 1 to about $431,000 in year 5.

Asset sale with and without lease back options are very comparable options and consistently result in high equity ratio and average net farm income, and very small increases or even decreases in present value of ending net worth over the five years. Unlike the case with the base economic assumptions, asset sale - lease back option ends up in more favorable present value of ending net worth and equity ratios than with asset sale - no lease back option across all debt/asset situations. This is because of the higher crop prices assumed for the optimistic economic assumptions which made the land sold (dryland wheat) more profitable. Thus, leasing back the land sold improved the financial condition for the farm under this policy option compared to the asset sale - no lease back option. Both measures result in present value of ending net worth from $268,000 to $285,000 for the 70 percent D/A situation, from $440,000 to $443,000 for the 40 percent D/A situation and about $561,000 for the 20 percent D/A situation with relatively high coefficients of variation. The coefficients of variation associated with asset sale - no lease back, however, are always less than the corresponding values associated with asset sale - lease back option.

Other policy options, including interest reduction and debt deferral, are comparable using present value of ending net worth and equity ratio across all debt to asset ratio situations. Interest rate reduction option, however, results in more favorable average net farm income than the debt deferral. Debt deferral, unlike the case with the base economic scenario, results in relatively high present value of ending net worth. For the 70 percent D/A situation, these two options result in present value of ending net worth from $294,000 to $303,000, and equity ratio from 43 to 44 percent. For the 40 percent D/A situation, the present value of ending net worth is from $470,000 to $475,000 and the equity ratio is about 68 percent. For the 20 percent D/A situation, these two options

result in present value of ending net worth from $585,000 to $587,000 and equity ratio of 84 percent. Interest reduction results in relatively high average net farm income while debt deferral results in the lowest average net farm income across all debt/asset situations. As with all other policy options, the financial condition of the 70 percent D/A ratio situation is improving over the five-year period. With debt deferral option, the debt to asset ratio, for example, decreases from 61 percent in year 1 to 55 percent in year 5 and adjusted net worth increases from $314,000 in year 1 to $429,000 in year 5 of the planning horizon.

As a rough measure of the overall attractiveness of the options, all six options with the original plan under the optimistic economic assumptions are ranked for each measure and the unweighted ranks are summed for each option. The results are compared among debt/asset ratio situations and presented in Table XXII. For the 20 percent debt/asset ratio situation, equity infusion and debt reduction options rank first and the interest reduction ranks next. For the 40 percent D/A situation, debt reduction ranks first and the equity infusion ranks second. For the 70 percent debt/asset situation, equity infusion ranks first, while the debt reduction ranks second. As with the base economic assumptions, debt deferral option ranks the lowest compared to other policy options, while the original plan ranks the lowest compared to all policy options. Unlike the case of base economic scenario, both asset sale with and without lease back options rank very comparable across D/A ratio situations. They both rank third for the 20 and 40 percent D/A ratio situations and fourth for the 70 percent D/A ratio situation.

TABLE XXII

RANK OF POLICY OPTIONS BY DEBT/ASSET SITUATIONS
FOR THE OPTIMISTIC ECONOMIC SCENARIO

Policy Options	Beginning Debt to Asset Ratio Situation					
	20 Percent		40 Percent		70 Percent	
	Sum of Ranks	Overall Rank	Sum of Ranks	Overall Rank	Sum of Ranks	Overall Rank
Debt reduction	9	1	8	1	8	2
Interest reduction	10	2	13	4	12	3
Debt deferral	17	4	15	5	16	5
Asset sale - no lease back	13	3	13	4	13	4
Asset sale - lease back	13	3	11	3	13	4
Equity infusion	9	1	10	2	7	1
Original plan	20	5	21	6	22	6

Original Plan - Pessimistic Economic Scenario

Pessimistic economic assumptions include a reduction of the maximum government commodity program payment limit to $30,000 instead of $50,000 in each year of the five years of analysis and a 2 percent annual reduction in land value starting in the second year of the planning horizon. The reduction in government program payment is implemented to reflect the government commodity program policy trend of shifting the risk responsibility from the public sector to the private sector in farming. As before, the Southwest Oklahoma farm is assumed to receive $10,000 in non-farm income over the five-year period.

Tables XXIII and XXIV depict the performance measures for all farm situations under the pessimistic assumptions. Under pessimistic economic assumptions, the financial condition of the original plan deteriorates substantially for all beginning debt/asset ratio situations, particularly the 70 percent debt/asset ratio. The coefficient of variation decreases as the beginning debt/asset ratio decreases for all performance measures across all D/A ratio situations. With a beginning debt to asset of 70 percent, the original plan has zero probability of financial survival and the equity ratio declines to 5 percent at the end of the five-year period. Average net farm income is –$48,000 and present value of ending net worth is only $28,000 (Table XXIII). Table XXIV shows that the financial condition of the 70 percent debt/asset ratio situation is deteriorating dramatically over the planning horizon. The probability of financial survival decreases from 100 percent in year 1 to 96 percent in year 2, 38 percent in year 3, 8 percent in year 4 and zero percent in year 5 of the planning horizon. Debt to asset ratio increases from 68 percent in year 1 to 99 percent in year 4, indicating that the farm was declared technically

