A RISK PROGRAMMING ANALYSIS OF ALTERNATIVE TILLAGE SYSTEMS FOR A REPRESENTATIVE WHEAT FARM UNDER THE PROVISIONS OF EXISTING GOVERNMENT PROGRAMS

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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
December, 1993

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ACKNOWLEDGMENT

I express my sincere appreciation and gratitude to my major advisor, Dr. Francis Epplin for his intellectual contribution, understanding, support, and a continuous encouragement for this study. Appreciation is also expressed for his patience and counseling throughout the course of my doctoral program. I greatly appreciate my committee members, Dr. Daniel J. Bernardo, Dr. Thomas F. Peeper, and Dr. R. Joe Schatzer for their assistance, encouragement and guidance in completing this study.

I would like to record my great indebtedness to the head and the faculty of the Department of Agricultural Economics at Oklahoma State University for given me the opportunity to do my graduate study at this well respectable department. I would also like to express my deep gratitude to all those who helped me complete this manuscript.

Mrs. Betty Harris typed the entire manuscript. Her work was exceptional for both its high quality and for the speed. I am very grateful to Betty.

Finally, I wish to express my deep appreciation to my wife Anisa, daughters Lamiss and Lamia, and son Mohamed for their understanding sacrifice and encouragement during this endeavor.

DEDICATION

To my parents, Mr. & Mrs. Ahmed Al-Sakkaf, I dedicate this dissertation.

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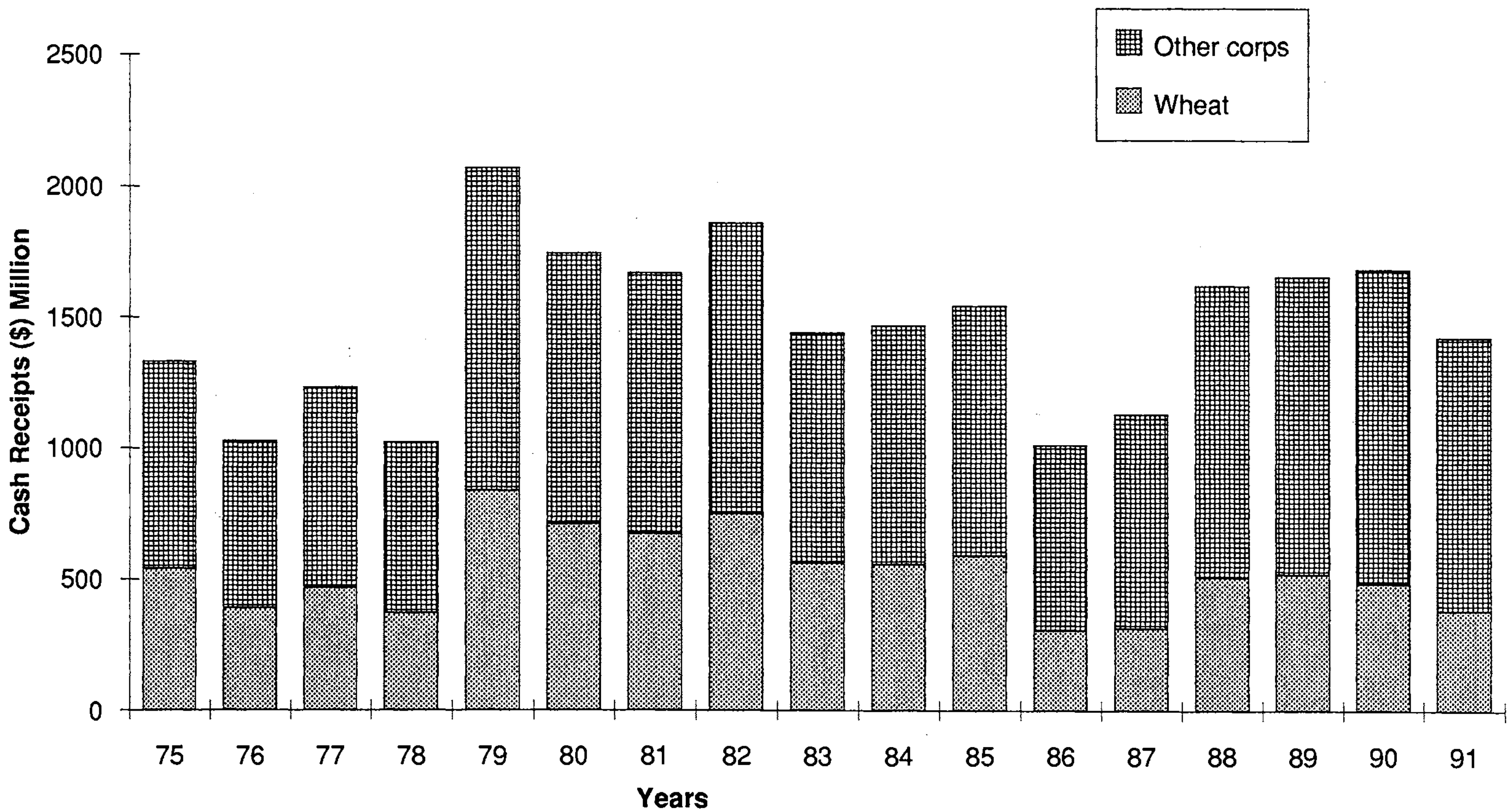
CHAPTER I

INTRODUCTION

Oklahoma is generally viewed as a rural state. Agriculture is an important sector of Oklahoma's economy. Oklahoma's gross state product (GSP) grew from $11.2 billion in 1970 to $59.2 billion in 1990. Cash receipts valued at the farm and ranch gates, almost doubled from about $1.5 billion in 1980 to $2.8 billion in 1990 after adjustments for inflation (Applegate). In addition, the associated industries of agriculture generated an output of approximately $5.5 billion in 1990. Therefore, a total of 15.4 percent of the GSP is generated from production agriculture and associated industries (Scifres and Osborn).

Winter wheat (*Triticum aestivum L.*) is the predominant field crop produced in Oklahoma. In 1990, 9.65 million crop acres were harvested in the state. Two-thirds of these harvested acres were in winter wheat. Moreover, Oklahoma ranked third among all states in wheat production and second in winter wheat production (Oklahoma Agricultural Statistics).

The production of hard red winter wheat for grain increased substantially during the period of 1970 to 1990, especially in the mid-1970's. Much of this increased production has been attributed to improvements in technology. Figure 1 shows the share of cash receipts excluding government payments attributable to wheat and other crops in Oklahoma, during the period from 1975 to 1990 (Oklahoma Agricultural Statistics).



Sources: Oklahoma Agricultural Statistics, Oklahoma Department of Agriculture

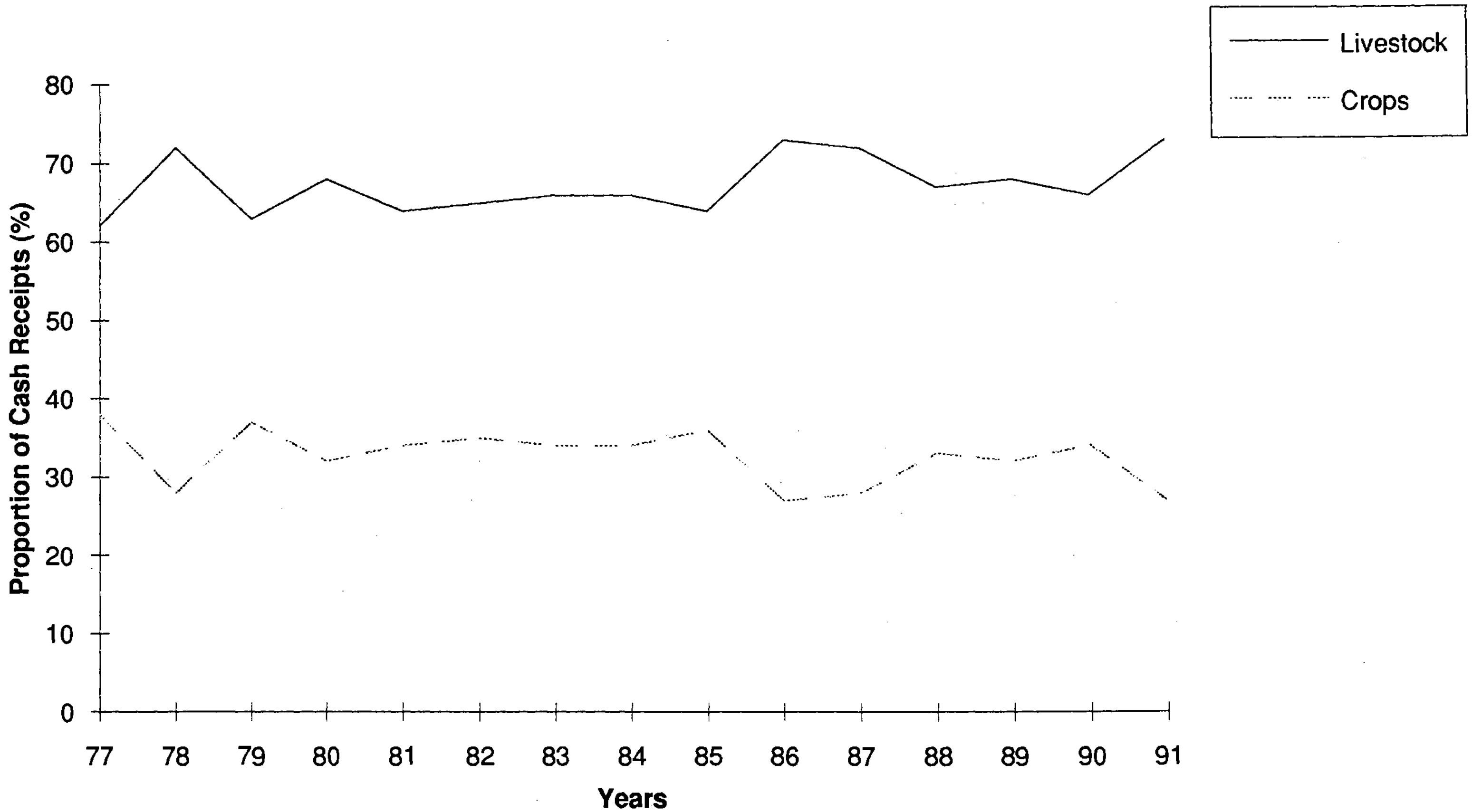
Figure 1. Cash Receipts Excluding Government Payments Attributable to Wheat and to all other Crops in Oklahoma, 1975-1991.

Livestock, especially beef production, is also a vitally important sector in Oklahoma (Scifres and Osborn). The importance of livestock in generating income increased gradually during the period from 1975 to 1990 (Figure 2). Continued growth in livestock production is dependent in part upon locally produced forages and feed grains.

As a result of the unique climate, soils, and growing season, livestock may be grazed on wheat forage in the state during the winter months, typically from late November to early March. If the livestock are removed from the wheat prior to the crop's jointing stage, the wheat will mature and produce a grain crop (Rodriguez et al.). The forage value of the 1991 wheat crop, a season during which an estimated 3.75 million of the state's 7.4 million acres of wheat were grazed, was estimated to be at least $135 million (Horn; Scifres and Osborn).

Government policies influence the economics of production and have widespread consequences for individual farmers as well as for the state. For example, in Oklahoma during the past 50 years direct government payments to farmers have varied significantly depending on prevailing policy and production levels of targeted commodities. Direct government payments declined from $25 million in 1940 to $6 million in 1955. They increased to $118 million in 1970 and decreased again to $19 million in 1975. Direct federal government subsidies increased to $319 million in 1990, when the payments accounted for about eight percent of the cash receipts generated by agriculture (Scifres and Osborn).

The state's wheat producers are confronted with many uncertainties. Wheat grain and forage yields vary with weather and market prices vary from season-to-season in



Sources: Oklahoma Agricultural Statistics, Oklahoma Department of Agriculture.

Figure 2. Proportion of Cash Receipts Attribute to Crops and Livestock, Excluding Government Payment 1977-1991.

response to changes in the international wheat market. In the major wheat producing region of the state, most of the crop acres are monocropped to continuous wheat. Because of the climate there are relatively few opportunities to diversify to summer crops. However, there are limited opportunities to mitigate production risk in a given season by altering planting dates, tillage systems, and varieties (Epplin et al.,1993). Supplementary winter grazing of the wheat forage is a major diversification practice. Participation in government programs is also an important risk management tool.

Society at large is increasingly concerned about externalities. Wheat production practices, especially tillage systems, influence external consequences such as soil erosion and water quality. In 1985, federal legislation was passed which initiated a process of internalizing the costs of soil erosion. Farmers who farm highly erodible lands will be required to implement soil conserving production practices to maintain eligibility for direct agricultural payments and other federal programs (Aw-Hassan and Stoecker).

The federal wheat commodity program which has provided subsidy payments to participating farmers in years of low market prices has played an important role in reducing the price risk of producing wheat in Oklahoma. However, by 1995, those who farm highly erodible land will be required to fully implement a conservation compliance plan to continue to qualify for federal commodity program deficiency payments.

In Oklahoma, over seven million acres exceed the USDA's highly erodible classification (Stiegler). Most of the affected acreage has historically been in continuous wheat production. In Oklahoma most conservation plans which have been prepared for implementation on highly erodible land include the use of a residue management program. Residue management typically refers to the use of a production system (tillage practices) which will result in retaining plant residue on the soil surface throughout the year. Farmers of highly erodible land, who continue to use conventional tillage practices and bury old crop residue to control weeds and prepare a seedbed for the next crop, will be out of compliance and jeopardize the loss of government payments. Studies have been conducted to evaluate the consequences of alternative tillage systems and government commodity programs on risk (Helms et al., Gillespie et al., Williams et al., and Olson and Eidman). However, little research has been conducted to estimate the impacts that conservation compliance requirements will have on farmers who historically have been continuous wheat producers in the Great Plains (Rowell et al., Aw-Hassan and Stoecker).

The purpose of the present study is to generate additional information which could be used by farmers confronted with the conservation compliance requirements. The study will use actual yields obtained from an experiment station study in which different tillage systems (residue management alternatives) were compared. It will also incorporate the consequences of noncompliance and nonparticipation as well as compliance and participation in federal commodity programs. In addition, the diversification strategy of grazing wheat forage during the winter months will be evaluated. Hence, the two major risk management tools available to continuous wheat producers in Oklahoma will be incorporated into the study. The design of the study is to determine risk efficient tillage and wheat-stocker strategies for a representative Oklahoma wheat-stocker farm given existing and proposed government policies.

Objectives

The overall objective of this research is to determine efficient production strategies for continuous wheat producers in Oklahoma. The specific objectives are to:

1) Determine risk efficient tillage strategies for a representative Oklahoma wheat farm given existing and proposed government policies.
2) Determine risk efficient tillage and wheat-stocker strategies for a representative Oklahoma wheat-stocker farm given existing and proposed government policies.
3) Determine the impact of proposed government policies on farm income.

Organization of the Study

The remainder of this dissertation is organized into five chapters. Chapter II includes a review of literature of studies of the economics of alternative tillage systems, government program impacts on the economics of production alternatives, methods used to determine risk efficient farm plans given the existence of government programs, and a synopsis of the federal wheat commodity program relevant to producers in Oklahoma. The focus of the material presented in Chapter III is on the conceptual framework and methods for selecting risk efficient farm plans.

The research model, including the objective function, activities, constraints, assumptions, and data sources used to conduct the study are presented in Chapter IV. The risk efficient strategies and other results are presented in Chapter V. A presentation of the findings and conclusions of the work are included in Chapter VI.

CHAPTER II

REVIEW OF LITERATURE

This chapter includes a review of selected literature pertinent to the economics of alternative tillage systems, the impact of government programs on the economics of production alternatives, and methods used to select risk efficient farm plans given variable yields and prices. The chapter also includes a brief description of the 1990 wheat commodity program as well as some proposed government policies which if implemented would impact upon wheat and stocker producers in Oklahoma.

Outcomes in terms of yields, prices, and net revenue from dryland wheat production in Oklahoma are not certain. Weather, pest populations, and disease incidence vary from year-to-year, and from farm-to-farm and field-to-field in a given year. Crop yields vary in response to the stochastic environment in which they are grown. In years of unfavorable weather or relatively high populations of pests, crop yields may be reduced such that production costs can not be covered. In years of better than average weather and few pests, yields may be substantially higher than expected.

Crop and livestock prices are also stochastic. Season average wheat prices vary from year-to-year depending upon global production and use of wheat as well as prices for competing food grains.

Those who produce wheat and stocker cattle in Oklahoma are engaged in a risky business. There is some chance that in a given year returns from their efforts will be less than necessary to cover the variable production costs or to meet debt obligations. While the potential for losses can not be eliminated, several tools for managing production and marketing risks are available to producers.

One risk management tool that may be used by wheat farmers is to participate in government commodity programs which effectively mitigate downside price risk. That is, on the average, farmers who elect to participate, generally by idling (or not harvesting for grain) a specified percent of their normal wheat acres, are guaranteed that the price will not fall below a federally mandated floor price (loan rate).

Government Commodity Programs

Government intervention in the marketplace began with depression era of 1930's. Since 1933, several production and marketing control programs has been used for many commodities including wheat. The original policies were designed primarily to increase and stabilize the market price of agricultural commodities by imposing a mandatory restriction of total production or amounts marketed (Ray).