TABLE XXIII

MEAN AND COEFFICIENT OF VARIATION FOR SELECTED FINANCIAL MEASURES, DIFFERENT POLICY OPTIONS, AND DIFFERENT BEGINNING D/A, STOCHASTIC RUN, PESSIMISTIC ECONOMIC SCENARIO

Beginning Financial Situation	Policy Option	Present Value of Ending Net Worth		Equity to Asset Ratio at End of Last Solvent Year, All Iterations		Average Annual Net Farm Income for Years Simulated		Probability of Financial Survival[1]
		Mean	CV	Mean	CV	Mean	CV	
70% D/A	Original plan	28,388	80.40	.052[2]	80.10	-47,574	-15.23	0
	Debt reduction	150,054	41.78	.254	40.80	-1413	-575.57	84
	Interest reduction	146,062	40.03	.249	38.81	-18,425	-44.03	80
	Debt deferral	87,850	89.27	.144[3]	88.59	-23,030	-33.08	50
	Asset sale - no lease	123,283	37.39	.294	38.08	-16,130	-44.04	92
	Asset sale - lease	141,366	34.68	.330	35.34	-21,109	-36.28	94
	Equity infusion	287,974	11.83	.487	11.62	-22,682	-37.10	100
40% D/A	Original plan	305,729	9.29	.517	9.11	-20,724	-38.20	100
	Debt reduction	352,149	5.77	.600	5.73	6708	112.14	100
	Interest reduction	352,784	4.68	.599	4.61	631	1174.62	100
	Debt deferral	344,863	7.47	.559	7.03	-5148	-140.21	100
	Asset sale - no lease	343,840	4.69	.752	4.49	5141	117.07	100
	Asset sale - lease	347,393	5.35	.750	4.55	-916	-739.91	100
	Equity infusion	432,920	5.56	.733	5.39	-3231	-240.02	100
20% D/A	Original plan	447,760	3.97	.758	3.78	-1147	-638.79	100
	Debt reduction	469,284	2.83	.797	3.10	12,805	55.63	100
	Interest reduction	470,800	3.41	.792	3.03	12,920	55.52	100
	Debt deferral	468,700	3.82	.766	3.53	6146	115.40	100
	Asset sale - no lease	450,545	3.03	.928	.61	14,779	40.06	100
	Asset sale - lease	445,563	3.06	.930	.60	8763	74.58	100
	Equity infusion	508,733	3.67	.860	3.33	8012	90.32	100

[1]The probability of financial survival is the probability of farm's intermediate and/or long-term equity will remain equal or above 20 percent. It is computed as the number of technically solvent iterations divided by the total number of iterations, 50.

[2]The original farm was declared technically insolvent in 1989.

[3]The farm was declared technically insolvent in 1990.

TABLE XXIV

SELECTED FINANCIAL MEASURES FOR 70 PERCENT DEBT/ASSET FOR DIFFERENT POLICY OPTIONS OVER YEARS OF PLANNING HORIZON, DETERMINISTIC RUN, PESSIMISTIC ECONOMIC SCENARIO

Policy Option	Net Worth Adjusted for Unrealized Capital Gains, Depreciation and Contingent Liability					Percentage Change in Adjusted Net Worth (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
Original plan	244,156	212,927	173,772	6897	NA	8.44	-12.79	-18.34	-96.03	NA
Debt reduction	375,756	335,308	304,907	273,007	232,720	66.90	-10.76	-9.07	-10.46	-14.76
Interest reduction	246,293	245,037	237,031	230,133	215,402	9.39	-.51	-3.27	-2.91	-6.40
Debt deferral	290,144	308,877	280,895	244,527	63,875	28.87	6.46	-9.06	-12.95	-73.88
Asset sale - no lease	247,091	240,299	223,531	206,457	183,894	76.68	-2.75	-6.98	-7.64	-10.93
Asset sale - lease	246,096	243,603	233,721	224,368	207,169	75.96	-1.01	-4.06	-4.00	-7.67
Equity infusion	453,447	446,583	436,160	426,970	406,626	11.71	-1.51	-2.33	-2.11	-4.77

Policy Option	Debt to Asset Ratio					Probability of Financial Survival (%)				
	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990	1st Year 1986	2nd Year 1987	3rd Year 1988	4th Year 1989	5th Year 1990
Original plan	.683	.718	.766	.990	NA	100	96	38	8	0
Debt reduction	.576	.584	.616	.652	.714	100	100	100	100	84
Interest reduction	.668	.675	.681	.708	.735	100	100	100	100	80
Debt deferral	.623	.604	.651	.701	.915[1]	100	100	100	100	50
Asset sale - no lease	.538	.571	.596	.622	.680	100	100	100	100	92
Asset sale - lease	.539	.554	.567	.598	.647	100	100	100	100	94
Equity infusion	.411	.408	.413	.458	.499	100	100	100	100	100

NA = Figure is not available because the farm was declared technically insolvent in year 1989. The farm is declared technically insolvent when intermediate and/or long-term equity ratio is less than 20 percent.

[1]The farm was declared technically insolvent in year 1990 since D/A is greater than 80 percent.

insolvent in year 4 (1989). Net worth declines from $244,000 in year 1 to only $7000 in year 4 of the planning horizon.

Farms with beginning debt to asset ratios of 40 and 20 percent under the pessimistic economic scenario do have 100 percent probability of financial survival, however, the financial condition deteriorates over the five-year period compared with the original plan under the base economic scenario. When the beginning debt/asset ratio is 40 percent, the original plan results in average net farm income of -$21,000, equity ratio of 52 percent, and present value of ending net worth about $306,000. With the 20 percent debt/asset ratio, the original plan has an equity ratio of 76 percent, present value of ending net worth of nearly $448,000, and average net farm income of -$1100. The coefficients of variation associated with solvency as measured by both the equity ratio and present value of ending net worth are much higher under the pessimistic economic scenario than the corresponding coefficients of variation under the base economic scenario. However the coefficients of variation associated with average net farm income are much lower under the pessimistic economic scenario than under the base economic scenario for the 70 and 40 percent debt to asset ratio situations.

Impact of Financial Policy Options

For all beginning debt to asset ratio situations, the six financial policy options generally result in improvement in all financial measures when compared to the original plan across all beginning debt to asset ratio situations. However, there is still apparent problem in profitability, particularly for the 70 percent debt/asset ratio situation. Average net farm income associated with all policy options is always negative for the 70 percent D/A ratio situation, negative or very low for the 40 percent D/A situation, and low for

the 20 percent D/A ratio situation. While the probability of financial survival is 100 percent for the 40 and 20 percent debt/asset ratio situation with all policy options, it ranges from 50 percent with debt deferral option to 100 percent with equity infusion option for the 70 percent D/A ratio situation (Table XXIII). Also, the financial condition for the farm situations, while improved compared to the original plan, is deteriorating over the years of the planning horizon with all six policy options. For the 70 percent D/A ratio situation, adjusted net worth under debt deferral option, for example, decreases from $296,000 in year 1 to about $64,000 in year 5 (Table XXIV). For all policy options, the coefficients of variation associated with risk and solvency measures decrease as the beginning debt to asset ratio decreases. Also, the coefficient of variation associated with solvency and risk measures for all policy options, in general, is always lower than the CVs of the original farm plan across all D/A ratio situations.

As with the base and optimistic scenarios, the six policy options have differential impacts on the financial performance measures. For the 40 percent D/A ratio situation, for example, the average net farm income is about $7000 with debt reduction option and -$5000 with debt deferral option (Table XXIII). The impact of these policy options, however, is fairly consistent across all debt to asset ratio situations. The equity infusion results in the highest present value of ending net worth, relatively high equity ratio, and relatively very low average net farm income across all debt to asset ratio situations. This option results in negative average net farm income for both 70 and 40 percent D/A ratio situations. The present value of ending net worth is about $288,000, $433,000, and $509,000 for the 70, 40, and 20 percent D/A ratio situations, respectively. Equity infusion is the only option that results in a 100 percent probability of financial survival for the 70 percent debt/asset ratio situation.

The coefficients of variation associated with this option are relatively low for the 70 percent D/A ratio situation and relatively very high for the 40 and 20 percent D/A ratio situations.

Debt reduction and interest rate reduction are very comparable using the present value of ending net worth and equity ratio across all debt/asset ratio situations. They consistently result in relatively high present value of ending net worth and equity ratio. These two options result in equity ratio, for example, of about 25 percent for the 70 percent D/A ratio situation, 60 percent for the 40 percent D/A ratio, and about 80 percent for the 20 percent D/A ratio situation. Debt reduction results in the highest average net farm income for the 70 and 40 percent D/A ratio situation and relatively high for the 20 percent D/A ratio situation while interest rate reduction results in relatively high average net farm income across all debt to asset ratio situations. For the 70 percent debt/asset ratio situation, the financial condition is deteriorating over years of planning horizon using both options. While the probability of financial survival for the 70 percent D/A situation remains 100 percent up to the fourth year of planning horizon for both policy options, it drops to 84 percent for debt reduction and to 80 percent for the interest reduction in the fifth year of planning horizon. Also, adjusted net worth decreases from about $376,000 in year 1 to $233,000 in year 5 for the debt reduction option and from $246,000 in year 1 to $215,000 in year 5 for the interest rate reduction option (Table XXIV).