The Agricultural Adjustment Act of 1933 and subsequent farm bills enacted during the 1930's set up nearly every farm program institution that exists in 1983 (Rasmussen). While parts of the initial 1933 bills were declared unconstitutional, the basic farm policy remained intact (Knutson et al.) including: the goal of parity price, the establishment of price support loans through the Commodity Credit Corporation (CCC), provisions for controlling production through diversion payments, provisions for commodity storage, and provisions for crop insurance.

The parity price is defined as that price which today gives a unit of the commodity the same purchasing power as it had in 1910-1914. Non-recourse loans were begun in 1934 and have continued through the years as a means for linking price supports with production and marketing controls. The Commodity Credit Corporation (CCC) offered these loans to eligible producers as credit usually for a marketing year. Stored grain is used as collateral for the loan. The farmer may forfeit the grain in lieu of repaying the loan. Forfeiture would be an appropriate strategy if the market price for the stored grain is less than the federally mandated loan rate. Hence, the loan rate is an effective floor price.

The conservation compliance provision of the Food Security Act (FSA) of 1985, as amended by the Food, Agriculture, Conservation, and Trade Act (FACTA) of 1990, applies to highly erodible fields in which annually tilled crops are planted. Its purpose is to discourage the production of crops on highly erodible cropland. Farmers must fully implement a conservation plan by December 31, 1994 to be eligible for certain USDA program benefits. The eligibility of programs that are subjected to compliance with the highly erodible land under the FSA are: price and income supports, crop insurance, Farmers Home Administration Loans, Commodity Credit Corporation storage payments, and CRP.

FACTA expanded the number of programs for which eligibility is subject to conservation compliance. Included in the group are: Agricultural Conservation Program, CRP cost-share payments, Disaster Assistance, including the emergency Conservation Program and Livestock Feed Program, PL-566-the small Watershed

Program (loans and cost share), Great Plains Conservation Program, and Water Quality Incentives Program. Selected government program terms are defined in Table 1.

Economics of Alternative Tillage Systems

Traditionally, conventional tillage has played an important role in controlling weeds. However, the area under reduced tillage is increasing and accounted for almost one-third of the area farmed in the United States in 1982 (Christensen and Magleby). In general, reduced tillage systems substitute the use of herbicides for tillage operations to accomplish weed control.

Tice et al. evaluated the economics of seven tillage systems for continuous wheat production. They concluded that as a result of the expensive herbicide program, no-tillage was the most costly alternative. However, yield differences were not considered.

Lockeretz reported that reduction in production costs per acre for several crops, including wheat, from conservation tillage was less than 10 percent and in some cases the cost of the additional herbicide offset the reduction in tillage costs.

Jolly et al. examined farm-level risks and returns for corn and soybeans grown in rotation for three conservation tillage systems and one conventional moldboard plow system. Experimental yield data obtained during the 1976 to 1980 growing seasons were used in the analysis. Returns over operating costs and returns to land and management were estimated. Standard deviations of returns were used as a measure of risk. They concluded that based upon short run economic criteria the conventional system was

Table 1. Definitions of Government Program Terms.

Terms	Definition
Acreage Reduction Program (ARP)	A voluntary land retirement program conducted by the Commodity Credit Corporation (CCC) in which participating farmers idle a prescribed portion of their crop acreage base of wheat, feed grains, cotton, or rice
Conservation Compliance Provision	Requires farmers with highly erodible cropland to implement an approved conservation plan. The plan must be completed by 1995 for the farm operation to remain eligible for specified federal program benefits
Conservation Plan	A combination of land uses and practices to improve and protect soil productivity and to prevent soil deterioration
Conservation Reserve Program (CRP)	A program designed to reduce erosion on 40-45 million acres of farmland. It was authorized by the Food Security Act of 1985. Producers who sign contracts agree to convert highly erodible cropland to approved conservation uses for 10 years. In exchange, producers receive an annual rental payment
Conservation Tillage	Any farming methods that maintain effective ground cover and disturb the soil as little as possible. In addition, it provides for weed control, seed germination, and plant growth
Crop Acreage Base	Base acreage determined by historical cropping practices. It is a farm's 5-year average acreage of wheat or feed grains and 3-year average of cotton or rice planted for harvest, plus land not planted because of acreage reduction or diversion programs
Deficiency Payment	A payment made by the Commodity Credit Corporation (CCC) to farmers participating in wheat, feed grain, rice, or cotton programs. It is based on the difference between the target price and either the higher of market price or price support (loan) rate
Direct Payments	Payment made directly to producers including deficiency payments, annual paid land diversion payments or conservation reserve payments

Table 1. (continued)

Loan Rate (price support rate)	The price per unit at which the Commodity Credit Corporation provides loans to farmers enabling them to hold their crops for later sale
Non-recourse Loans	Loans based upon the price support made by the Commodity Credit Corporation (CCC) to participating farmers. Stored commodity is used as collateral for the loan. The farmer either may forfeit the commodity in lieu of repaying the loan or repay the loan with interest
Normal Flex Acreage	This provision requires mandatory 15 percent reduction in payment acreage. However, producers are allowed to plant any crop on this acreage, except fruits and vegetables
Target Price	A price set by the USDA which is used to calculate the deficiency payments. The 1990 Farm Bill set the wheat target price at $4 for crop years 1990 through 1995
Triple Base	The planting flexibility concept used in the Food, Agriculture, Conservation, and Trade Act (FACTA) of 1990 which divides the crop acreage base into three categories: acreage removed from production under ARP; the permitted acreage on which program crop is planted and deficiency payments may be paid; and the nonpayment acreage on which producer may plant any Commodity Credit Corporation -- specified crop (except fruit and vegetable) but do not receive deficiency payments
0/92	A program provision that allows wheat and feed grain producers to devote all or portion of their permitted acreage to conserving uses and receive deficiency payments on that acreage. The program makes deficiency payments for a maximum of 92 percent of a farm's maximum payment acreage

Source: USDA. Provisions of the Food, Agriculture, Conservation, and Trade Act of 1990. ERS Agriculture Information Bulletin No. 624, June 1991.

preferred. That is, in the short run, growers who adopt a conservation tillage system may incur an economic penalty.

Doster et al. used crop budgets to compare six tillage systems for continuous corn and a corn-soybeans rotation in Indiana for different soil types. Yield data were obtained from field trials. Budgets were estimated for twelve hypothetical farms to compare the effects of tillage systems on net returns. They concluded that alternative tillage systems that did not include a moldboard plow were economically competitive. They did not have access to yields over a historic time period and did not consider differences in risk across systems.

Klemme used stochastic dominance to compare a conventional tillage system with several alternatives including till-plant and no-till for corn and soybean production in north central Indiana. Experimental yield data over the period from 1975 to 1982 were used in the analysis. To focus on the effects of stochastic yields, input and output prices were held constant in 1982 dollars. Klemme concluded that the conventional tillage system was more economical in the short run relative to the alternatives evaluated. However, the alternative systems would have been found to be more competitive if external costs such as those associated with soil erosion had been incorporated into the analysis.

Epplin and Tice reported cost estimates for alternative tillage systems for continuous winter wheat production. They found that production costs were higher per acre for no-till than for conventional tillage systems. However, they did not have data to consider differences in yield or yield variation between the systems.

Setia used expected utility maximization and safety-first criteria to compare three alternative conservation management systems. A stochastic modelling system which models soil loss and economic returns was used to calculate annual net return per acre, variability in annual net returns, soil loss, and variability in annual soil loss for each management system. Monte Carlo simulation was used to overcome the problem of predicting directly the effect of price and yield on variability in net returns. Optimal soil conservation management systems were found to vary, depending upon the risk preferences of the managers.

Williams used stochastic dominance to evaluate alternative tillage systems for wheat and grain sorghum production on the Central Great Plains of Kansas. He concluded that conservation tillage systems would be preferred by risk averse managers. He also evaluated the consequences of crop insurance. He found that improvements in crop yields and reductions in fuel, labor, and repair costs more than offset the increased chemical costs of the conservation tillage system.

Williams, et al. (1987) used stochastic dominance to compare reduced tillage systems for wheat and sorghum production in the Central Great Plains of Kansas with conventional tillage. Experimental yield data and average seasonal prices from 11 years (1973-1983) were used along with the cost of production of 1984 to compute the expected return distributions. They concluded that, in general, reduced tillage systems generated higher returns than other cropping systems and that using reduced tillage methods would be the optimal management strategy.

Mikesell et al. used stochastic dominance with respect to a function to compare three tillage systems (conventional; ridge; no-till) and three cropping alternatives (continuous grain sorghum; continuous soybeans; a soybean-grain sorghum rotation). They concluded that conventional tillage for continuous grain sorghum would be preferred by risk averse managers. However, they found that their results are sensitive to production costs and yields.

Henderson and Stonehouse used linear programming to evaluate tillage systems for five soil textures and two slopes. They concluded that fall plowing was the most profitable system on sandy loam and silt loam soils. Zero tillage was the optimum system on loam soils. However, inclusion of a penalty for soil loss had little influence on the optimum solution.

Epplin and Beck used stochastic dominance to evaluate three alternative tillage systems for winter wheat production in the southern Great Plains. Two of the alternative production systems were one-till and no-till which used herbicides to control weeds. The third alternative was a conventional tillage system. Grain yields were obtained from a four-year yield experiment station trial. Forage yield data were not available. However, the value of forage was estimated by budgeting returns and costs of a stocker steer. Estimates of net returns to land, management, and overhead were computed for the three tillage systems and four alternative planting months. One of the conventional tillage strategies was found to be preferred.

Williams et al. (1989) used stochastic dominance with respect to a function (SDWRF) to compare conservation tillage systems (no-till) with conventional tillage systems for continuous grain sorghum, soybeans, continuous wheat, and rotations including these crops. Yield data were obtained from experiments conducted in northeastern and west central Kansas over a ten year period. Conventional tillage systems were found to be the most risk efficient strategies for risk-averse individuals. However, intermediate tillage systems and external costs associated with soil erosion were not incorporated into the analysis.

Several studies have been conducted in Oklahoma to evaluate the impact of alternative wheat production systems on input requirements and whole farm machinery investment (Epplin et al., 1982), production cost (Epplin et al., 1983), and soil erosion (Tice and Epplin). Also, the impact of alternative production was compared for different size farms (Epplin and Tice).

The review of prior studies of the impact of alternative tillage systems on the profitability of crop production suggests that conservation tillage has little short-run advantage over conventional tillage. However, conservation tillage systems may be economically competitive when external costs are considered. Moreover, by 1995, farmers who till highly erodible soil will be required to implement soil conservation compliance plans to continue to qualify for federal commodity program deficiency payments.

Government Program Impacts on the Economics of Production Alternatives

Government programs directly influence agricultural production. Numerous researchers have conducted economic analysis to evaluate the impacts of government programs on the relative economics of alternative farming systems.

Scott and Baker used quadratic programming (QP) to derive the mean-variance efficient frontier for a typical cash grain farm in central Illinois. The production activities included corn, soybeans, oats, wheat, and idle land (set aside) to be used to meet the requirement for the 1972 government feed-grain program. Ten years of yield and price data were used to calculate the mean expected return and variance-covariance matrix.

The model was structured to evaluate the impact of the government price support and land set aside programs on farm income and optimal cropping patterns. Scott and Baker found that the preferred strategy for a risk neutral farmer was to produce only corn. The preferred strategy for a farmer with moderate aversion to risk included a combination of three acres of soybeans for every acre of corn and the minimum amount of set aside required for participation in the government program. However, they concluded that risk averse farmers would maximize their utility by implementing a plan of about equal acreage of corn and soybeans along with the required set aside.

Musser and Stamoulis used QP to investigate the hypothesis that federal agricultural commodity programs generally reduce income risk for farm firms. They used the Food and Agricultural Act of 1977 and constructed a representative farm model for Georgia. The model was used to drive efficient mean-variance frontiers for a participating and nonparticipating farm. Market prices were used when they exceeded the loan rate. Deficiency payments and disaster payments were added to the gross revenue for each crop at the appropriate historical level to calculate the distribution of net returns. They concluded that participation in the government program would be preferable to nonparticipation for most farmers.

Kramer and Pope used stochastic dominance to analyze benefits of participation in the farm commodity program under the Food and Agricultural Act of 1977. The federal commodity nonrecourse loan rates were used to determine the value of crops and target prices were used to determine the deficiency payments to producers. They used the USDA index of prices paid for production expenses to deflate prices to adjust for inflation. None of the deflated price data required detrending. The yield data were detrended as deemed appropriate. Cost data were obtained from the University of California Cooperative Extension Service budgets. Kramer and Pope concluded that small changes in program parameters affect participation and that farm size also can influence participation.

McSweeny et al. used the mean-squared forecast error (MSFE) as a measure of uncertainty in a quadratic risk programming model. They argued that the use of variance of realized returns assumes that the distribution of realized returns is the same as the distribution anticipated by the decision maker prior to the start of production which is not consistent with the conceptual model of how farmers form expectations. They concluded that the MSFE method is more appropriate than the commonly used procedures based only on realized market data and selected detrending methods.

Helms et al. used a whole-farm simulation analysis to investigate producer preferences for adoption of alternative tillage strategies under provision of both 1981 and 1985 farm bills for a nonirrigated wheat farm. They concluded that government payments play a significant role in decisions about tillage and other production practices. Moreover, results of their stochastic dominance analysis showed that a risk-averse producer would optimize utility by selecting a combination-tillage practice and participate in the government program.

Richardson et al. used the farm level income policy simulation model (FLIPSIM) to quantified the economic impact of the conservation compliance provision of the 1985 farm bill for a representative dryland cotton in Dawson County, Texas. Six management scenarios were simulated over a 5-year period (1989-1993). They concluded that most farmers would either elect to comply with the required conservation plans or enroll in the Conservation Reserve Program (CRP). Average income would decline for those who chose not to comply with the conservation requirements.

Gillespie et al. calculated the costs and returns for 35 crop-tillage combinations for the Sand Mountain region of Alabama under the conservation provisions of the 1985 farm bill. They found that the most profitable crop and associated practice was no-till straight-row corn. The most profitable farm program was the optional paid land diversion program, which allocated 35 percent of the base acreage to set-aside purposes. They concluded that farmers could conserve soil under the 1985 farm bill and continue to earn a high net return.

Hickman et al. used enterprise budgeting to evaluate the impact of conservation compliance requirements on a representative northeastern Kansas farm. Numerous strategies for achieving compliance were considered. They used long-range (1990-1995) estimates for target prices, cash prices, and set-aside. Conservation compliance options were found to have higher net returns than noncompliance options. However, they concluded that net returns would decline as a result of the legislation.

Perry et al. found that most researchers who have evaluated the crop-mix decision using mean-variance models have relied on historical data (yields and prices). They argue that historical data may not fully reflect current conditions, particularly when decision involve government-supported crops. They developed generalized equations for calculating per-acre income, mean, and variance values for both government supported and non-programs crops. These equations can be summarized as follows:

$$RP = \begin{cases} P \bullet Y & \text{when } P > T \\ P \bullet Y + G \bullet (T - P) & L < P \leq T \\ P \bullet Y + G \bullet (L - P) + G \bullet (T - L) & A < P \leq L \\ (A - M - P) \bullet Y + G \bullet (L - A) + G \bullet (T - L) & M < P \leq A \\ A \bullet Y + G \bullet (L - A) + G \bullet (T - L) & P \leq M \end{cases}$$

where:

RP = gross income per acre of planted cropland under the program,

T = the target price,

L = the formula loan rate,

A = the adjusted loan,

M = the marketing loan, and

G = proven yield.

Williams et al. (1990) used stochastic dominance to analyze conventional tillage,. a two-tillage system, and no-tillage, for five crops rotations; wheat-fallow, grain sorghum-fallow, continuous wheat, continuous sorghum, and wheat-grain sorghum-fallow. Four scenarios involving participation and nonparticipation in government commodity programs were examined. Yields from field experiments and historical price data for the period (1976-1986) and 1986 production costs were used to calculate distributions of net returns. Loan rate, target prices, and the acreage reduction requirement for 1987 cropping year were used in the calculations. They concluded that risk averse managers should select conventional tillage wheat-grain sorghum-fallow rotation when government payments are not considered. However, the results are quite sensitive to production costs and yield changes. Participation in government programs increase average net return and lower variation of return. Government commodity program provisions did not encourage the use of the no-tillage system.

Hoag and Holloway used mixed integer programming to examined the profitability of participation in commodity programs on seventeen surveyed North Carolina farms. They concluded that individual farm acreage base and crop yield strongly affect the profitability of conservation compliance. Farms with more base acreage and higher base yields for program crops have a greater incentive to comply.

Rowell et al. evaluated the economic impact of conservation compliance for a representative farm in Kansas. They concluded that production in violation of conservation compliance would result in lower net returns.

Aw-Hassan and Stoecker used the EPIC simulation model to provide an estimate of the long-term impacts of alternative tillage systems on soil erosion and soil erosion on wheat yield. They evaluated four tillage systems for continuous wheat production for Grant County, Oklahoma. They found that under the current conservation compliance policy a disk-chisel tillage system would meet the residue requirement on highly erodible land and would result in higher net income than either a moldboard plow or sweep tillage system.

Olson and Eidman presented a theoretical model of the weed control decision and developed a MOTAD programming model to study the impact of alternative government policies on weed control choices. A representative farm of 400 crop acres for southeast

Minnesota was modelled. Herbicide usage, mechanical weed control, and variability of federal policy was incorporated into the analysis. They found that the variation in returns may influence a farmer to select the herbicide control strategy even though it has lower returns than the mechanical weed control system.

This section has included a review of some studies conducted to evaluate the impact of government programs on the relative economics of alternative farming systems. In general, participation in government programs is preferable to non-participation. Historically, participation in government commodity programs has not encouraged the use of conservation tillage. However, farmers will be required to implement soil conserving production practices on highly erodible lands to maintain eligibility for direct agricultural payments and other federal programs.

Methods Used to Determine the Efficient Farm Plans Given Government Programs

Farmers who participate in government programs are often required to impose restrictions on the acres devoted to program crops on the land that they farm. A variety of analytical methods have been used to incorporate the government program participation decision into the analysis.

Enterprise budgeting is a common analytical tool used to evaluate alternative farm plans. For example, Gillespie et al., Hickman et al., and Rowell et al. used budgeting to evaluate the impact of government commodity programs, including conservation compliance, on net returns for a representative farms. These studies computed estimates of the net returns to alternative production systems. However, the returns variability and risks associated with each system were not considered.

To incorporate risk into farm planning analysis, efficiency criteria are frequently used in both theoretical and empirical analysis. For example, stochastic dominance has been used to analyze the net benefits of participation in farm commodity programs (Kramer and Pope).

Whole farm analysis is a more appropriate method than single enterprise analysis for evaluation of alternative tillage systems because changes in machinery requirements can have a relatively large impact on capital requirements and income.

Risk programming is a technique used to determine risk efficient farm plans subject to the resources of the farm and institutional constraints. Quadratic programming has been used to select risk efficient whole farm plans given government programs (Scott and Baker; Musser and Stamoulis; and McSweeny, et al.). Market prices were used to calculate the crop values when prices exceeded the loan rate. Target prices were used to calculate the deficiency payments. Models can be structured to generate efficient mean-variance frontiers for participation and nonparticipation situations. Simulation models have also been used to generate farm plans given government programs (Helms et al.).

Kramer and Pope and McSweeny et al. argued that using historical government program parameters would be misleading for a model designed to evaluate current period decision making. They suggested that the current program parameters be used as if the parameters had been in effect throughout the entire period used to generate the distributions of returns.

In this section, a review of methods used to incorporate government programs into farm models was presented. Most researchers have used a whole farm risk programming technique. This study also uses risk programming technique for a whole farm analysis. Moreover, it will follow the procedure suggested by McSweeny et al. to incorporate the government program into the analysis by using the current program parameters as if the parameters had been in effect throughout the entire period used to generate the distribution of returns for the various production activities.

CHAPTER III

CONCEPTUAL FRAMEWORK AND METHODS FOR SELECTING RISK EFFICIENT WHOLE-FARM PLANS

Planning methods such as budgeting and linear programming that researchers can used to systematically evaluate the effect of alternative production systems on the profitability of farming have become routine decision making tools. Procedures have also been developed to aid with the selection of risk efficient farm production plans. In this chapter, the concept of risk is explained. The conceptual framework for farm decision making under risk and some empirical techniques of measuring risk are discussed. This chapter also includes a review of alternative methods for selecting risk efficient whole-farm plans.

The Concept of Risk

Risk has been defined in many ways. In 1921, Knight argued that if the probabilities of uncertain outcomes are known, the problem of selecting from among several alternatives is one of risk. In contrast, if the probabilities are unknown, the problem is one of uncertainty. With the introduction of the concept of subjective probability, the differentiation between risk and uncertainty has blurred to the extent that the terms have become interchangeable in the agricultural economics literature.

In applied research, risk is generally defined in the context of variability of income or net returns. It is usually quantified by a standard statistical measure of dispersion such as variance, standard deviation, or coefficient of variation. Risk may also be defined as a chance of loss, or the probability that net income (Y) will fall below some disaster level such as:

$$P_r\,(Y < d) = \alpha \qquad [3.1]$$

where Y is income and d is some disaster level.

Farm Decision Making Under Risk

Yields from crop and livestock production activities and market prices for crop and livestock products are stochastic variables. Outcomes from crop and livestock production vary with weather and other factors such as pests. Farming is a risky business. Farm managers encounter many choices from which they must decide upon a course of action. These choices ultimately result in a mix or portfolio of enterprises and production practices. These decisions may be based upon the criteria of maximizing expected income or profit. However, for many farmers the selection criteria may also include some consideration of risk. For example, Lin et al. performed an empirical test of the profit maximization hypothesis relative to the expected utility maximization hypothesis for a group of large scale California farmers. They concluded that the latter best explained the behavior of these farmers.

Under the profit maximization framework, the optimal farm plan for different farmers with identical technology and resources will be the same. An optimal linear programming solution for a representative farmer selected from a homogeneous group will be useful for all individual farmers in that group. However, under the expected utility framework, the optimal farm plan depends on each individual's utility function. Often utility functions are expressed in terms of expected income and income variability.

The classical underlying economic theory of firm management is based upon the profit maximization assumption. The basic model is static and deterministic. It is appropriate for many types of analysis. However, farming is dynamic and stochastic. Economists have developed basic extensions of the deterministic model of the firm in an attempt to provide more appropriate tools for decision making.

The Bernoullian utility theorem provides a useful theoretical basis for the analysis of the behavior of individuals in a stochastic environment, that is, an environment in which the outcome of alternative actions which influence the welfare of the individual are not known with certainty. The theory and empirical application of risk management has concentrated on the analysis of the trade-off between expected income and risk as measured by the variability of income. This theory is based on the explicit or implicit assumption that decision makers possess positive marginal utility for money. Further, most decision makers are assumed to be willing to trade-off some expected income to reduce the probability of incurring a loss resulting from an uncertain event.

Consumer theory is built upon the assumption that individuals derive utility from the consumption of goods and services which can be purchased with money income. Hence, indirectly, utility is a function of income (Freund; Kaiser and Boehlje; Varian). A utility function can be written as:

$$U = f(Y) \tag{3.2}$$

where Y is the income earned from the execution of a specific farm plan. If the utility function of the farmer were known and tractable, a unique optimal farm plan could be determined by maximizing the function. Utility theory has been very useful for explaining qualitative aspects of the behavior of managers, including farmers. However, it is difficult to precisely quantify the utility functions of individuals.

Utility functions can be elicited directly from an individual by conducting carefully designed gambling games with the individuals or through econometric analysis (Binswanger; Dillon and Scandizzo). However, such methods are often expensive and practical considerations force analysts to assume functional forms that are computationally convenient. Utility functions are unique to decision makers and may not be stable over time. They may change with income level and other socioeconomic conditions of the household (Dillon and Scandizzo; Binswanger). Hazell (1982) concluded that direct elicitation of utility functions is not likely to be widely adopted for farm planning.

While efforts to derive utility functions have not been very successful, substantial efforts have been devoted to describe the theoretical properties of various functional forms. One functional form which has been frequently used is the quadratic. A quadratic utility function may be written as follows:

$$U(Y) = a + \alpha Y + \beta Y^2 \qquad [3.3]$$

where a, α and β are constants (Hazell and Norton, 1986; Kaiser and Boehlje; and Dillon). The expected value of (3.3) is:

$$E[U(Y)] = a + \alpha E(Y) + \beta E(Y^2) \qquad [3.4]$$

$$E[U(Y)] = a + \alpha E(Y) + \beta E(Y^2) - \beta E(Y)^2 + \beta E(Y)^2 \qquad [3.5]$$

$$E[U(Y)] = a + \alpha E(Y) + \beta V(Y) + \beta E(Y)^2 \qquad [3.6]$$

where E(Y) is the mean of income and V(Y) denotes the variance of income. Hence, for those farmers for which a quadratic utility function is appropriate, expected utility can be specified in terms of mean and variance such that:

$$U = f[E(Y), V(Y)] \qquad [3.7]$$

where E denotes mean or expected income and V refers to the variance of expected income. For a given level of utility ($U°$), an indifference curve depicting the willingness of a farmer to forgo some expected income (E) to reduce variance of expected income (V) can be plotted in EV space.

For a rational producer, $\frac{\partial U}{\partial E}$ must be positive over some range of the utility function, i.e. if the variance of income is constant, utility increases with an increase in expected income. The farmer is expected to prefer farm plans with higher income and lower variance. If two farm plans have the same variance, the plan with higher income will be preferred.

A farmer's attitude towards risk can be inferred from the shape of his or her utility function. If β is positive, it indicates that the decision maker is a risk preferrer and variability of income is desired. That is, for a given level of expected income, more variance is preferred to less. On the other hand, if β is negative, the decision maker is said to be risk averse. That is, over some range of expected income the decision maker is willing to sacrifice some expected income to reduce the variability of income (risk) (Dillon, 1971; Kaiser and Boehlje). A decision maker is considered to be risk neutral if $\beta = O$.

Graphically, if a decision makers' utility (on the vertical axis) as a function of income (on the horizontal axis) is concave to the origin, the decision maker is said to be risk averse. A linear utility function implies risk neutrality. A convex function would be appropriate to represent the preferences of a risk preferring decision maker. A decision maker may have a utility function with both concave and convex segments indicating changes in risk attitudes for different levels of income. Figure 3 includes segments of utility functions to indicate the various shapes to represent the three classes of decision makers (risk averse, risk neutral, risk preferring).

Risk Efficiency Criteria

A risk efficiency criteria is a decision rule which may be used to compare two or more alternatives in terms of expected income and risk. In general, for a given level of expected income, an alternative with less risk (variance) is relatively more risk efficient than an alternative with more risk. A number of risk efficiency criteria have been developed to overcome the problems associated with attempts to directly estimate individual utility functions. The advantage of using these criteria is that they may be applicable for classes of, rather than for individual, decision makers.

Mean-variance (EV), mean-absolute deviation (MAD), first degree stochastic dominance (FSD), second degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDRF) are examples of risk efficiency criteria. They are widely used in both theoretical and empirical analysis. They are appropriate tools for risk analysis in situations where a single person, or a group of persons, whose unknown utility functions satisfy the assumptions of the criteria. Utility maximizing alternatives

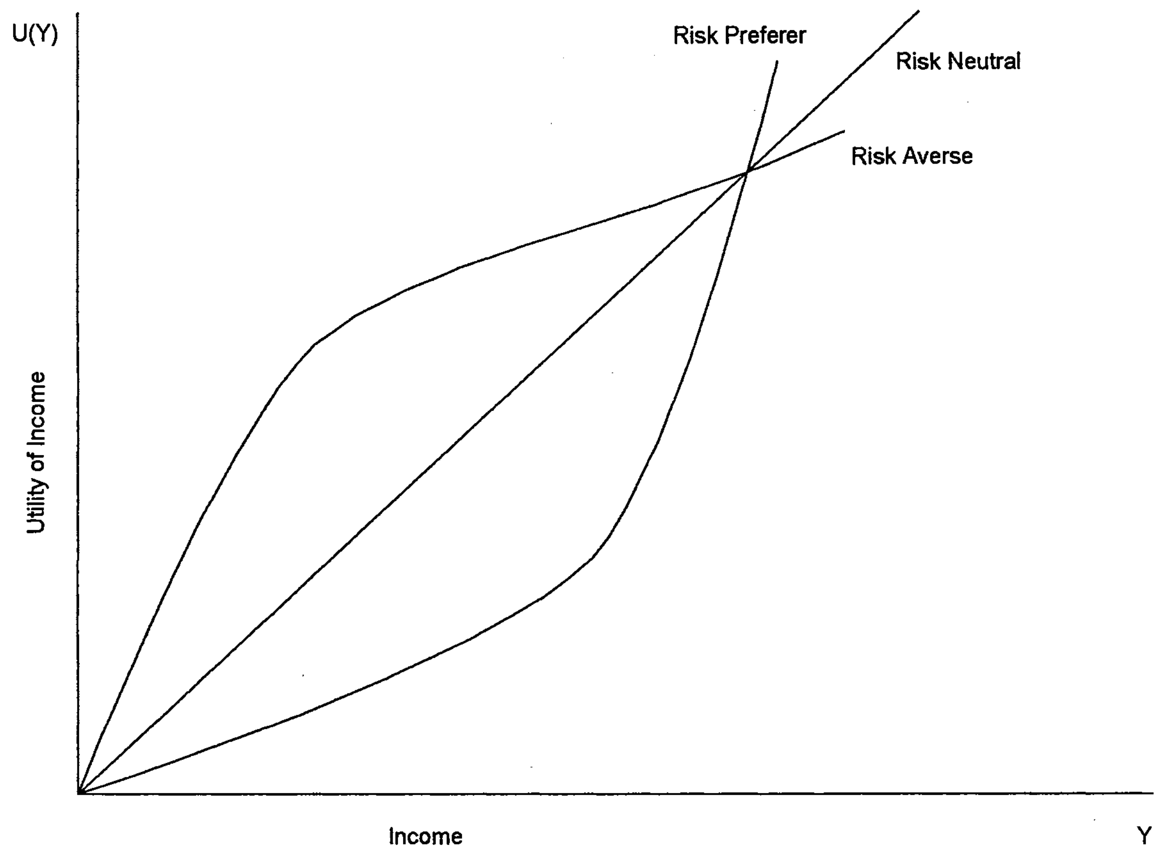


Figure 3. Three Functional Forms of Utility Function.

are not precisely determined by use of a risk efficiency criterion. Rather, a criterion can be used to separate potential alternatives into two mutually exclusive sets - an efficient set and an inefficient set.

Mean-variance (EV) is the simplest approach to efficiency analysis. Alternative one is preferred to alternative two if $(E(X_1) \geq E(X_2)$ and $V(X_1) \leq V(X_2)$ with at least one being a strict inequality. Hence, the EV method separates alternative feasible farm plans into two sets. Those that are on the EV frontier are said to be "risk efficient" and are members of the risk efficient set. Those that are feasible but are not on the frontier are said to be inefficient. For any given level of expected income (E(Y)), a plan which is on the frontier is said to dominate plans that are not on the frontier.

The theory of stochastic dominance provides several additional risk efficiency criteria. These criteria include First Degree Stochastic Dominance (FSD), Second Degree Stochastic Dominance (SSD), and Stochastic Dominance with respect to a Function (SDRF).

First Degree Stochastic Dominance

Under FSD, a farm plan with an outcome distribution defined by cumulative distribution function F(Y) is preferred to an alternative plan with cumulative distribution function G(Y) if

$$F(Y) \leq G(Y) \qquad [3.8]$$

for all possible values of Y and if the inequality is strict for some value of Y. FSD is the least restrictive of the SD criteria. FSD is an appropriate criteria for decision makers who have positive marginal utility of income and prefer more income to less income.

Second Degree Stochastic Dominance

Under SSD, an alternative with the cumulative distribution F(Y) is preferred to a second alternative with cumulative distribution function G(Y) if

$$\int_{-\infty}^{y} F(Y)\, dy \leq \int_{-\infty}^{Y} G(Y)\, dy \qquad [3.9]$$

for all possible values of Y, and if the inequality is strict for some value of Y. SSD is appropriate for decision makers whose utility functions have positive, nonincreasing slopes at all outcome levels.

Stochastic Dominance with Respect to a Function

For narrowing the efficient set beyond FSD and SSD, stochastic dominance with respect to a function (SDRF) offers the most discrimination and flexibility (King and Robison). SDRF orders uncertain choices for decision makers whose absolute risk aversion functions lie within specified upper and lower bounds $r_1(Y)$ and $r_2(Y)$. The interval can be as wide or as narrow as desired where intervals of $-\infty$ and $+\infty$ would yield the same ordering as FSD and interval of 0 and $+\infty$ would yield the same ordering as SSD.

The solution procedure requires the identification of a utility function U(Y), which minimizes:

$$\int_{-\infty}^{\infty} [G(Y) - F(Y)]U'(Y)dy \qquad [3.10]$$

subject to:

$$r_1(Y) \leq \frac{-U''(Y)}{U'(Y)} \leq r_2(Y) \textit{ for all values of } Y \qquad [3.11]$$

Expression [3.10] accounts for the differences between the expected utilities of F(Y) and G(Y). If, for the decision makers defined by the absolute risk aversion bonds, the minimum of the difference is positive, then F(Y) is preferred to G(Y). This implies that the expected utility of F(Y) is always greater than that of G(Y). If the minimum is zero, the alternatives can not be ranked. If the minimum is negative, the solution requires the identification of the utility function which minimizes

$$\int_{-\infty}^{\infty} [F(Y) - G(Y)]\ U'(Y)dy \qquad [3.12]$$

subject to the same constraint in equation [3.11].

Using stochastic dominance with respect to a function does not guarantee a complete ordering because the minimum of both [3.10] and [3.12] can be negative, which implies that neither distribution is unanimously preferred by the relevant group of decision makers.

Stochastic dominance analysis is also useful for approximating the value of information. Mjelde and Cochran show that a producer's willingness to pay a premium for information equals the amount which can be charged in each state of nature before the producer is indifferent between buying and not buying the information. Two cumulative distribution functions (cdf) are generated; one cdf (F(Y)) uses decisions obtained while utilizing the information; the other cdf (G(Y)) users decisions obtained without utilizing the information. The lower bound on the information is the minimum value of the premium, π, such that $F(Y - \pi)$ no longer dominates $G(Y)$. The upper bound on the information is the minimum premium such that $G(Y)$ dominates $F(Y - \pi)$. Mathematically, the lower bound is given by: Min π such that $EU(F(Y - \pi)) - EU(G(Y)) \leq 0$ for at least one U in u, where E is the expectation operator and u is the admissible class of utility functions. The upper bound differs in that the strict inequality holds for all decision maker defined by u.