Asset sale with and without lease back options are comparable and attractive options particularly for the 70 percent D/A ratio situations. Both options rank relatively very high in the probability of financial survival and equity ratio, and relatively low in present value of ending net worth. The equity ratio associated with these two options is about 93 percent for the 20 percent D/A ratio situation, 75 percent for the 40 percent D/A ratio situation, and from

30 to 33 percent for the 70 percent D/A ratio situation. The probability of financial survival for the 70 percent D/A ratio situation is 92 percent with asset sale - no lease back option and 94 percent with asset sale - lease back option. Asset sale - no lease back option, however, results in more favorable average net farm income than the asset sale - lease back option across all debt/asset ratio situations. The coefficients of variation associated with the solvency and risk as measured by present value of ending net worth and equity ratio are relatively low for both options compared to the other policy options and original plan across all debt/asset ratio situations.

Debt deferral option, as with the base economic scenario, appears to be unattractive option across all beginning debt/asset ratio situations. This option always results in the lowest equity ratio and average net farm income compared to the other policy options. For the 70 percent D/A ratio situation, the farm was declared technically insolvent in year 5 (1990) with only 50 percent chance of financial survival at the end of the five-year period. The probability of financial survival for both the 40 and 20 percent D/A ratio situation, however, remains 100 percent at the end of the five-year period. The financial condition for the 70 percent D/A ratio situation deteriorates faster over the years of the planning horizon with this policy option than with any other policy options. For example, the percentage change in adjusted net worth is 63, 6, –9, -13, and -74 in years 1, 2, 3, 4, and 5 of the planning horizon (Table XXIV).

All six policy options with the original plan under the pessimistic economic scenario are ranked for each of the four financial measures and the unweighted ranks are summed for each option. The results are compared among the beginning debt to asset ratio situations as a rough indicator of the overall attractiveness of these options and presented in Table XXV. For the 20

TABLE XXV

RANK OF POLICY OPTIONS BY DEBT/ASSET SITUATIONS
FOR THE PESSIMISTIC ECONOMIC SCENARIO

Policy Options	Beginning Debt to Asset Ratio Situation					
	20 Percent		40 Percent		70 Percent	
	Sum of Ranks	Overall Rank	Sum of Ranks	Overall Rank	Sum of Ranks	Overall Rank
Debt reduction	11	3	9	1	11	2
Interest reduction	10	2	11	3	16	5
Debt deferral	17	5	18	4	24	6
Asset sale - no lease back	9	1	10	2	13	4
Asset sale - lease back	13	4	11	3	12	3
Equity infusion	10	2	10	2	8	1
Original plan	21	6	22	5	28	7

percent D/A ratio situation, asset sale - no lease back option ranks first and both interest rate reduction and equity infusion options rank second. When beginning debt/asset is 40, debt reduction ranks first and both asset sale - no lease back and equity infusion options rank second. For the 70 percent D/A ratio situation, equity infusion ranks first and debt reduction ranks second. As with base and optimistic economic scenarios, debt deferral option ranks last compared to the other policy options while the original plan ranks last compared to all policy options across all debt/asset ratio situations.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Financial stress in the U.S. farm sector is widely recognized and well documented. The incidence of insufficient cash flows, credit problems, loan delinquencies, foreclosures, and bankruptcies in agriculture have reached significant levels. Moreover, a rippling effect has occurred to significantly affect the well-being of many farm lenders, agribusinesses, and rural communities whose financial performance is strongly influenced by economic conditions in agriculture. Highly leveraged farms are affected most by this financial stress.

Farmers respond to risk by adopting risk reducing, risk shifting, and risk bearing strategies. Financial strategies are distinguished from other risk management strategies by their emphasis on increasing the farm's risk bearing capacity. Several financial management strategies including debt restructuring and asset restructuring have been suggested by government and non-government institutions as a possible means to alleviate farm financial problems. Also, government program payments have contributed to improve farm cash flows, making it possible for farmers to make scheduled debt payments. Reduced commodity program payment to individual farmers would have important impacts on the financial viability of farm operations. Little is known about the sensitivity of farm financial performance to the level of government payments, however.

The main objective of the overall study is to evaluate the impacts of various financial policy options as well as the impact of the government commodity program payments on the financial performance and long-run probability of financial survival of farms under different assumptions of beginning leverage positions and economic outlooks. To accomplish the objective, three different farm situations representing a 20, 40, and 70 percent beginning debt to asset ratio situations were specified and simulated over a five-year period starting in 1986. The original farm situations were evaluated under six financial policy options and six levels of government commodity payment. The financial policy options include 35 percent debt reduction, 35 percent interest rate reduction, two-year debt deferral, 35 percent asset sale with and without lease back and 35 percent equity infusion. The government program payment levels include $50,000 (original plan), $40,000, $30,000, $20,000, $10,000, and $0.0 (no government payment). Each farm situation with all six policy options were evaluated under three economic scenarios, including a basic or the most likely scenario, an optimistic economic scenario, and a pessimistic economic scenario.