A risk efficiency criterion is not sufficient to fully answer the practical question of how farm resources should be allocated among competing crop and livestock activities to maximize the expected utility of the farmer. This limitation of risk efficiency criteria as a practical decision rule can be alleviated to some extent through the use of risk programming.

Risk Programming

Risk programming is a technique which can be used to identify risk efficient farm plans for several of the risk efficiency criterion, given the potential alternative farm activities and the resource constraints. It is a technical procedure which can be used to evaluate an infinite number of possible combinations of different levels of alternative enterprises to find the best feasible enterprise level combination that maximizes the expected utility for alternative assumptions regarding risk preferences.

Risk programming techniques are useful even if the specific utility function is not known. In this case, a set of solutions in terms of combination of specific activity levels for different levels of income can often be generated. The set of solutions, shows the optimal mix of activity levels to minimize risk, expressed in terms of one of the risk efficiency criteria. Therefore, each individual decision maker with resource constraints and production alternatives included in the programming model, but with different utility functions, can maximize his or her own expected utility by choosing one of the solutions in the risk efficient set.

This technique was first used when a quadratic programming (QP) model was constructed and solved to minimize portfolio variance for alternative levels of expected return (Markowitz). A QP model was also the first risk programming model applied to the agricultural sector (Freund). QP has served as the major risk programming model, used for the analysis of risk associated with agricultural production. It has also been used for decision making in agricultural credit marketing and long-term investment.

A quadratic risk programming model incorporates the EV risk efficiency criteria to the optimization of alternative activity levels. This method is consistent with the expected utility framework in that the objective function, which is expressed in terms of expected income and variance of income, corresponds to a quadratic utility function (Mapp et al., 1979).

Another widely used risk programming model is minimization of total absolute deviations (MOTAD) as developed by Hazell. Originally MOTAD was presented as a substitute to QP for researchers who did not have access to a reliable QP solution algorithm (Hazell, 1982).

Methods for Selecting Risk Efficient Whole-Farm Plan

In risk programming models it is important to identify the key elements of risk to be studied. The major sources of risk and uncertainty are as follows:

a) uncertainties in activity costs, yield and prices (objective function risk);

b) change in production technology (technical coefficient risk); and

c) uncertainties in the availability of resources (right hand side risk).

Farm prices and yields are major sources of risk that affect the objective function. Most risk programming models are constructed to evaluate objective function coefficient uncertainty. In many studies, prices and yield risk are combined to consider variability in gross margins for individual crop and livestock enterprises. QP is the most common risk programming method.

Quadratic Programming

The general formulation of a QP model as developed by Freund is as follows:

$$\text{Max } E[U(X)] = X'U - \phi X'\sigma X \qquad [3.13]$$

subject to:

$$A\,X \leq B \qquad [3.14]$$

$$X \geq O \qquad [3.15]$$

where X is a vector of activity levels, U is vector of expected returns, B is a vector of resource constraints, σ is a variance covariance matrix, and ϕ is a risk aversion coefficient.

An alternative form of QP model reported by Hazell and Norton (1986) is:

$$\text{Min} \quad V = \sum_{j=1}^{n} \sum_{k=1}^{n} X_j \, X_k \, \sigma_{jk} \qquad [3.16]$$

subject to:

$$\sum_{j=1}^{n} F_j \, X_j = \lambda \qquad (\lambda = 0 \text{ to unbounded}) \qquad [3.17]$$

$$\sum_{j=1}^{n} a_{ij} \, X_j \leq b_i \qquad (\text{for all i, i} = 1 \text{ to m}) \qquad [3.18]$$

$$X_j \geq O \qquad (\text{for all j, j} = 1 \text{ to n}) \qquad [3.19]$$

where F_j denotes the expected gross margin of the jth activity and λ is a scaler.

The major difference between these two formulations is the specification of ϕ and λ. The advantage of using Freund's formulation is that it directly specifies the risk aversion parameter associated with each point on the frontier (Boisvert and McCarl).

QP is appropriate for risk averse or risk neutral decision makers whose utility is a function of expected income and associated income variance (Hazell, 1971). The risk efficient EV frontier can be traced by parameterizing λ. By definition, farm plans, or portfolios, on the frontier have the minimum variance among all possible plans with the same level of expected income.

Segment OB in Figure 4 describes the EV efficient frontier. The other three curves in Figure 4 denote hypothetical iso-utility curves denoting the farmer's preference between risk and income. Given the curves, point A in Figure 4 depicts the point of

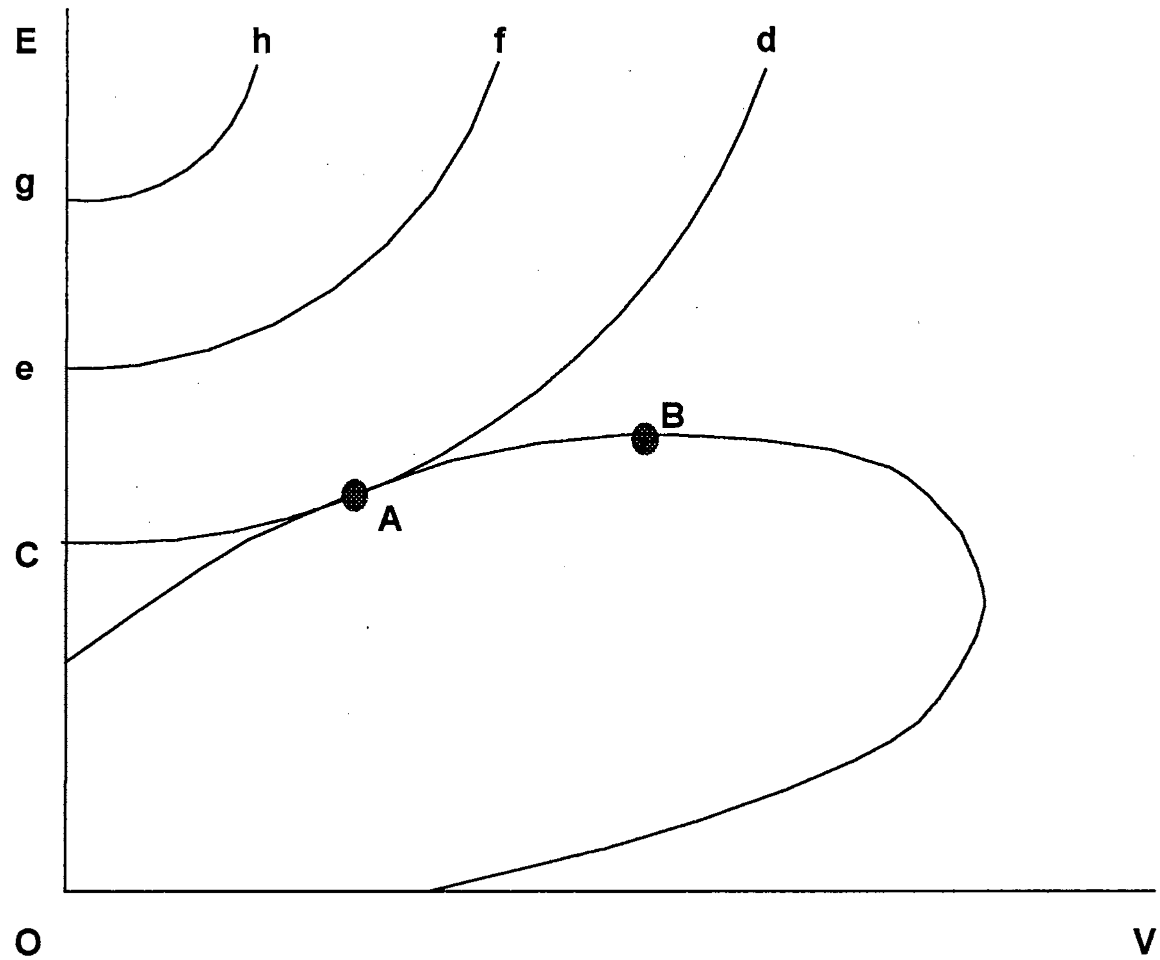


Figure 4. The Optimal E-V Farm Plan.

utility maximization. The farm plan that is associated with point A is the optimal farm plan. Hence, if the decision maker's EV utility function is known, an optimal farm plan can be identified on the frontier.

In the past, due to limited access to QP computer software, computational difficulties, and doubts about the performance of the available packages, applications of QP were limited. Early algorithms tended to suffer from rounding errors, and any two solution packages seldom performed the same (Hazell, 1971; McCarl and Tice). However, with the development of new powerful microcomputers and nonlinear optimization routines, these problems have become less important.

MOTAD

MOTAD is a linear programming alternative to QP. The objective function for MOTAD is to minimize the sum of the absolute deviation of income from a specified level of expected income. The mean-absolute deviation (EA) risk efficiency frontier can be derived by parameterizing the expected income. Moreover, a good approximation of the QP derived EV frontier can be derived from the MOTAD solutions by use of the Fisher constant that relates sample MAD to population variance (Hazell and Norton).

If the gross margins from the various production alternatives are normally distributed, farm plans that minimize the total absolute deviation are equivalent to those that minimize variance. In other words, assumptions and restrictions associated with QP or EV analysis apply to EA analysis.

Since the minimization of total absolute deviation is equivalent to the minimization of either the positive or negative deviations, researchers typically set up the model to minimize one or the other. The MOTAD problem formulated by Hazell is presented as follows:

$$\text{Minimize} \sum_{j=1}^{n} Y_h' \qquad [3.20]$$

subject to:

$$\sum_{j=1}^{n} (C_{hj} - g_j)\, X_j + Y_h' \geq o \qquad \text{for all h, h} = 1,\ldots, \text{s} \qquad [3.21]$$

$$\sum_{j=1}^{n} F_j\, X_j = \lambda \qquad [3.22]$$

$$\sum_{j=1}^{n} a_{ij}\, X_j \leq b_i \qquad \text{for all i, i} = 1,\ldots, \text{m} \qquad [3.23]$$

$$X_j\,,\; Y_h' \geq o \qquad [3.24]$$

where $$Y_h' = \sum_{j=1}^{n} (C_{hj} - g_j)\, X_j \qquad [3.25]$$

C_{hj} = gross margin for observation h of activity j

g_j = average gross margin for activity j

X_j = level of activity j

F_j = expected net revenue for activity j

λ = income level

a_{ij} = technical coefficient

b_i = resource constraint

This model was considered a linear approximation of QP with cost and computational advantages. But, it is argued that the validity of MOTAD depends on how well it approximates expected utility solutions rather than how closely it approximates

QP solutions (Johnson and Boehlje). Even if the estimate of variance of income is incorrect for each farm plan due to the fact that sample MAD is a less efficient estimator of population variance, it is still possible to correctly identify the plan with the smallest value of variance for each alternative level of income. Moreover, it is also argued that the MAD may sometimes out-perform the sample variance when outcome distributions are skewed (Thomson and Hazell).

Target MOTAD

Tauer developed Target MOTAD. It provides solutions which are members of the SSD efficient set. The Target MOTAD model would be appropriate decision makers who seek to maximize expected returns subject to the constraint that returns not fall below a critical target level. In Target MOTAD, expected returns are maximized with a restriction on the level of negative deviations from the target. Mathematically, the model is:

$$E(z) = \sum_{j=1}^{n} F_j X_j \qquad [3.26]$$

subject to:

$$\sum_{j=1}^{n} a_{kj} X_j \leq b_k \qquad k = 1, \ldots, m \qquad [3.27]$$

$$T - \sum_{j=1}^{n} C_{rj} X_j - Y_r \leq o \qquad r = 1, \ldots, s \qquad [3.28]$$

$$\sum_{r=1}^{s} P_r Y_r = \lambda \qquad \lambda = M, \ldots, 0 \qquad [3.29]$$

$$X_j , Y_r \geq o \qquad [3.30]$$

where E(z) is expected return of the plan or solution; F_j is the expected return of activity j; X_j is the level of activity j; a_{kj} is the technical requirement of activity j for resource or constraint k; b_k is the level of resource or constraint k; T is the target level of return; C_{rj} is the return of activity j for state of nature or observation r; Y_r is the deviation below T for state of nature or observation r; P_r is the probability that state of nature or observation r will occur; λ is a constant parameterized from M to 0; m is the number of constraint and resource equations; s is the number of states of nature or observations; and M is a large number.

Since deviations are not measured from the mean, as is the case with MOTAD, total negative deviations below the target do not as a rule equal total negative deviations. Using a target, this framework standardizes the risk reference point across all activities considered, (while in MOTAD the risk reference point is equal to and moves with the mean). Further, Watts et al. observe that ". . .Target MOTAD will never choose a dominated plan, regardless of the target selected. . ." (Watts et al. p. 179). Target MOTAD treats risk as negative deviations from a target level. It offers considerable advantages for examining risk-return tradeoffs in the context of whole farm planning, compared to MOTAD which treats both negative and positive deviations as a source of risk. Even though it seems logical to penalize negative returns as a source of risk, it does not seem to be rational to view positive deviation as a source of risk. Moreover, Target MOTAD has no restrictive distributional assumptions made in its formulation. Therefore, the Target MOTAD framework is applicable to cases where income distributions are not normal. This, together with the fact that all Target MOTAD solutions are efficient by the SSD criterion, explains why the Target MOTAD method has emerged as a common tool for evaluation of risky alternative production strategies.

Some Applications of Target MOTAD

Pederson and Bertelsen used Target MOTAD and simulation methods to analyze the opportunity to reduce whole-farm risk in a diversified cash farm crop. Forty possible activities were specified in the model. Results showed that risk reduction was achieved through traditional enterprise diversification. Risk-efficient strategies derived from the Target MOTAD model were simulated to monitor farm financial performance.

Novak et al. applied Target MOTAD to assess the risks and returns of several cropping systems including a sustainable cotton rotation. The Universal Soil Loss Equation (USLE) was used to calculate potential annual soil losses from sheet and rill erosion under the six cropping systems. Ten years of data were used to analyze the profitability of six rotations. Risk-returns for soil losses of three tons/acre/year were analyzed using Target MOTAD model. The results indicated that diversification in rotations resulted in the least risk for a given level of target income.

Misra and Spurlock developed a Target MOTAD model to analyze intra-year impacts on profit due to the variations in timing of planting and harvesting as well as to capture inter-year impacts on profit that arise from fluctuations in weather and economic factors. Delays in field work may occur due to unfavorable weather or due to the limited capacity of the planting or harvesting equipment. The loss in profit due to less timeliness is considered in the model. Even though earliness showed significant benefits, a combination of maturity management practices performed better than a single practice.

Paxton, Vandeveer, and Lavergne evaluated the potential benefits of irrigation with the aid of a Target MOTAD model. They used subjective yield expectations data for developing enterprise gross margin series. Yield estimates for both dryland and irrigated conditions were obtained from farmers by a direct interview. The target income used in the model was an expected income level that allowed the farm to meet all of its financial obligations. Results showed that irrigation offers substantial potential to increase farm income and to reduce relative risk.

In this chapter, the conceptual framework and methods for selecting risk efficient whole-farm plans were examined. The concept of expected utility as related to whole-farm planning were explored. Hazell's MOTAD formulation developed as an alternative QP, was described and critiqued. The theoretical validity of the MOTAD formulation was examined, when the critical assumption of normality is violated. The Target MOTAD approach was also described. It is considered to have a more robust theoretical foundation for modelling risk in the context of whole-farm planning than either QP or MOTAD.

CHAPTER IV

THE MODEL AND DATA DEVELOPMENT

The purpose of this chapter is to describe the various data sources and methods used to obtain the information necessary for the construction of a representative farm model. This chapter begins with a description of the hypothetical farm which is designed to represent a typical Garfield County, Oklahoma winter wheat and stocker cattle farm. This is followed by a description of the agronomic study of alternative wheat tillage systems from which the wheat grain yield data used for the analysis were derived. The methods used to obtain machinery complements, stocker cattle production coefficients, and wheat and stocker cattle prices over time are described. The chapter concludes with a discussion of the method used to obtain the data necessary to incorporate the federal wheat commodity program into the risk programming model.

The Representative Farm

Information from the 1987 agriculture census, pertaining to Garfield County is presented in Table 2. The representative farm used in this analysis consists of 600 acres of cropland, reflecting the average farm size in Garfield County of 536 acres (Table 2). The federal government commodity program wheat base acreage is 570 acres. The total wheat acreage base for Garfield County is 95 percent of the total cropland.

Table 2. Farms, Land in Farms, and Cropland in Garfield County, 1987.

Number of Farms	1182
Land in Farms (Acres)	633,271
Total Cropland (Acres)	466,678
Average Farm Size (Acres)	536

Source: Agricultural Census, Oklahoma, 1987.

The set of potential production activities for the representative farm includes wheat for grain, wheat for winter grazing stocker steers and grain, and wheat exclusively for grazing stocker steers. Wheat can be produced on the farm with any of seven tillage systems. The model also includes activities which are necessary to evaluate the economics of participation in the wheat commodity program.