A whole farm simulation model (FLIPSIM V) was used to simulate all these policy options and strategies over the 1986-90 period under deterministic and stochastic environments of crop yields and prices. The model recursively simulates a farm firm by using the ending financial position for one year as a beginning position for the second year, and so on. Independent empirical probability distributions were used to generate random yields and prices for the stochastic run using a ten-year series of trend-adjusted yields and real (1985) Oklahoma seasonal prices. The five-year planning horizon was replicated 50 times, generating a different set of random

prices and yields each year. The same sets of random yields and prices were used for each farm situation and policy option analyzed.

During the simulation period, the farm situations were not allowed to grow through purchasing or leasing additional farmland, and the cash flow surplus was used for early repayment of intermediate- and/or long-term liability. Furthermore, farms were not allowed to sell crop land to remain technically solvent. Cash flow deficits were covered by obtaining loans secured by crops in storage, intermediate asset or farmland. Once the debt of intermediate- and/or long-term assets rises above 80 percent, the farm was declared technically insolvent.

The results of the financial policy options and strategies were compared to the original plan and evaluated in terms of their impacts on farm profitability, risk, and solvency at the end of the five-year period. Four financial performance measures were used including: 1) probability of farm financial survival, measured as the probability that farm remains solvent at the end of the simulation period (1990); 2) present value of ending net worth, measured as the discount (6.58 percent discount rate) net worth of the farm in last year of solvency or at the end of the five-year period; 3) average annual net farm income; and 4) equity ratio at the last solvent year. The variability associated with each measure, expressed by the coefficient of variation, is also examined and compared among the policy options and strategies.

The farm situations selected are typical for Jackson County of Southwest Oklahoma and represent a full time family farm operation with the farm operator being both manager and laborer. The base farm situation is a 1260 acre farm unit, 960 of which are owned and 300 of which are rented on a one-third/two-thirds crop share lease arrangement. The production organization for each farm situation includes 480 owned acres of dryland wheat, 300 rented

acres of dryland wheat, 100 owned acres of irrigated grain sorghum, and 380 owned acres of irrigated cotton. In addition, wheat pasture supports an average of 250 stocker steer annually. Overall, the beginning net worth is $688,000, $521,000, and $261,500 for the 20, 40, and 70 percent beginning debt to asset ratio situations, respectively.

The farm operator participates in government commodity programs for wheat, grain sorghum and cotton. Participation in commodity programs for all three crops would result in deficiency payments in excess of the $50,000 maximum government payment limit. Thus, the government payment income was restricted to $50,000 per year for the five-year planning horizon. The deficiency payment is the product of the crop's payment rate (lesser of target price minus average price or target price minus loan rate), national allocation factor, farm program yield, and harvested acreage. Farm operator is also assumed to earn a $10,000 annual off-farm income.

Production operating costs, yields, and prices for the crop and livestock enterprises were based on the Oklahoma State University Crop and Livestock Enterprise Budgets for Southwest Oklahoma for 1986. Input prices, crop and livestock prices, and annual percentage changes for other economic variables were adjusted during the planning horizon using the macroeconomic projections of Wharton Economic Associates and the 1985 House Farm Bill.

Base Economic Scenario Results

The input data described earlier for the three farm situations is consistent with the base economic scenario. Farmland value was assumed constant over the five-year period for the base economic scenario.

Original Farm Plans

The results of the original farm plan under the base economic scenario clearly support the observed financially stressed farm condition for the highly leveraged farm situation (70 percent D/A). Given the base economic assumptions, it is not too surprising to find that the financial condition for the 70 percent D/A ratio situation is deteriorating over the five years even though the farm survives at the end of the five-year planning horizon. The coefficients of variation associated with the performance measures increase as the beginning D/A ratio increases. This suggests, as expected, that high risk and instability are associated with farm financial survival and viability for the highly leveraged farm situation. For the 70 percent D/A ratio situation, the probability of financial survival is 82 percent, the present value of ending net worth is $157,000, the equity ratio is 25 percent and the average annual net farm income is -$15,000. Both 40 and 20 percent debt to asset ratio situations end the five-year period with 100 percent chance of survival and slightly improved financial performance. The equity ratio is 61.8 percent for 40 percent D/A ratio situation and 80.1 percent for 20 percent D/A ratio situation. Both 40 and 20 percent D/A ratio situations have positive average annual net farm income.

Government Commodity Program Payments

The government commodity program income has substantial impact in maintaining the survivability and economic viability especially for the highly leveraged farm situation (70 percent D/A). As government program payment decreases, the financial performance for the 70 percent D/A ratio situation dramatically deteriorates and the coefficient of variation associated with the risk and solvency measures increase. When government program payments

are reduced to $30,000, the 70 percent D/A ratio situation has almost no chance of financial survival. With no government program payments, the 70 percent D/A ratio situation results in sharply reduced present value of ending net worth and ending equity ratio, and large negative average net farm income.