Available family labor is assumed to be equivalent to one full time person. The total amount of labor hours by month that the operator devotes to farm production practices are calculated by assuming that eight hours are available for work per day from March to October and 10 hours per day during the rest of the year.

The hours available to conduct field work each month were computed based upon estimates provided for the region by Kletke and Sestak. These estimates are based upon historical weather data and observations regarding the amount of time necessary for a field to dry after a rain prior to field operations. A timeliness level of 85 percent was assumed which means a machinery complement must be assembled such that the farm operator can perform the required field operations in the correct time period in 17 of 20 years (Kletke and Sestak). The calculated field work time hours per month for the representative farm are contained in Table 3.

Agronomic Study of Wheat Response to Tillage

The experiment station study was conducted for ten consecutive years (1977-1986) on a Grant silt loam soil (Udic Arguistolls) at the North Central Research Station near Lahoma, Oklahoma. Five tillage systems plus one no-till system were evaluated using

Table 3. Hours Per Month Assumed to be Available for Field Work on the Representative Farm.

Month	Days/Month	Hours/Day	Hours/Month
January	23.75	8	190
February	23.00	8	184
March	24.00	8	192
April	19.25	10	193
May	17.50	10	175
June	20.25	10	203
July	23.25	10	233
August	23.75	10	238
September	21.00	10	210
October	20.75	8	166
November	22.50	8	180
December	23.75	8	190

Source: Kletke and Sestak.

24 by 40 feet plots in a randomized complete block design with four replications. The six treatments were repeated on the same plots for ten years. During the course of the study the station received an average of 28 inches of annual rainfall.

The five tillage methods differed in terms of primary, secondary, and tertiary tillage operations. In most years, primary tillage was conducted in July and secondary tillage in August. Timing of tillage operations was adjusted in response to emergence and growth of summer weeds, and in three of the ten years the secondary tillage operations were conducted twice. Field operations conducted for each of the six systems are described in Table 4. Tillage implements used in the study are described in Table 5.

The Chisel and Sweep systems represent two types of stubble-mulching (Runyan; Zingg and Whitfield). Primary tillage for the Chisel system was conducted with 14 inch sweeps operated at a depth of 2 to 3 inches. The Chisel system should not be confused with chisel plowing with twisted shanks or chisel spikes which would generally be conducted to a depth of 6 to 9 inches. Tillage operations for the Sweep system consisted of three or four passes with a single 8 foot blade operated at a depth of 3 inches.

Precise measurements of surface residue remaining at seeding were not taken. However, two of the systems, the Plow-23cm (moldboard plow operated at a depth of 9 inches) and Plow-15cm (moldboard plow operated at a depth of 6 inches), used a moldboard plow for the primary tillage operation and left essentially no residue from the previous wheat crop on the soil surface at planting. At the other extreme, the only soil disturbance for the no-till system occurred when the plots were seeded. The remaining three systems were intermediate in terms of surface residue remaining and included the

Table 4. Field Operations Conducted for Each Production System.

System	Primary	Secondary	Tertiary
	(field operations)		
Chisel	chisel	chisel(1.3 X)*	chisel
Plow-23 cm	plow	disk (1.3 X)	springtooth (2X)
Disk	disk	disk (1.3 X)	disk
Plow-15 cm	plow	disk (1.3 X)	springtooth (2X)
Sweep	sweep	sweep (1.3 X)	sweep
No-till	spray	spray (0.3 X)	spray
Modified No-till	spray	spray (1.3 X)	spray

*In three of the ten years two secondary field operations were performed.

Table 5. Description of Tillage Implements, Depth of Operation, and Impact on Surface Residue.

Implement	Description	Surface Residue remaining after One Pass (%)*
Chisel	14 inch sweeps operated at a depth of 2 to 3 inches	80
Disk	flexible offset tandem disk operated at a depth of 3 to 4 inches for primary tillage and slightly deeper in secondary and final tillage operations	60
Plow	moldboard plow with scalloped rolling coulters operated at a depth of 9 inches for the Plow-23cm system and at a depth of 6 inches for the Plow-15cm system	0-5
Springtooth	springtooth harrow with a spiketooth harrow attachment with two rows of spikes	95
Sweep	single 8 foot Noble blade with a single gang mulch treader attached operated at a depth of 3 inches	90

* Estimate from prior studies (Johnston and Stiegler).

Disk, Chisel, and Sweep systems. Based upon prior research, the Disk system would be expected to maintain 19 percent of the previous crop's residue on the surface at planting time. The narrow 14 inch sweeps of the Chisel system would be expected to incorporate 46 percent of the residue and maintain 54 percent on the surface. Three passes of the 8 foot wide sweep of the sweep system would be expected to result in a seedbed which maintained 70 percent of the previous crop's residue on the surface (Johnston and Stiegler).

Two applications of glyphosate at a rate of 2 pints/acre were used for weed control in the summer for the No-till system. In three of the ten years, in which summer rainfall was above average, three applications of glyphosate were used. Glyphosate was applied with a compressed air plot sprayer with a carrier volume of 30 gallons/acre. No additional herbicide was used on the No-till plots, and no herbicides were used on the other five treatments.

Glyphosate was applied to control plant growth during the time between harvest in June and no-till drilling in the fall. Herbicide technology has advanced since the study was designed in 1976. If the study were initiated today, a lower rate of glyphosate, or some other herbicide or combination of herbicides would be used. During the course of the 10 year study an average of 4.6 pints/acre of glyphosate were applied per year on the no-till plots. At current prices this is $27/acre. This value is included on the No-till budget.

Use of herbicides to control weeds throughout the entire summer, in a region which receives 28 inches of annual rainfall, is expensive. One no-till continuous wheat study conducted in the region in which a combination of herbicides was used reported an annual cost of $43.50/acre for herbicides (Epplin et al.). Because of substantial changes in herbicide technology since the study was initiated, a modified no-till activity is included in the model. It is based upon the assumption that equivalent weed control could be achieved with a different herbicide program. Yields for the modified no-till system are assumed to be equal to those obtained with the no-till system used in the experiment.

The hard red winter wheat cultivar Danne was seeded in late September or early October, depending upon soil moisture, to each plot in all years at a rate of 60 pounds/acre. When the study was initiated, a commercial no-till drill was not available to the researchers. Initially, an attempt was made to use a standard hoe drill with spear-point openers. However, the surface residue from prior wheat crops would not flow freely between the spear-points in the no-till plots, and the spear-points did not form a furrow with consistent depth (Runyan).

A conventional hoe drill with 10 inch row spacing was substantially modified and used to seed all plots. Ripple rolling coulters (designed for use on a no-till corn planter) 18 inches in diameter were mounted in front of the spear-point openers to cut residue. Two 55 gallon drums filled with concrete were mounted on the drill to provide down force essential for the coulters and openers to function. Press wheels 20 inches in diameter followed the openers.

Diammonium phosphate was broadcast at a rate of 100 pounds/acre and ammonium nitrate at a rate of 186 pounds/acre to each plot each year. The forage was not winter-grazed. Plots were harvested in June of each year with a combine equipped with a straw spreader. The stubble height remaining after harvest ranged from 12 to 18 inches.

To reflect changes in technology since the study was designed in 1976, several deviations relative to type and level of input use were budgeted. For example, ammonium nitrate was the primary source of nitrogen actually used in the experiment. It was replaced by 28-0-0 in the No-till and Modified No-till budgets and by 82-0-0 in the budgets for the other production systems. A seeding rate of 1.5 bushels/acre was used in the case of grazed wheat and one bushel/acre seeding rate for non-grazed wheat. Glyphosate was used as the primary herbicide in the study and is budgeted in the No-till budget. However, Landmaster® is used in the modified No-till budget.

Wheat Yields

Wheat yields obtained from each treatment for each of the ten years and the ten-year average yields are included in Table 6. Data were analyzed separately for each year and then combined and analyzed for all ten years (Epplin et al.). In eight of the ten years, yields were statistically significantly different across the six treatments at a probability level of 0.05. The Plow-15cm treatment resulted in statistically significantly greater yields than the No-till treatment in seven of the ten years.

When averaged over the ten years, yields from both plow treatments, Plow-23cm and Plow-15cm, were greater than yields of the other four treatments. The mean yield for both the Plow-23cm and Plow-15cm treatments was 34 bushels/acre. Average yield from the Disk treatment was 31 bushels/acre which was statistically significantly less than that obtained from either Plow treatment but greater than that obtained from plots of the

Table 6. Wheat Yield for Ten Years at Lahoma, Oklahoma from Alternative Production Systems.

	---Wheat Yields by Year (bushels/acre)---										
Treatment	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Mean
Chisel	21.6	24.3	51.0	30.3	26.9	23.2	28.0	29.6	14.9	24.6	27.4
Plow-23cm	29.4	35.6	48.0	29.9	26.9	40.7	40.2	54.2	14.0	23.3	34.2
Disc	27.8	31.9	52.3	33.9	23.6	36.2	30.8	34.1	13.5	22.1	30.6
Plow-15cm	34.0.	38.2	50.2	35.4	23.9	36.6	32.3	46.5	14.3	30.1	34.2
Sweep	20.1	23.0	48.5	24.8	22.7	20.9	22.5	32.3	13.2	23.2	25.1
No-till	16.5	28.7	50.7	18.1	32.0	14.7	9.9	37.1	13.7	21.4	24.3

Chisel treatment (27 bushels/acre). Yields from the Chisel treatment exceeded those of the Sweep and No-till treatments. The lowest mean yield of 24 bushels/acre was obtained from the No-till treatment. Over time, cheat (Bromus secalinus L.) became a serious weed problem in the No-till and Sweep plots. Relative yield results are consistent with those reported by others for the more humid regions of the Great Plains (Bauer and Black; Daniel et al.; Davidson and Santelmann; Harper; Heer and Krenzer).

Measurements of surface residue at planting were not recorded. However, based upon prior research of the effects of tillage operations on residue, the average wheat grain yields obtained from the six treatments were inversely related to the amount of residue from the previous wheat crop retained on the surface at planting. That is, the highest yields were obtained from tillage systems which incorporated all residue of the previous crop, and the lowest yields were obtained from treatments which maintained the largest percentage of residue on the surface.

In general, yields obtained from experiment station trials are preferred over county and state average yields for farm level analysis because the variability on an experiment station is more likely to approximate the variability experienced by individuals who farm in the vicinity of the station. Data from the agronomic study and county and state average yields were fitted with ordinary least squares to verify differences in variability and to test for trends in wheat grain yields. The results, which are reported in Table 7, show that the experiment station yields were indeed more variable than county and state average yields. No significant trends in average yields were present in either the experiment station or the county or state averages. Hence, it is not necessary to detrend the grain yields for the programming model.

Table 7. Linear Trend Analysis of Wheat Yields.[a]

Yield	Mean	Standard Deviation	$\hat{\beta}_0$	$\hat{\beta}_1$	R^2
Average yields obtained in experiment (1977-1986)	29.31	9.58	35.27	-1.08 (-1.03)[b]	.12
Garfield County average yields:					
1977-1986	35.48	4.54	36.45	-.177 (-.37)	.01
1982-1991	34.16	5.50	38.03	-.884 (-1.58)	.24
1977-1991	34.57	5.08	37.36	-.35 (-1.16)	.09
Oklahoma State Average yields 1977-1986	31.20	4.05	29.53	.303 (.66)	.05

Source: Agricultural Statistics, Oklahoma Department of Agriculture.

[a] The regression equation is $\hat{Y} = \hat{\beta}_o + \hat{\beta}_1 X$, where $\hat{Y}$ is wheat yield in bushels per acre and X is year with 1977 or 1982 equal 1.

[b] Values in parentheses are estimated student t-values. All computed t-values are smaller than the critical t-value of 2.306 at the 5 percent level of significance for eight degrees of freedom.

Preparation of Machinery Complements

A machinery selection model developed by Kletke and Sestak was used to prepare machinery complements for a farm of 600 acres for each of the seven systems. The machinery complements contain only those implements required to complete the tillage and seeding operations for the farm with the assumption that the entire farm is seeded each year to winter wheat. For example, the Plow-23cm complement includes a tractor, moldboard plow, disk, springtooth, and conventional grain drill. The machinery complements do not include a combine or grain truck since most of the wheat produced in Oklahoma is harvested and hauled by custom operators. Custom harvesting costs are included directly in the enterprise budgets which are reported in Tables 8 and 9. Complements for the No-till and Modified No-till systems are identical.

Annual machinery ownership (depreciation, insurance, taxes, and interest) and operating costs (fuel, oil, lubricants, repairs, and labor) were computed for the 600 acre farm and converted to a per acre basis. Results are summarized in Tables 8 and 9. The machinery labor requirements by month for the 600 acre wheat farm for each of the seven tillage systems are reported in Table 10.

Stocker Steer Production on Winter Wheat

In the southern Great Plains, including Oklahoma, hard red winter wheat is grown for two purposes -- to produce wheat for grain and to produce forage for cattle. Stocker cattle may be grazed on winter wheat from November through February and the grain crop may be harvested in June. If the stocker cattle are permitted to graze the wheat

Table 8. Enterprise Budgets for Grain Only Wheat Production for Seven Tillage Systems With 1991 Prices.

Item	Units	Price	Chisel Quantity	Chisel Value	Plow-23cm Quantity	Plow-23cm Value	Disk Quantity	Disk Value	Plow-15cm Quantity	Plow-15cm Value	Sweep Quantity	Sweep Value	No-till Quantity	No-till Value	Modified No-till Quantity	Modified No-till Value
Receipt																
Wheat	bu.	$ 2.85	27.40*	78.09	34.20	97.47	30.60	87.21	34.20	97.47	25.10	71.54	24.30	69.26	24.30	69.26
Total Receipts				78.09		97.47		87.21		97.47		71.54		60.51		60.51
Operation Inputs																
Wheat Seed	bu.	$ 5.00	1	5.00	1	5.00	1	5.00	1	5.00	1	5.00	1	5.00	1.5	7.50
18-46-0	cwt.	$12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00
Anhydrous Ammonia (82-0-0)	cwt.	$ 9.00	0.63	5.67	0.63	5.67	0.63	5.67	0.63	5.67	0.63	5.67	0	0.00	0	0.00
Fertilizer Application	acre	$ 2.50	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.50	1	2.50
28-0-0	cwt.	$ 6.85	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1.86	12.74	1.86	12.74
Land Master	oz	$ 0.15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	132	19.80
Glyphosate	pint	$ 5.85	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4.66	27.26	0	0.00
Machinery Labor	hrs.	$ 6.00	0.82	4.92	0.91	5.46	0.58	3.48	0.79	4.74	0.56	3.36	0.36	2.16	0.44	2.64
Fuel Lube and Repair	acre			8.69		10.30		6.16		8.60		5.42		4.60		5.53
Annual Operating Capital	$	$ 0.09	27.21	2.45	28.82	2.59	24.23	2.18	27.01	2.43	23.59	2.12	49.70	4.47	45.16	4.06
Custom Harvest & Haul																
Base Charge	acre	$12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00
Excess for > = 20	bu.	$ 0.12	7.40	0.89	14.20	1.70	10.60	1.27	14.20	1.70	5.10	0.61	4.30	0.52	4.30	0.52
Hauling	bu.	$ 0.12	27.40	3.29	34.20	4.10	30.60	3.67	34.20	4.10	25.10	3.01	24.30	2.92	24.30	2.92
Total Operating Cost	$/acre			54.91		58.83		51.43		56.25		44.20		86.17		79.70
Machinery Fixed Cost	$/acre			17.57		21.65		19.78		21.65		15.57		14.96		14.96
Total Operating & Fixed Cost	$/acre			72.47		80.48		71.21		77.90		64.77		91.00		94.80
Return to land, labor, overhead, risk and management	$/acre			5.62		16.99		16.00		19.57		6.77		-21.75		-25.54

* Average yield obtained in the ten year experiment.

Table 9. Enterprise Budgets for Grain and Grazing Wheat Production for Seven Tillage Systems With 1991 Prices.

			Chisel		Plow-23cm		Disk		Plow-15cm		Sweep		No-till		Modified No-till	
Item	Units	Price	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Receipt Sources																
Wheat	bu.	$ 2.85	27.40*	78.09	34.20	97.47	30.60	87.21	34.20	97.47	25.10	71.54	24.30	69.26	24.30	69.26
Total Receipts				78.09		97.47		87.20		97.47		71.54		69.26		69.26
Operation Inputs																
Wheat Seed	bu.	$ 5.00	1.5	7.50	1.5	7.50	1.5	7.50	1.5	7.50	1.5	7.50	1.5	7.50	1.5	7.50
18-46-0	cwt.	$12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00
Anhydrous Ammonia (82-0-0)	cwt.	$ 9.00	1.12	10.08	1.12	10.08	1.12	10.08	1.12	10.08	1.12	10.08	0	0.00	0	0.00
Fertilizer Application	acre	$ 2.50	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.50	1	2.50
28-0-0	cwt.	$ 6.85	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3.29	22.54	3.29	22.54
Land Master	oz	$ 0.15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	132	19.80
Glyphosate	pint	$ 5.85	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4.66	27.26	0	0.00
Machinery Labor	hrs.	$ 6.00	0.82	4.92	0.91	5.46	0.58	3.48	0.79	4.74	0.56	3.36	0.36	2.16	0.44	2.64
Fuel Lube and Repair	acre			8.69		10.30		6.16		8.60		5.42		4.60		5.53
Annual Operating Capital	$	$ 0.09	32.39	2.92	34.01	3.06	29.42	2.90	28.77	2.59	47.76	4.30	58.92	5.30	54.38	4.89
Custom Harvest & Haul																
Base Charge	acre	$12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00	1	12.00
Excess for > = 20	bu.	$ 0.12	7.40	0.89	14.20	1.70	10.60	1.27	14.20	1.70	5.10	0.61	4.30	0.52	4.30	0.52
Hauling	bu.	$ 0.12	27.40	3.29	34.20	4.10	30.60	3.67	34.20	4.10	25.10	3.01	24.30	2.92	24.30	2.92
Total Operating Cost	$/acre			62.28		66.21		58.81		63.63		56.57		99.29		92.84
Machinery Fixed Cost	$/acre			17.57		21.65		19.78		21.65		15.57		14.96		14.96
Total Operating & Fixed Cost	$/acre			79.85		87.86		78.59		85.28		72.14		114.25		107.80
Return to land, labor, overhead, risk and management	$/acre			-1.78		9.61		8.62		12.19		-0.69		-44.99		-38.54

* Average yield obtained in the ten year experiment.

Table 10. The Machinery Labor Requirements for the Representative Wheat Farm for Each of the Alternative Tillage Systems.

Month	Chisel	Plow-23cm	Disk	Plow-15cm	Sweep	No-till	Modified No-till
January							
February							
March							
April							
May							
June							
July	132.51	211.05	70.87	140.64	64.83	41.25	41.25
August	251.83	169.86	169.86	169.86	161.83	12.38	12.38
September	110.30	163.04	105.15	163.04	112.10	167.29	167.29
October							
November							
December							

beyond the jointing stage of the wheat plants (typically the middle of March) grain yield will be reduced.

Stocker steer activities on winter wheat and stocker steers on wheat for grazeout are included as potential activities for the representative farm. It is assumed that wheat yield is not affected by winter grazing from November to the middle of March. However, for the grazeout activity, in which grazing is extended from the first of March to the first of May, the entire grain crop is sacrificed. The model will include three alternatives for stocker steers: winter grazing, winter grazing and grazeout, and grazeout.

Walker et al. reported that most wheat pasture stocker cattle for North Central Oklahoma are purchased between October 1 and October 15. They also reported that on average 73 percent of the wheat stockers are placed on the wheat between November 1 and November 18. More than 70 percent of the stockers purchased to graze wheat weigh between 351 and 500 pounds (Walker et al.). The production coefficients used in the model are based upon estimates included in enterprise budgets prepared by Teague et al.

Time series information regarding the impact of weather and climate on yield (weight gain) of stocker steers on wheat is not available for the region. Hence, for the purposes of this study, the technical parameters are assumed to be deterministic (fixed). Assumptions regarding technical parameters are as follows:

Winter Grazing: purchase steers at 450 pounds on October 15; 2 percent death loss; 3 percent shrink; 2 pounds average net gain per day; 0.5 head per acre stocking rate; placed on winter wheat pasture for 135 days; removed and sold on March 1 at weight of 690 pounds (Teague et al.).

Winter Grazing and Grazeout: purchase at 450 pounds on October 15; 2 percent death loss; 3 percent shrink; 2.1 pound average net gain per day; 0.5 head per acre stocking rate during winter grazing months (November through February); 1 head per acre stocking rate during grazeout months (March to May 1); placed on wheat pasture for 195 days; removed and sold on May 1 at weight of 825 pounds (Teague et al.).

For both the winter grazing and winter grazing and grazeout activities it is assumed that the animals require two weeks of supplemental feeding and conditioning, from October 15 to November 1, prior to placement in the wheat field. It is assumed that all animals are purchased in October. Animals for the winter grazing and grazeout activity are simply "carried over" into the grazeout months. The third livestock production activity is for animals that are purchased in the Spring for grazeout. Technical parameters for this activity are as follows:

Grazeout: purchase at 690 pounds on March 1; no death loss; 3 percent shrink; 2.68 pound average net gain per day; 1 head per acre stocking rate; placed on wheat fields for 60 days from March 1 to May 1; sold at 825 pounds on May 1.

Total cost of livestock production for 1991 excluding the cost of purchasing the steer calves and the cost of wheat pasture were obtained from Teague et al. for stocker steers on grazing winter wheat and grazeout. These estimates are included in Tables 11 and 12. The cost for stocker steers on grazeout wheat pasture is assumed to be the same as stocker steers on grazing and grazeout excluding the cost of medicines, feed during conditioning and forage cost. Moreover, the cost of salt and minerals was computed by subtracting the cost on the grazing budget from the cost on the grazing and grazeout

Table 11. Enterprise Budget for Stocker Steers on Winter Wheat Pasture in North Central Oklahoma.

Operating Inputs	Units	Price	Quantity	Value
Steer Calves	cwt	$102.75	4.50	$462.38
*Med. Feed during				
Cond.	lbs.	0.12	110.00	13.20
Wheat Pasture Charge				
Leased Pasture	cwt	0.00	0.00	0.00
Own Pasture				
Owned Land	cwt	3.60	4.50	16.19
Rented Land	cwt	7.65	4.50	34.43
Grain Sorghum Stalks Pasture Charge				
Leased Pasture	hd	0.00	1.00	0.00
Own Pasture				
Owned Land	hd	0.90	1.00	0.90
Rented Land	hd	1.95	1.00	1.95
*Forage	lbs	0.02	400.00	8.65
*Salt & Minerals	lbs	0.22	15.75	3.47
*Hedging Charge	cwt	1.00	7.11	7.11
*Vet Services	hd	9.00	1.00	9.00
*Vet-Med-Ls Supp.	hd'	2.08	1.00	2.08
*Hired Livestock				
labor	hr	5.50	0.11	0.60
Machinery & Equipment				
*Fuel & Lube	dol			5.57
*Repairs	dol			3.66
TOTAL VARIABLE COSTS				$569.19
Fixed Costs	Units			Value
Machinery				
*Depreciation	dol			11.47
*Taxes	dol			0.32
*Insurance	dol			0.12
Equipment				
*Depreciation	dol			3.37
*Taxes	dol			0.25
*Insurance	dol			0.15
TOTAL FIXED COSTS				$15.69
Production				
Days held on				
pasture	135			
Death Loss	0.02			
Shrink	0.03			
Gain/Day	2.00			
Ending Weight	7.11			
Steers	cwt	90.47	6.90	$623.94
Residual Above Total Variable Costs, Per Head				$54.76
Residual Above Total Variable and Fixed Costs, Per Head				$39.07

Source: Adapted from Teague, et.al.

* Cost of items with asterisks are summed to obtained the gross cost of the activity for the programming models.

Table 12. Enterprise Budget for Stocker Steers on Grazeout Wheat Pasture in North Central Oklahoma.

Operating Inputs	Units	Price	Quantity	Value
Steer Calves (400-500)	cwt	$102.75	4.50	$462.38
*Med. Feed during				
Cond.	lbs.	0.12	110.00	13.20
Wheat Pasture Charge, Grazeout Wheat Portion				
Leased Pasture	cwt	0.00	0.00	0.00
Own Pasture				
Owned Land	cwt	1.60	6.00	9.57
Rented Land	cwt	3.40	6.00	20.43
Grain Sorghum Stalks Pasture Charge, Winter Wheat Portion (incl.G.S. Stalks)				
Leased Pasture	cwt	0.00	0.00	0.00
Own Pasture				
Owned Land	cwt	3.79	4.50	17.05
Rented Land	cwt	8.09	4.50	36.42
*Forage	lbs	0.02	400.00	8.65
*Salt & Minerals	lbs	0.22	22.75	5.01
*Hedging Charge	cwt	1.00	8.51	8.51
*Vet Services	hd	9.00	1.00	9.00
*Vet-Med-Ls Supp.	hd	2.08	1.00	2.08
*Hired Livestock				
labor	hr	5.50	0.11	0.60
Machinery & Equipment				
*Fuel & Lube	dol			5.57
*Repairs	dol			3.66
TOTAL VARIABLE COSTS				$602.12
Fixed Costs	Units			Value
Machinery				
*Depreciation	dol			11.47
*Taxes	dol			0.12
*Insurance	dol			0.32
Equipment				
*Depreciation	dol			3.37
*Taxes	dol			0.25
*Insurance	dol			0.15
TOTAL FIXED COSTS				$15.69
Production				
Days held on				
pasture	195			
Death Loss	0.02			
Shrink	0.03			
Gain/Day	2.10			
Ending Weight	8.51			
Steers	cwt	83.22	8.25	$686.55
Residual Above Total Variable Costs, Per Head				$84.43
Residual Above Total Variable and Fixed Costs, Per Head				$68.74

Source: Adapted from Teague, et.al.

* Cost of items with asterisks are summed to obtained the gross cost of the activity for the programming models.

budget. Livestock labor requirements were obtained from the enterprise budgets prepared by Walker et al.

Prices and Costs

Time series of prices for wheat grain and stocker cattle were used to estimate the net returns resulting from each production activity. For the model, 1982-1991 wheat grain and stocker prices were used rather than the prices which prevailed over the time period of the field experiment (1977-1986). Table 13 includes the mean, standard deviation, and coefficient of variation for wheat prices for both time periods. Since there is no significant trend in wheat yields (Table 7) and no correlation between average yields (Table 14) and prices over the two periods of 1977 to 1986 and 1982 to 1991, the more recent prices 1982-1991 were used to conduct the analysis.

Correlation Between Yields and Prices

A simple correlation between average wheat yields and wheat prices over the period from 1977 to 1986 was calculated to determine if wheat prices and yields were correlated over the time period. This test was conducted to justify the use of the more recent prices 1982-1991 instead of the 1977-1986 prices which was the period during which the experiment was conducted, since in the aggregate, one would expect that prices and yields are correlated. The results indicate that over the time period of the study wheat prices were not correlated with the average yield obtained from the experiment. The null hypothesis of zero correlation could not be rejected at 5 percent level of significant (Table 14).

Table 13. Mean, Standard Deviation, and Coefficient of Variation for Average Annual Prices, 1977 to 1986 and 1982 to 1991.

Time Period	Mean	$/bushel Standard Deviation	Coefficient of Variation
1977-1986	3.3	.61	.188
1982-1991	3.1	.55	.177

Table 14. Correlation Between Yields and Prices, 1977-1986.

Yield Source	Coefficient of Correlation (r)	$t = \frac{(r)\sqrt{(n-2)}}{\sqrt{1-r^2}}$
Experiment	.50357	1.65*
County	.67645	2.22*
State	.49905	1.64*

* Not significant at 5 percent level of significance (the computed t-values are smaller than the critical t value of 2.306 at the 5 percent level of significance for eight degree of freedom).

Operating Capital

The annual operating capital required for each alternative wheat production system was calculated and is reported in the budgets. The annual operating capital in 1991 dollars for each of the livestock activities was calculated to be \$179.22, \$294.85, and \$109.70 for stocker steers on grazing, grazing and grazeout, and grazeout wheat pasture, respectively. Annual operating capital is the amount of operating capital in "annualized units" necessary to conduct the crop or livestock production activity. For example, consider that the grazeout activity requires approximately \$660 of operating capital for two months. That is, \$660 must be invested in the enterprise and is not available for investment elsewhere. The cost of this amount of capital is equivalent to the cost of \$110 of capital for one year. Hence, the activity requires \$110 of "annual" operating capital. Capital is not a constraint in the model. The total annual operating capital required for the farm will be determined by the model and is available at a fixed price of nine percent per annum in 1991 dollars.

Derivation of Real Prices

In most risk programming applications time series prices are adjusted to reflect the real rather than nominal value over time. Brink and McCarl used the parity index to express all gross margins in constant dollar values to remove the upward trend often associated with gross margins per acre over time. Mapp et al. adjusted prices for trend where appropriate and expressed returns and costs in constant dollars. They adjusted the cost of production for each activity by using the index of prices paid by farmers.

Wheat Prices

Wheat prices used in the model are Oklahoma season average prices. This is consistent with the practice used by other researchers (Mikesell et al.; Williams et al.). To adjust prices to a 1991 basis, the implicit price deflator for gross domestic product was used. The index numbers for 1981 through 1991 were divided into their associated 1991 index to obtain the adjustment factor (McSweeny and Kramer). Table 15 includes the implicit price deflator for gross domestic product from 1981 through 1991, as well as the corresponding adjustment factors. Nominal and real wheat prices are presented in Table 16.

Livestock Prices

Livestock prices used in the analysis are based upon monthly average prices which prevailed at the Oklahoma City stockyards. Prices reported for 400 to 500 pound steers were used to represent the price for 450 pound steers in the model. A similar procedure was used to obtain prices for 690 pound steers. The average prices for steers weighing between 600 and 700 pounds and steers weighing between 700 and 800 pounds (Table 17) were adjusted to 1991 prices using the implicit price deflator for gross domestic product, 1982 to 1991 (Table 18).

Gross Margins

Gross margins for each of the alternative crop and livestock production systems are calculated based upon an assumption of nonparticipation in government programs. The estimated gross margins for the wheat production activities were calculated by

Table 15. Implicit Price Deflators for Gross Domestic Product, 1981-1991.

Year	Index Number	Inflation Factor
1981	78.9	1.49
1982	83.8	1.41
1983	87.2	1.35
1984	91.0	1.29
1985	94.4	1.25
1986	96.9	1.22
1987	100.0	1.18
1988	103.9	1.13
1989	108.5	1.09
1990	113.2	1.04
1991	117.8	1.00

Source: Economic Report of the President Transmitted to Congress, Washington: G.P.O., January, 1983.

Table 16. Season Average Wheat Prices and Wheat Prices in 1991 Dollars, 1982-1991.

Year	Price ($/bu.)	Price in 1991 dollars $/bu.
1982	3.65	5.13
1983	3.51	4.74
1984	3.35	4.34
1985	2.91	3.63
1986	2.28	2.77
1987	2.46	2.90
1988	3.57	4.05
1989	3.97	4.31
1990	2.50	2.60
1991	2.85	2.85
Mean		3.75

Source: Agricultural Statistics, Oklahoma Department of Agriculture.

Table 17. Livestock Prices at the Oklahoma City Stockyards in Nominal Dollars, 1981-1991.

	Buy		Sell	
	October	March[a]	March[a]	May
Year	400-500 lbs ($/cwt)	600-700 and 700-800 lbs. ($/cwt)	600-700 and 700-800 lbs. ($/cwt)	700-800 lbs. ($/cwt)
1981	65.40	[b]	[b]	[b]
1982	67.95	70.50	70.50	63.71
1983	66.89	67.40	67.40	61.01
1984	71.61	67.40	67.40	63.08
1985	71.94	59.94	59.94	53.12
1986	93.38	70.35	70.35	69.85
1987	100.55	83.55	83.55	79.90
1988	100.71	83.31	83.31	76.76
1989	104.25	85.00	85.00	86.80
1990	104.63	92.63	92.63	89.66
1991	[b]	82.30	82.30	79.06
Mean	85.76	75.18	75.18	71.68

[a] The average value of the two series (the buying and selling weight is 690 lbs).

[b] Observations not needed for analysis.

Table 18. Livestock Prices at the Oklahoma City Stockyards in 1991 Dollars, 1981-1991.

	Buy		Sell	
	October	March[a]	March[a]	May
Year	400-500 lbs ($/cwt)	600-700 and 700-800 lbs. ($/cwt)	600-700 and 700-800 lbs. ($/cwt)	700-800 lbs. ($/cwt)
1981	97.45	[b]	[b]	[b]
1982	95.81	99.41	99.41	89.83
1983	90.30	90.99	90.99	82.36
1984	93.09	87.62	87.62	82.00
1985	89.93	74.93	74.93	66.90
1986	113.92	85.83	85.83	85.22
1987	118.65	98.59	98.59	94.28
1988	113.80	94.14	94.14	86.74
1989	113.63	92.65	92.65	94.61
1990	108.82	96.34	96.34	93.25
1991	[b]	82.30	82.30	79.06
	103.54	90.28	90.28	85.38

[a] The average value of the two series (the buying and selling weight is 690 lbs).
[b] Observations not needed for analysis.

multiplying wheat prices in 1991 dollars by the average yields per acre less variable production costs in 1991 dollars. For the purposes of the study, prices for inputs other than stocker steers, and quantities of inputs used were assumed to be deterministic. Thus, the production costs and input levels for the crop and livestock production activities were assumed to be fixed at 1991 levels. The estimated gross margins for the wheat production activities are summarized in Tables 19 and 20.

Government Programs

Previous researchers who have incorporated the provisions of government programs into risk programming models have used historical price distributions with historical prices replaced by the commodity loan rates when the latter were greater (Musser and Stamoulis; Scott and Baker). Crop historical prices were multiplied by historical yield observations to obtained the gross revenue distribution. Deficiency payments were added to each income value based on target price and commodity program yields. The modified income distribution was then used to calculate expected returns from participation in government programs.

Modelling the government commodity programs poses crucial methodological questions, since the nature and structure of the programs have changed over time. There are two modelling choices: a) consider the government programs as varying over years and hence model the riskiness of participation using historical program parameters, b) regard historical program parameters as irrelevant in the current decision making context, and impose the current program parameters for the entire period under consideration treating the current program specifications as if they have been in effect throughout the

Table 19. Estimated Gross Margins of Grain Only Wheat Production Activities in 1991 Prices, 1982-1991.