For the 40 and 20 percent debt to asset ratio situations, reductions in government commodity payments reduce the financial well-being of the farm in terms of present value of ending net worth, equity ratio and average net farm income, and increase the relative variability of these performance measures. The probability of financial survival, however, remains 100 percent at the end of the five-year period for both 40 and 20 percent D/A ratio situations. At $30,000 government program payment (level 3), the average net farm income becomes negative even for the 20 percent D/A ratio situation. With no government program payments, there is apparent problem with profitability as measured by a big negative average net farm income for both 40 and 20 percent debt to asset ratio situations.

The original plan for the 70 percent D/A ratio situation under the six government program payment levels were ordered using first-, second-degree stochastic dominance and stochastic dominance with respect to function (SDWRF) criteria. Using all these criteria, the original plan with $50,000 government payment (level 5) dominates the original plan with all other government program payment levels using both present value of ending net worth and average net farm income. The original plan with no government program payment was dominated by all other farm plans.

Financial Policy Options

The original farm situations were also evaluated under six financial policy options including 35 percent debt reduction, 35 percent interest rate reduction, two-year debt deferral, 35 percent asset sale with and without lease back, and 35 percent equity infusion. All these policy options substantially improved the financial performance for all farm situations over the five-year period and reduced the relative variability for the performance measures as measured by the coefficients of variation compared to the original farm plans. For the 70 percent D/A ratio, all six policy options result in 100 percent probability of financial survival at the end of the five-year period and improved performance measures compared to the original plan. However, the financial performance under some policy options including debt deferral and debt reduction is deteriorating over years of planning horizon. Average net farm income is still negative with debt deferral option for the 70 percent D/A ratio situation. For the 40 and 20 percent D/A ratio situations, the debt deferral option results in the lowest average net farm income.

The six policy options have differential impacts on profitability, risk and solvency. The impact, however, is fairly consistent among the beginning debt to asset ratio situations. Equity infusion consistently results in relatively low average net farm income and relatively high equity ratio and present value of ending net worth. Asset sale with and without lease back are very attractive and comparable options. These two options consistently result in relatively high average net farm income and equity ratio, and relatively low present value of ending net worth which is expected since these two options were implemented by selling 35 percent of the total assets. Debt reduction results in the highest average net farm income and large increases in present value of

ending net worth across all debt to asset ratio situations. Interest reduction option consistently results in relatively high present value of ending net worth and average net farm income across all beginning debt to asset ratio situations. Debt deferral option always ranks the lowest in average net farm income and relatively low in present value of ending net worth and equity ratio.

Rankings of a particular policy option varies among individual managers depending on their relative emphasis on profitability, liquidity, risk, and solvency. However, as a rough indicator of the overall attractiveness of the options, all six policy options with the original plan were ranked for each measure and unweighted ranks were summed for each policy option. Using this indicator shows that equity infusion and asset sale - no lease back options rank first for the 20 percent D/A ratio, debt reduction and asset sale - no lease back rank first for the 40 percent D/A ratio situation, and equity infusion option ranks first for the 70 percent D/A ratio situation. Debt deferral ranks the lowest among all beginning debt to asset ratio situations.

First-, second-degree stochastic dominance and the SDWRF criteria were used to rank the six policy options as well as the original farm plan for the 70 percent D/A ratio situation using both present value of ending net worth (PVNW) and average net farm income (ANFI). Using these three criteria, equity infusion is the only option that dominates all other options in PVNW while the debt reduction is the only option that dominates all other policy options in ANFI. Again, debt deferral option was dominated by all other policy options while the original plan was dominated by all options in both PVNW and ANFI.

Optimistic Economic Scenario Results

Optimistic economic scenario reflects a five percent improvement in farm gross return in each year of the planning horizon and a 2 percent annual growth in land value over years of planning horizon starting in the second year.

Original Farm Plans

As expected, the optimistic economic scenario resulted in considerably more favorable financial performance than the base economic scenario for all beginning debt to asset ratio situations. The coefficients of variation associated with risk and solvency measures are much lower compared to the corresponding ones under the base economic scenario across all debt to asset ratio situations. Under the optimistic economic scenario, even the farm situation with 70 percent D/A ratio ends up in better financial condition with 100 percent chance of financial survival at the end of the five-year period and $242,000 present value of ending net worth. Moreover, the financial condition for the 70 percent D/A ratio situation is improving over the years of the planning horizon. However, there is still problem in terms of profitability as reflected by negative average net farm income of $15,000 for this farm situation.

Similarly, farm situations with 40 and 20 percent D/A ratios end up in improved financial condition over the five-year period with 100 percent probability of financial survival. The present value of ending net worth is $440,300 and $572,000 for the 40 and 20 percent D/A ratio situations, respectively. As with the base economic scenario, the relative variability associated with performance measures increases as the beginning debt to

asset ratio increases and is much lower than the corresponding ones under the base economic scenario.