Year	Chisel	Plow-23cm	Disk	Plow-15cm	Sweep	No-Till	Modified No-Till
1982	46.15	68.68	76.62	104.37	44.23	-11.33	-4.80
1983	50.08	96.31	84.66	110.34	49.73	41.54	48.07
1984	157.26	136.85	161.48	148.14	152.17	126.55	133.08
1985	45.19	36.41	56.85	58.13	30.98	-28.62	-22.09
1986	12.10	4.77	1.18	-2.14	5.86	-2.66	3.87
1987	2.18	45.60	38.43	35.41	1.23	-51.87	-45.34
1988	47.74	89.58	57.57	59.44	31.39	-54.60	-48.07
1989	63.07	162.26	81.10	130.62	41.60	66.14	72.67
1990	-26.26	-35.19	-30.64	-32.69	-24.18	-58.06	-51.53
1991	5.01	-6.03	-3.56	15.06	6.83	-33.51	-26.98
Mean	40.25	59.92	52.37	62.67	33.99	-0.64	5.89

Table 20. Estimated Gross Margins of Grain and Grazing Wheat Production Activities in 1991 Prices, (from grain only) 1982-1991.

Year	Chisel	Plow-23cm	Disk	Plow-15cm	Sweep	No-Till	Modified No-Till
1982	39.23	61.77	70.71	97.48	37.33	-23.62	-17.09
1983	43.17	89.40	78.75	103.43	42.83	29.25	35.78
1984	150.35	129.94	155.57	141.23	145.27	114.26	120.79
1985	38.28	29.50	50.94	51.22	24.08	-40.91	-34.38
1986	5.19	-2.14	-4.73	-9.05	-1.04	-14.95	-8.42
1987	-4.73	38.69	32.52	28.50	-5.58	64.16	-57.63
1988	40.83	82.67	51.65	52.53	24.49	-66.89	-60.36
1989	56.16	155.35	75.19	123.71	34.70	53.85	60.38
1990	-33.17	-42.10	-36.55	-39.60	-31.08	-70.35	-63.82
1991	-1.90	-12.94	-9.47	8.15	-.07	-45.00	-39.27
Mean	33.34	53.01	46.46	55.76	27.09	-12.93	-6.40

period. In other words, the latter approach would evaluate risk as if the current program parameters had been in place throughout the entire time period used to generate the returns distributions.

McSweeny and Kramer argued that as government programs have changed over the years, using historical program parameters, would not correctly depict the consequences of current program specifications on risk. They proposed a general method of modelling government programs, in which current program parameters are used as if the parameters had been in effect throughout the period of consideration.

Based upon the work reported by Aw-Hassan and Stoecker, it was assumed, that if continuous wheat was grown on land classified as highly erodible because of water erosion, farmers who used either the Plow-23cm or the Plow-15cm system would be out of compliance and would not qualify for deficiency payments. However, farmers who used any of the other five alternative methods are assumed to meet conservation compliance requirements.

Government Commodity Program Parameters

Data required for modelling the government programs were: the program parameters such as the target price, national statutory loan rate, national effective loan rate, local loan rate and set-aside requirements of the 1991 program, and the 5-month and 12-month US average prices required for computing deficiency payments for wheat. All program parameters except the local loan rate were based on program provisions for the 1991 crop year.

The local loan rate for Garfield County was obtained from Teague et al. The 5-month (June-October) and 12-month US average prices for the entire period were computed based on US average monthly prices published in Agricultural Prices (National Agricultural Statistics Services). Table 21 includes the program parameters which were used to calculate returns per acre for government program participation. These assumptions were used in calculating the gross returns per acre as if the 1991 government programs had been in place over the time period of 1982 to 1991.

Table 22 includes the nominal and 1991 adjusted market prices, US-5 month average prices and US-12 month average prices. McSweeny and Kramer used 1984 government programs parameters and adjusted all prices to 1984 prices using the index of price paid by farmers to put the past prices in 1984 dollars.

The 1985 legislation divided deficiency payments into two parts: a primary deficiency payments and a final deficiency payment. The primary deficiency payment is what has traditionally been referred to as the deficiency payment. The final deficiency payment is made to farmers if the Secretary of Agriculture uses discretionary power to reduce the loan rate by 20 percent to promote exports (the loan rate after reduction is referred to as the national effective loan rate NELF). If this occurs, producers will receive a final deficiency payment to provide the same total return as if the loan rate had not been reduced.

Deficiency payments are determined by the difference between the target price and the higher of the market price or the loan rate. For the purpose of computing deficiency payments, market price is a season average. The following equation adapted

Table 21. Commodity Program Parameters for Garfield County, North Central Oklahoma (1991 Crop Year).

Parameter	Wheat
Target Price ($/bu.)	4.00
National Statutory Loan Rate ($/bu.)	2.44
National Effective Loan Rate ($/bu.)	1.95
Local Loan Rate ($/bu.)	1.95[a]
Deficiency Payment ($/bu.)	1.28
Set-Aside (Percent)	5.00

[a] Teague et al.

Source: Agricultural Outlook, Economic Research Services, USDA, May 1993.

Table 22. Nominal and Adjusted (to 1991 dollars) U.S. Five Month Average Prices, U.S. Twelve Month Average Prices and Local Market Prices, 1982-1991.

Year	Local Market Prices $/bu	Adjusted Local Market Prices $/bu	US5P[a] $/bu	Adjusted US5P	US12P[b]	Adjusted US12P
1982	3.65	5.15	3.34	4.70	3.52	4.95
1983	3.51	4.74	3.95	4.66	3.45	4.78
1984	3.35	4.36	3.35	4.33	3.40	4.40
1985	2.90	3.64	2.92	3.64	3.11	3.88
1986	2.28	2.87	2.62	2.75	2.62	3.19
1987	2.46	2.90	2.33	2.80	2.95	3.48
1988	3.57	4.05	3.54	4.02	3.28	3.72
1989	3.97	4.33	3.82	4.15	3.93	4.23
1990	2.50	2.60	2.67	2.78	2.99	3.11
1991	2.85	2.85	2.78	2.78	3.78	3.78

[a] Five month U.S. average price.

[b] Twelve month U.S. average price.

from McSweeny and Kramer was used to compute the different components of government payments.

$$[\text{MAX (MP, LLR)}]\ Y + [\text{TP - MAX (US5P, NSLR)}] \bullet \text{PY} \bullet (\text{1-SA-FA}) + [\text{NSLR - MAX (US12P, NELR)}] \bullet \text{PY} \bullet (\text{1-SA-FA}) \quad [4.1]$$

where, MP is the market price, LLR is the local loan rate, Y is the wheat yield, TP is the target price, US5P is the 5-month US average price, NSLR is the national statutory loan rate, PY is the program yield, SA is the set aside percent, FA is the normal FELX percent. US12P is the 12-month US average price and NELR is the national effective loan rate. The market price is the season average price. Government payments per acre are presented in Table 23.

Set-Aside Acres

To be eligible for deficiency payments, a producer must agree to set-aside a predetermined proportion of the farm's wheat base acres to conserving uses. However, wheat producers in Oklahoma have been permitted to seed wheat on the set-aside land and have been permitted to graze the set-aside land. Hence, the only restriction is that it not be harvested for grain and grazed beyond a specific date, usually May 15. In the case of grazed wheat production systems, the set-aside acres were modeled to be used in either grazing, grazing and grazeout, or grazeout activities.

The model was constructed to provide for alternative uses of the set-aside acres. If the land is to be grazed, it is treated in the same fashion as the non set aside land except that it is not harvested. For non-grazed wheat production systems, the variable

Table 23. Deficiency Payments and 0/92 Payments Estimated Risk Programming Model.

Year	Target Price $/bu	US5P (1991 dollars) $/bu	Deficiency Payment[a] $/bu	Program Yield bu/acre	Deficiency Payment $/acre paid[b]	0/92 Payments $/acre paid[b]
1982	4.00	4.70		35		
1983	4.00	4.66		35		
1984	4.00	4.33		35		
1985	4.00	3.64	0.36	35	12.60	11.60
1986	4.00	2.75	1.25	35	43.75	40.25
1987	4.00	2.80	1.20	35	42.00	38.64
1988	4.00	4.02		35		
1989	4.00	4.15				
1990	4.00	2.78	1.22	35	42.70	39.28
1991	4.00	2.78	1.22	35	42.70	39.28
Mean					18.38	16.91

[a] The deficiency payment is zero if the target price is less than the US5P and equal to the target price minus the US5P otherwise.

[b] Acre paid = Base (1 - SA - FA), where SA = set-aside percent and FA = normal flex percent.

cost per acre for set-aside for each of the alternative tillage systems were adjusted to reflect maintenance cost by assuming certain field operations would be conducted (Table 24).

0/92 Program

In addition to the government commodity programs as described above, the 0/92 program is also available to wheat farmers. Under this program, producers are allowed to devote all or a portion of their wheat base acres to conserving uses and receive deficiency payments of 92 percent (Table 23) of what would have been received if wheat had been planted and harvested for grain subject to the set-aside provision. Farmers have the choice of allocating some proportion of their wheat acreage base to this program and be paid deficiency payments on that proportion on the 0/92 basis and to receive regular commodity program participation payments from the base acres allocated to the regular program. Base acres allocated to the 0/92 program may be seeded to wheat and grazed until June 1. The model was constructed such that any proportion of the wheat acreage base may be allocated to the 0/92 program.

Model Structure and Parametric Solutions

A conventional LP model is constructed to maximize expected total gross margins subject to technical, resource, and non-negativity constraints. The Target MOTAD model as described in Chapter III is constructed to maximize expected returns subject to technical, resource, and non-negativity constraints, and subject to achieving a targeted

Table 24. Field Operations Budgeted for Each Tillage System for Set-Aside Acres.

System	Primary ------------------Field Operations	Secondary -------------------
Chisel	chisel	chisel
Plow-23 cm	plow	plow
Disk	disk	disk
Plow-15 cm	plow	plow
Sweep	sweep	sweep
No-till	spray	spray
Modified No-till	spray	spray

level of income. A basic LP model was constructed and extended into a Target MOTAD model. This was done to incorporate risk as measured by two parameters. These are the target level T, and the level of expected short-fall from T as defined by λ (equation 3.29).

McCamley and Kliebenstein determined that the optimal solution for any specific combination of T and λ typically shares a basis with optimal solutions for a large number of other T and λ combinations. Therefore, although the number of Target MOTAD enterprise mixtures is usually infinite, the number of bases associated with these mixtures is finite. Given a value of λ, there exists a target income, denoted by $T_L(\lambda)$, such that the model with a target income level less than $T_L(\lambda)$ will be identical to the deterministic linear programming solution. There also exists another target income value, denoted by $T_u(\lambda)$, such that a model with a target income exceeding $Tu(\lambda)$ is infeasible (Zimet and Spreen). In this study, the $T_L(\lambda)$ and $T_u(\lambda)$ for $\lambda = 0$, were determined for each scenario. Then several target income levels that have values between $T_L(\lambda)$ and $T_u(\lambda)$ were used in the analysis when negative income deviation are prohibited and negative income deviation ignored. Moreover, a target income is specified for the farm • risk is measured as the expected short fall (λ) from the target. The parameter λ was initially set at a large value. In this case, the Target MOTAD model was equivalent to the deterministic linear programming. As λ was reduced, solutions that varied from the deterministic LP occurred. All optimal solutions and associated farm plans are reported. The parametric routine of MPSX as described in Chapter 6 of Hazell and Norton was used to identify the basis change points on the expected mean deviation below the target frontier.

The livestock activities which used wheat pasture during grazing and grazeout months were linked to wheat activities (grazing, grazing and grazeout, and grazeout) with balance or transfer rows.

Mixed Integer Programming

A basic assumption of standard linear programming is that the activities in the model are continuous variables. That is, they can take on noninteger values. Participation in the government program can not be treated as a continuous variable. It is an either-or proposition and may be considered a zero-one type integer variable which takes on a value of one if it is economical for the farm to participate and a value of zero if participation is not economical.

An evaluation of the economics of government program participation with traditional linear programming would require that two models be solved -- one for participation and another for nonparticipation. The more profitable of the two would be the optimal choice. Any time a variable is changed, both models should be solved and the solutions compared. This procedure was followed in this study for evaluating government programs participation. If the program participation decision had been set up as a zero/one integer variable, with appropriate relationships to the non-integer crop-mix variables, the model would directly determine the optimal of combined program participation and crop mix decision (Hoag and Holloway).

CHAPTER V

RESULTS OF THE ANALYSIS

The purpose of this study was to generate information which could be used by Oklahoma farmers who produce wheat for grain and grazing. More specifically, the model as described in the previous chapter was designed to determine the economics of alternative tillage systems for wheat production; the economic consequences of noncompliance and nonparticipation as well as compliance and participation in wheat commodity programs; and the economics of grazing the wheat forage under the institutional constraints of the wheat programs. It was designed to determine risk efficient tillage and government program participation strategies for Oklahoma farmers who produce wheat for grain as well as farmers who produce wheat for grain and grazing.

This chapter includes a presentation and analysis of the results of the risk programming model. The chapter is divided into two sections. The first section includes the results for models which did not include grazing activities. These models are designed to represent farms in the region which produce wheat for grain. The second section includes a summary of the results from models designed to represent farms on which wheat is produced for both grain and forage production. The value of the forage is determined by the stocker steer production activities which are included in these models.

Risk efficient farm plans are generated which would be appropriate for risk neutral as well as risk averse farmers. The Target MOTAD method was used to determine the risk efficient farm plans for six alternative situations as follows:

Scenario 1: Grain, no participation in government commodity programs.

Scenario 2: Grain, participation in government commodity programs with land not classified as highly erodible.

Scenario 3: Grain, participation in government commodity programs with land classified as highly erodible.

Scenario 4: Grain and Forage for Stocker Steers, no participation in government commodity programs.

Scenario 5: Grain and Forage for Stocker Steers, participation in government commodity programs with land not classified as highly erodible.

Scenario 6: Grain and Forage for Stocker Steers, participation in government commodity programs with land classified as highly erodible.

The following sections contain the results of the analysis for the six scenarios. Based upon the work reported by Aw-Hassan and Stoecker, it was assumed that if continuous wheat was grown on land classified as highly erodible because of water erosion, farmers who use either the Plow-23 or the Plow-15 system would be out of compliance and would not qualify for deficiency payments. However, all other wheat production systems (Disk, Sweep, Chisel, No-till, Modified No-till) are assumed to meet conservation compliance requirements. A listing of the abbreviated names and a descriptive summary for the activities of the model is included in Table 25.

Table 25. Definition of Production Activities Selected by the Risk Programming Models.

Variable Names	Definitions
CHISEL	The production of one acre of wheat for grain with the chisel tillage system.
DISK	The production of one acre of wheat for grain with the disk tillage system.
PLOW-15cm	The production of one acre of wheat for grain with the plow-15cm tillage system.
SWEEP	The production of one acre of wheat for grain with the sweep tillage system.
GGDI	The production of one acre of wheat for grain and grazing with the disk tillage system.
GGPL15	The production of one acre of wheat for grain and grazing with the plow-15 cm tillage system.
GGOSW	The production of one acre of wheat for grazing and grazeout with the sweep tillage system.
SCH	One acre of set-aside tilled with chisel system.
SDI	One acre of set-aside tilled with the disk tillage system.
SPL15	One acre of set-aside tilled with the plow-15cm tillage system.
SSW	One acre set-aside tilled with the sweep tillage system.

Table 25. (continued)

SGGODI	One acre of set-aside prepared for wheat grazing and grazeout with the disk tillage system.
SGGOPL15	One acre of set-aside prepared for wheat grazing and grazeout with the plow-15cm tillage system.
STKWW	The production of one stocker steer on winter wheat pasture from November to March 1.
STKGZ	The production of one stocker steer on winter wheat pasture from November to May 1.

Tillage Strategies for a Wheat Grain Farm

This section includes a summary of the results of the mathematical programming analysis for a representative Oklahoma wheat farm. Results are presented which would be relevant for decisions makers who seek to maximize profit and can be said to be risk neutral as well as for producers who are risk averse.

Grain Farm Plans for Risk Neutral Producers

The appropriate objective function for a farmer who is risk neutral is to maximize expected returns. The mix of activities which will maximize expected returns can be obtained by standard linear programming (LP). The risk neutral results for Scenarios 1, 2, and 3 are summarized in Table 26.

The optimal strategy is to moldboard plow (Plow-15) the entire farm for both Scenarios 1 and 2. If the land is classified as highly erodible, and the farmer elects to participate in the government program, the Disk system is most economical. The expected return to the land, family labor, overhead, and management resources of the farm which chooses to not participate in the government commodity program (Scenario 1) is $34,336. Participation is expected to generate an average deficiency payment of $8,372 per year. The participating farm has an expected return of $40,790 if the land is nonerodible, and $35,351 if the land is erodible.

The results indicate that nonparticipation (Scenario 1) in the government programs is costly, and depending upon the farmer's utility function, may be irrational. Nonparticipation results in the lowest income and the highest variance across the three

Table 26. Profit Maximization Plans (LP Solution) for Three Scenarios for the Wheat for Grain Farm.