Financial Policy Options

The impacts of the six financial policy options evaluated under the optimistic economic assumptions are about as they were under the basic economic assumptions. All policy options result in 100 percent probability of financial survival and substantially improved financial condition for all beginning debt to asset ratio situations compared to the original plan under the base economic scenario. For the 70 percent D/A ratio situation, all six policy options result in positive average net farm income and improved financial condition over the years of planning horizon. Relative variability under the optimistic economic assumption is less than the corresponding one under the base economic assumption for all policy options.

As with the base economic scenario, the six policy options have differential impacts on the performance measures. Equity infusion option results in highest increases in present value of ending net worth, very high equity ratio, and relatively low average net farm income. Debt deferral and interest reduction options are very comparable options using present value of ending net worth and equity ratio among all debt to asset ratio situations. Interest reduction, however, results in more favorable average net farm income than with debt deferral. Debt deferral, unlike the case with the base economic scenario, results in relatively high present value of ending net worth. Debt reduction is very attractive option across all debt to asset ratio situations. This option always results in relatively very high average net farm income and present value of ending net worth and relatively high equity ratio across all debt to asset ratio situations. Asset sale with and without lease back are very

comparable options and consistently result in high equity ratio and average net farm income.

As a rough measure of the overall attractiveness of the options, all six policy options with the original plan were ranked for each performance measure and the unweighted ranks were summed and compared for each policy option. Using this indicator, both equity infusion and debt reduction options rank first for the 20 percent D/A ratio situation, debt reduction ranks first for the 40 percent D/A ratio situation, and equity infusion option ranks first for the 70 percent D/A ratio situation. Asset sale with and without lease back options rank very comparable among all debt to asset ratio situations, unlike the case with basic economic assumptions. As with the base economic scenario, debt deferral option ranks last among all options across all debt to asset ratio situations.

Pessimistic Economic Scenario Results

Pessimistic economic scenario includes a reduction of the maximum government program payment limit to $30,000 in each year of the five-year period and a 2 percent annual reduction in land value starting the second year.

Original Farm Plans

Under the pessimistic economic scenario, the financial condition of the original farm plan deteriorates substantially at the end of the five-year period for all beginning debt to asset ratio situations, particularly for the 70 percent D/A ratio situation. The relative variability associated with the solvency and risk measures for all farm situations are much higher than the corresponding ones under both optimistic and base economic scenarios. At the end of the

five-year period, the original plan for the 70 percent D/A ratio situation has zero probability of financial survival and only 5 percent equity ratio. The farm was declared technically insolvent in the fourth year (1989) with only $7000 net worth.

While farm situation with debt to asset ratio of 40 and 20 percent ends the five-year period with 100 percent, their financial conditions deteriorate over the period compared with the original plans under the base economic scenario. Both farm situations have negative average annual net farm income. The present value of ending net worth is $306,000 for the 40 percent D/A ratio situation and $448,000 for the 20 percent D/A ratio situation. As with both optimistic and base economic scenarios, the relative variability associated with present value of ending net worth and equity ratio decreases as the beginning debt to asset ratio decreases.

Financial Policy Options

As with the basic and optimistic economic scenarios, all six financial options improved the financial condition compared to the original plan for all beginning debt to asset ratio situations. However, there is apparent problem with the profitability for both 70 and 40 percent D/A ratio situations. The average net farm income associated with all policy options is always negative for the 70 percent D/A ratio situation, negative or very low for the 40 percent D/A ratio situation, and low for the 20 percent D/A ratio situation.

For the 70 percent D/A ratio situation, the probability of financial survival ranges from 50 percent with debt deferral option to 100 percent with equity infusion option. The 70 percent D/A ratio situation was declared technically insolvent in the fifth year (1990) of the planning horizon under the debt deferral option. For the 40 and 20 percent debt to asset ratio situations, while the

financial condition deteriorates over the five-year period, the probability of financial survival remains 100 percent with all policy options.

Again, the impacts of the six policy options on profitability, risk, and solvency are differential and are about the same as with basic and optimistic economic scenarios. When the policy options are compared using the sum of unweighted ranks, asset sale - no lease back option ranks first for the 20 percent D/A ratio, debt reduction ranks first for the 40 percent D/A ratio while equity infusion ranks first for the 70 percent D/A ratio situation. Debt deferral option ranks last compared to other policy options while the original plan ranks last compared to all policy options among all beginning debt to asset ratio situations.

Conclusions and Policy Implications

The results of this study clearly support the observed financial stress for the highly leveraged U.S. farms (70 percent D/A). The government commodity program payment is crucial for maintaining the farm survivability and economic viability for these farms. Reduction in government program payments has adverse impacts on all farms, but devastating only for the 70 percent D/A ratio situation. If the government commodity program direction is, as it has been, to shift the responsibility for managing risk in the farming sector from the public to private operators, then the $30,000 government payment level is the minimum tolerable for the Southwest Oklahoma farm situation depicted in this analysis. With this level of government program payment, the 70 percent D/A ratio situation has no chance to survive. Should the government program payment be eliminated, a serious long-run problem will be created even for the 20 percent D/A ratio situation. These farms cannot survive indefinitely unless substantial profitable adjustments in cropping and/or livestock activities are

made. Government programs targeted to assist these highly leveraged farms would be beneficial, while avoiding the high cost of untargeted government programs.

The six financial policy options analyzed offer promise in assisting farm's economic viability and long-run financial survival over the next five years for all beginning farm situations. These options also reduced the variability and instability associated with farm risk and solvency. The extent to which these options are helpful, however, varies with the economic assumptions and beginning debt to asset ratio situations. Under the basic and optimistic assumptions, all farm situations survive the next five years with deteriorating financial condition for the 70 percent D/A ratio situation with several policy options under the basic economic assumptions. Under the pessimistic economic assumption, only equity infusion option results in 100 percent chance of survival for the 70 percent D/A ratio situation. Furthermore, the financial condition is deteriorating over the years of the planning horizon with all the financial policy options. Without improvement in farmland values and crop and livestock prices, these highly leveraged farms have low chance of financial survival over the next five years even with these policy options. This indicates that the survivability of these farms will be very critical for another five-year period starting 1991.

The financial policy options have differential impacts on the farm profitability, risk, and solvency. The impacts, however, are fairly consistent among the beginning debt to asset ratio situations. The equity infusion option appears very attractive for the 70 percent D/A ratio situation since it results in the highest increase in net worth and equity ratio - the key measures of farm financial survival and solvency. While the asset sale options are attractive for all D/A ratio situations, they appear to be more favorable to the 70 percent D/A

ratio situation since they rank relatively high in equity ratio - the key measure of solvency. Debt reduction and interest rate reduction options appear reasonable for all beginning D/A ratio situations. The debt deferral option appears unattractive across all D/A ratio situations.

Because of the similarity between the study area and other areas of the country in terms of financial problems and macroeconomic aspects, it would be appropriate to generalize the implication and the results of this study to other farm situations similar to the original farms analyzed.

Limitation and Need for Future Research

As with all simulation models, numerous assumptions and projections must be made on the economic variables which are random by nature. Different projections for the economic variables, such as inflation and interest rates, growth in input costs, crop and livestock prices, and farmland values, would affect the financial performance and probability of financial survival of all farms at the end of the five-year period. Using linear programming or quadratic programming to determine the cropping patterns (production organization) instead of fixed cropping mixture over years of planning horizon, or using different marketing strategies, may provide a completely unique set of results. Assuming fixed cropping and livestock patterns, however, makes it possible to clearly trace out the impacts of the different policy options and strategies analyzed.

The farm was not allowed to sell farmland to remain solvent. However, allowing farm to sell farmland to remain solvent over years of planning horizon would substantially affect the probability of financial survival and ending net worth for the 70 percent D/A ratio situation. Also, in this analysis, a 20 percent minimum equity ratio was specified for the farm to remain technically solvent.

This level of equity ratio (credit policy) is considered very liberal by all farm lenders under the current financially stressed farm sector. Applying tighter credit policy by increasing the minimum equity required to obtain loans would affect the results across all farm situations, particularly the 70 percent D/A ratio situation.

Finally, the six financial policy options analyzed are treated as if they are feasible and readily available even under the conditions of severe financial stress. This may or may not be the case. Clearly, some forbearance and patience by lenders and/or government institutions would be necessary for adopting or taking advantage of these financial policy options analyzed.

Further simulation research should focus on using linear programming and/or quadratic programming techniques in determining the most appropriate cropping and livestock enterprise mixture over the years of planning horizon instead of using fixed mixture of crop and livestock enterprises. The feasibility of converting farming to the livestock activities (ranching) instead of cropping activities needs to be considered. Other considerations in this research are allowing the farm operator to sell farmland to remain solvent and using tighter credit policy reflected by using different higher minimum equity ratio required for solvency.

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VITA

Sa'ad A. Najim Al-Abdali

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE IMPACT OF FINANCIAL POLICY OPTIONS AND GOVERNMENT COMMODITY PROGRAM PAYMENTS ON FARM FINANCIAL SURVIVAL AND PERFORMANCE

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Missan, The Republic of Iraq, July 1, 1953, son of Mr. and Mrs. Abed Najim Al-Abdali.

Education: Graduated from Al-Sharkia High School, Baghdad, Iraq, in June 1971; received Bachelor of Science Degree in Agriculture with a major in Agricultural Economics from Baghdad University, Baghdad, in June 1975; received Master of Science Degree in Agricultural Economics from Ain-Shams University, Cairo, Egypt, in March 1980. Completed requirements for the Doctor of Philosophy degree at Oklahoma State University in May 1987.

Professional Experience: Associate Lecturer, Institute of Agricultural Technology, Baghdad, November 1975 to October 1977; Lecturer and Department Head of Agricultural Economics, Institute of Agricultural Technology, Babylon, Iraq, August 1980 to August 1982.

Professional Organizations: American Agricultural Economics Association, Western Agricultural Economics Association, and Oklahoma Agricultural Economics Association