		Farm Plan		
Characteristic	Unit	Scenario 1[a]	Scenario 2	Scenario 3
Expected Return	$	34,336	40,790	35,351
s.d.	$	32,379	22,935	21,225
c.v.		94	56	60
Activity				
Plow-15	acre	570	542	
Disk	acre			542
SPL15	acre		28[b]	
SDI	acre			28
Average Deficiency Payment	$		8,372	8,372
Capital	$	15,396	14,626	13,120

[a] Scenario 1 represents a farm that is not enrolled in the wheat commodity program. Scenarios 2 and 3 represent farms that are enrolled for participation in the program, with 2 on nonerodible land and 3 on erodible land.

[b] To qualify for deficiency payments, 5 percent (28 acres) of the base acres must be set-aside to conserving uses.

grain only scenarios. For those farmers whose utility functions can be expressed in terms of expected returns and variance, the nonparticipation scenario would not be appropriate. It is dominated by both the optimal plans for Scenario 2 and Scenario 3, since they both have greater expected returns and lower variance of expected returns. It is clear that government programs increase the expected returns, decrease the variance of expected returns, and are important for wheat producers in the region.

Grain Farm Plans for Risk Averse Producers

Target MOTAD was used to identify farm plans which would be appropriate for farmers who are risk averse. Feasible target income levels were arbitrarily selected such that the initial value of λ was set to zero. $T_L(\lambda)$ was estimated to be \$-20,000, while $T_u(\lambda)$ was \$1,000. These two target incomes and several others that have a value between $T_L(\lambda)$ and $T_u(\lambda)$ were chosen for the analysis. The parameter λ was initially set to zero such that income deviations below the target were prohibited. The parametric programming routine of MPSX was used to parameterize the value of λ to identify all basis changes until the Target MOTAD solution was equivalent to the deterministic linear programming solution. At each change of basis, the value of λ and the corresponding optimal solution and associated enterprise mix for each target income were reported.

Scenario 1. The optimal plan, expected income, and corresponding value of λ and T at which basis changes occurred for Scenario 1 are presented in Table 27. As could be expected, in the models which include only wheat for grain production activities, there is little opportunity for risk management by diversification. In the absence of government commodity programs, and with no opportunity to produce other

Table 27. Target MOTAD Farm Plans for the Wheat for Grain Farm Which Does Not Participate in the Government Programs.

Plan[a]	Target Return	Expected Deviation	Expected Return	Activities Level Plow-15	Slack[b]
	-----	$	-----	acres	-----
	-20,000	0	34,336[c]	570	
	-18,000	0	30,573	513	57
	-18,000	202	34,336	570	
B	-15,000	0	25,728	427	143
	-15,000	502	34,336	570	
	-12,000	0	20,582	342	228
	-12,000	801	34,336	570	
C	-9,000	0	15,437	256	314
	-9,000	1,101	34,336	570	
	-6,000	0	10,291	171	399
	-6,000	1,401	34,336	570	
D	-3,000	0	5,146	85	485
	-3,000	1,701	34,336	570	
	-2,000	0	3,430	57	513
	-2,000	1,337	26,358	438	132
	-2,000	1,826	34,336	570	
	-1,000	0	1,715	28	542
	-1,000	668	13,179	219	351
A	-1,000	2,026	34,336	570	

[a] The plans selected for stochastic dominance analysis.
[b] Land that is not farmed.
[c] LP solution.

crops, or to produce forage for livestock, the producer has little choice. The optimal strategy is to use the Plow-15 system. It is the only strategy among those reported in Table 27, for which all the land is farmed.

Scenario 2. Results for Scenario 2 are reported in Table 28. This scenario extended the previous scenario to include government commodity program participation. Provisions for set-aside requirements for the standard wheat program, deficiency payments, and the 0/92 program were incorporated into the model. Participation on the 570 acres of wheat base requires that 28 acres (5 percent of the base) be set aside to conserving uses. Harvest of the 5 percent set aside is prohibited. However, harvest of the 15 percent mandatory flexible acres is optional whereas harvest of the remaining 80 percent is required. Hence the full deficiency payment, which has an expected value of $8,372, may be received as long as 80 percent (456 acres) but no more than 95 percent (542 acres) is harvested for grain.

For Scenario 2 $T_L(\lambda)$ was estimated to be $400 and $T_u(\lambda)$ $7,000. Several target income levels ranging from $400 to $7,000 were arbitrarily selected. For each level of target income λ was parameterized from zero to the level necessary to obtain the profit maximizing solution. Farm plans generated under Scenario 2 are presented in Table 28. The results for Scenario 2 are essentially the same as those for Scenario 1. The appropriate strategy is to use the Plow-15 system. However, when provided the option to participate in the government program, it is clearly optimal to do so. One alternative is to use the Plow-15 system on 456 acres, set aside 24 acres to conserving uses and idle the 90 mandatory flexible acres. However, this alternative would reduce the expected

Table 28. Target MOTAD Farm Plans for the Wheat for Grain Farm Which has Nonerodible Land and Participates in the Government Programs.

Plan[a]	Target Return	Expected Deviation	Expected Return	Avg. Def. Pay.	Activities Levels				
					Plow-15	Sweep	SPL15	SSW	Slack[b]
	$				acres				
	400	0	40,789[c]	8,372	542		28[d]		
	1,000	0	39,798	8,372	523		28		19
	1,000	58	40,789	8,372	542		28		
G	2,000	0	38,097	8,372	495		26		49
	2,000	158	40,789	8,372	542		28		
H	3,000	0	36,398	8,372	467		24		79
	3,000	258	40,789	8,372	542		28		
	4,000	0	33,745	8,372	385	71	20	4	90
F	4,000	62	35,765	8,372	456		24		90
	4,000	358	40,789	8,372	542		28		
	5,000	0	30,534	8,372	272	184	14	10	90
	5,000	162	35,765	8,372	456		24		90
	5,000	458	40,789	8,372	542		28		
	6,000	0	27,322	8,372	158	498	8	16	90
	6,000	262	35,765	8,372	456		24		90
	6,000	558	40,789	8,372	542		28		
	7,000	0	24,111	8,372	45	411	2	22	90
	7,000	362	35,765	8,372	456		24		90
E	7,000	658	40,789	8,372	542		28		

[a] The plans selected for stochastic dominance analysis.
[b] Land that is not farmed.
[c] LP solution.
[d] The model is based on the assumptions of a 5 percent set aside requirement (28 acres) and a 15 percent mandatory flexible acres requirement. Also, 80 percent of the base (456 acres) must be harvested for grain to qualify for the full deficiency payment ($8,372).

income by $5,024 from $40,789 to $35,765. The results obtained for Scenario 2 are similar to those obtained for Scenario 1 in which only the profit maximizing farm plan utilizes all land.

Scenario 3. This scenario differs from 2 in that the land is assumed to be highly erodible such that the use of tillage systems which include a moldboard plow operation (Plow-23 and Plow-15) are not permitted. By assumption, farmers who use a moldboard plow on land classified as highly erodible would not fulfill conservation compliance requirements and would not qualify for deficiency payments.

A summary of results for Scenario 3 is presented in Table 29. As with both Scenarios 1 and 2, the farm is provided with few alternatives and has little opportunity to reduce risk by diversification. All plans which were generated include full participation in the commodity program which requires a set aside of 28 acres to conserving uses. When use of the moldboard plow systems are not permitted, the most economical alternative is the Disk system. The farm may elect to idle the mandatory flexible acres. However, to do so results in a decrease in the expected income from $35,351 by $4,181 to $31,170.

In summary, the results of the Target MOTAD analysis of Scenarios 1, 2, and 3 do not provide much additional information beyond that which would be generated from standard model constructed to maximize expected income. Plow-15 is the dominant system for Scenarios 1 and 2. However, for land classified as highly erodible, the Disk system is dominant. Participation in the government commodity program increases the expected returns and decreases the variance of expected returns. It is an important risk management tool for those farmers who produce wheat for grain in Oklahoma.

Table 29. Target MOTAD Farm Plans for the Wheat for Grain Farm Which has Erodible Land and Participates in the Government Program.

Plan[a]	Target Return	Expected Deviation	Expected Return	Avg. Def. Pay.	Disk	Sweep	SDI	SSW	Slack[b]
	------$------				------acres------				
I	1,650	0	35,351[c]	8,372	542		28[d]		
	2,000	0	34,811	8,372	529		28		13
	2,000	35	35,351	8,372	542		28		
K	3,000	0	33,298	8,372	499		26		45
	3,000	135	35,351	8,372	542		28		
	4,000	0	31,786	8,372	468		25		77
	4,000	235	35,351	8,372	542		28		
L	5,000	0	29,517	8,372	366	90	19	5	90
J	5,000	59	31,170	8,372	456		24		90
	5,000	335	35,351	8,372	542		28		
	6,000	435	35,351	8,372	542		28		
	6,000	0	26,730	8,372	213	243	11	13	90
	6,000	159	31,170	8,372	456		24		90
	7,000	0	23,942	8,372	61	395	3	21	90
	7,000	259	31,170	8,372	456		24		90
	7,000	535	35,351	8,372	542		28		

[a] The plans selected for stochastic dominance analysis.
[b] Land that is not farmed.
[c] LP solution.
[d] The model is based on the assumption of a 5 percent set-aside requirement (28 acres) and a 15 percent mandatory flexible acres requirement. Also, 80 percent of the base (456 acres) must be harvested for grain to qualify for the full deficiency parymetn ($8,372).

Tillage Strategies for a Wheat Grain and Forage Farm

This section includes a summary of the results of the risk programming analysis for a representative Oklahoma farm on which wheat may be produced for both grain and forage. The forage is assumed to be produced for grazing by stocker steers. Hence, the models include stocker production as well as wheat production activities. The stockers may graze during the winter, in which case the grain may be harvested. Alternatively, stockers may graze during the winter and spring (grazeout), or during the spring (grazeout), in which case the wheat is assumed to produce no grain.

Grain and Forage Farm Plans for Risk Neutral Producers

As noted previously, the utility maximizing plan for a risk neutral decision maker is the plan which maximizes expected returns. This plan can be determined by a standard linear programming model. The results of the models for the representative Oklahoma wheat-stocker farm are presented in Table 30. The expected incomes are \$50,302, \$57,323, and \$52,552 for Scenarios 4, 5, and 6, respectively.

Participation in government programs is clearly economical. An average deficiency payment of \$8,372 is estimated for both participating farms. If the land is nonerodible, participation adds \$7,021 to expected income. For erodible land, participation adds \$2,250. Participation also reduces the variability of expected returns. The coefficient of variation is 57 for Scenario 5, 59 for Scenario 6, and 82 for nonparticipation, Scenario 4. Therefore, participation in government commodity programs not only increases the expected return but also reduces risk.

Table 30. Profit Maximization Plans (LP Solution) for Three Scenarios for the Farm Which May Produce Wheat for Grain and Forage.

		Farm Plan		
Characteristics	Unit	Scenario 4	Scenario 5	Scenario 6
Expected Return	$	50,302	57,323	52,552
s.d.		41,562	32,507	31,235
c.v.		82	57	59
Activity				
GGPL15	acre	570	542	
GGDI	acre			542
SGGOPL15	acre		28	
SGGODI	acre			28
STKWW	head	285	257	257
STKGZ	head		28	28
Average Deficiency Payment	$		8,372	8,372
Capital Requirements	$	69,426	70,167	68,588

[a] Scenario 4 represents a farm that is not enrolled in the wheat commodity program. Scenarios 5 and 6 represent farms that are enrolled for participation in the program, with 5 on nonerodible land and 6 on erodible land.

The optimal tillage strategy includes the use of a moldboard plow (Plow-15) for both the nonparticipation scenario and the nonerodible land participation scenario. For land classified as highly erodible, the Disk tillage strategy is optimal. It was assumed that the tillage system used to produce wheat for grain would also be used on that portion of the land required for set aside.

A maximum stocking density of one-half stocker steer per acre was assumed for winter grazing and one stocker steer per acre for spring grazing (grazeout). For Scenario 4 (nonparticipation), the optimal strategy is to fully stock the 570 acres which are seeded to wheat. Hence, the optimal farm plan is to winter graze 285 stockers on the wheat.

The optimal plan for those who opt for participation, Scenarios 5 and 6, is to seed the entire 570 acres to wheat and fully stock with 285 stockers. On or about March 1, 257 of the 285 stockers should be sold. The remaining 28 animals should be concentrated at a stocking density of one animal per acre on the 28 set-aside acres (5 percent of the 570 acre wheat base). The set-aside acres should be "grazed out" and the 28 remaining steers sold on or about May 1.

Grain and Forage Farm Plans for Risk Averse Producers

Target MOTAD was used to generate risk efficient farm plans for the alternative tillage strategies for the grain and forage representative farms. Methods similar to those described previously were employed.

Scenario 4. Results for Scenario 4, the nonparticipation strategy, are reported in Table 31. No set-aside requirement or restrictions on tillage systems were imposed. By definition, the farm did not qualify for deficiency payments. The $T_L(\lambda)$ and $T_u(\lambda)$ for

$\lambda = 0$, were estimated to be -\$5,000 and \$4,000. Several target income levels between -\$5,000 to \$4,000 were used and λ was parameterized from zero to the level necessary to achieve the profit maximization (LP) solution. Moreover, two target levels of \$15,000 and \$30,000 were specified for the farm. The parameter λ was initially set at a large value. In this case, the Target MOTAD model was equivalent to the deterministic linear programming as λ was reduced, solutions that varied from the deterministic linear programming.

The optimal farm plans, expected income, and corresponding value of λ and T at which basis changes occurred are presented in Table 31. Ten plans in addition to the LP solution were identified. For each of the eleven plans the entire 570 acres is seeded to wheat. For 14 of the 17 plans, all 570 acres are winter grazed.

The optimal tillage strategy is to moldboard (Plow-15) all land which is used to produce wheat for grain and to use the Sweep system to produce wheat for grazeout. Since forage yield data were not collected in the experiment station study, the yield of forage is assumed to be the same across all tillage systems. Hence, the model selects the least expensive tillage system for use on land devoted to the production of wheat for grazeout.

Three of the plans call for less than full stocking. The diversified plan generated for a target income level of \$4,000 with zero deviation, includes 424 acres tilled with the Plow-15 system and 146 acres tilled with the Sweep system. All of the 146 Sweep acres should be winter grazed and grazed out. However, the plan calls for winter grazing only 315 of the 424 Plow-15 acres. All of the Plow-15 acres should be harvested for grain.

Table 31. Target MOTAD Farm Plans for the Wheat Grain and Forage Farm Which Does Participate in Government Programs.

Plan[a]	Target Return	Expected Deviation	Expected Return	Activities Levels				
	---$---			Plow-15	GGPL15	GGOSW	STKWW	STKGZ
				---acres---			---head---	
M	-5,000	0	50,302[b]		570		285	
	-3,000	0	49,327		544	26	259	26
	-3,000	207	50,302		570		285	
	-1,000	0	48,387		519	51	234	51
	-1,000	407	50,302		570		285	
N	1,000	0	47,448		495	75	210	75
	1,000	417	49,405		546	24	261	24
	1,000	638	50,302		570		285	
	2,000	0	46,568	10	468	91	188	91
	2,000	19	46,979		482	88	197	88
	2,000	838	50,302		570		285	
	3,000	0	44,250	60	391	118	137	118
	3,000	103	46,509		470	100	185	100
	3,000	1,038	50,302		570		285	
O	4,000	0	41,933	109	315	146	85	146
P	4,000	187	46,040		457	113	172	113
	15,000	1,613	40,874		321	249	36	249
	15,000	1,668	43,121		380	190	95	190
	15,000	3,438	50,302		570		285	
	30,000	6,251	44,969		429	141	144	141
	30,000	6,263	45,254		437	133	152	133
	30,000	7,065	49,882		559	11	274	11
	30,000	7,231	50,302		570		285	
	40,000	11,090	39,513		285	285		285
	40,000	11,692	50,302		570		285	

[a] The plans selected for stochastic dominance analysis.
[b] LP solution.

The plan calls for a total of 231 stockers for winter grazing with 85 sold on March 1 and the remaining 146 concentrated on the Sweep acres for grazeout. The expected income with this plan is reduced from $50,302 for the LP plan by $8,369 to $41,933. The plans reported in Table 31 indicate that winter grazing and grazeout options do provide opportunities for wheat producers in the region to reduce risk by diversification. Figure 5 present the E-MDBT frontiers for some target income in this scenario.

Scenario 5. Farm plans for producers who participate in government programs and farm nonerodible land (Scenario 5) are presented in Table 32. Seven plans, including the LP solution, were identified. All plans call for full participation. That is 5 percent of the land should be set aside for conserving uses in exchange for an expected deficiency payment of $8,372. All plans call for seeding the entire 570 acres to wheat. Ten of the eleven plans indicate that all land seeded to wheat should be winter grazed.

Diversification can be achieved by reducing the number of stockers. For example, to achieve a target income of $22,000 with zero deviation, the plan calls for use of the Plow-15 system on 480 acres, and the Sweep system on 90 acres. The plan includes 260 winter stockers with all but 48 of the Plow-15 acres winter grazed. A total of 149 of the stockers should be sold on or about March 1 with the remaining 111 retained on the grazeout acres and sold on May 1. The expected income from this diversified strategy is reduced from $57,323 for the LP solution by $4,531 to $52,792. However, the downside risk is reduced with the diversified strategy in which the target income of $22,000 is expected to be achieved in all periods (for all states of nature). Figure 6 present the E-MDBT frontiers for some target incomes in this scenario.

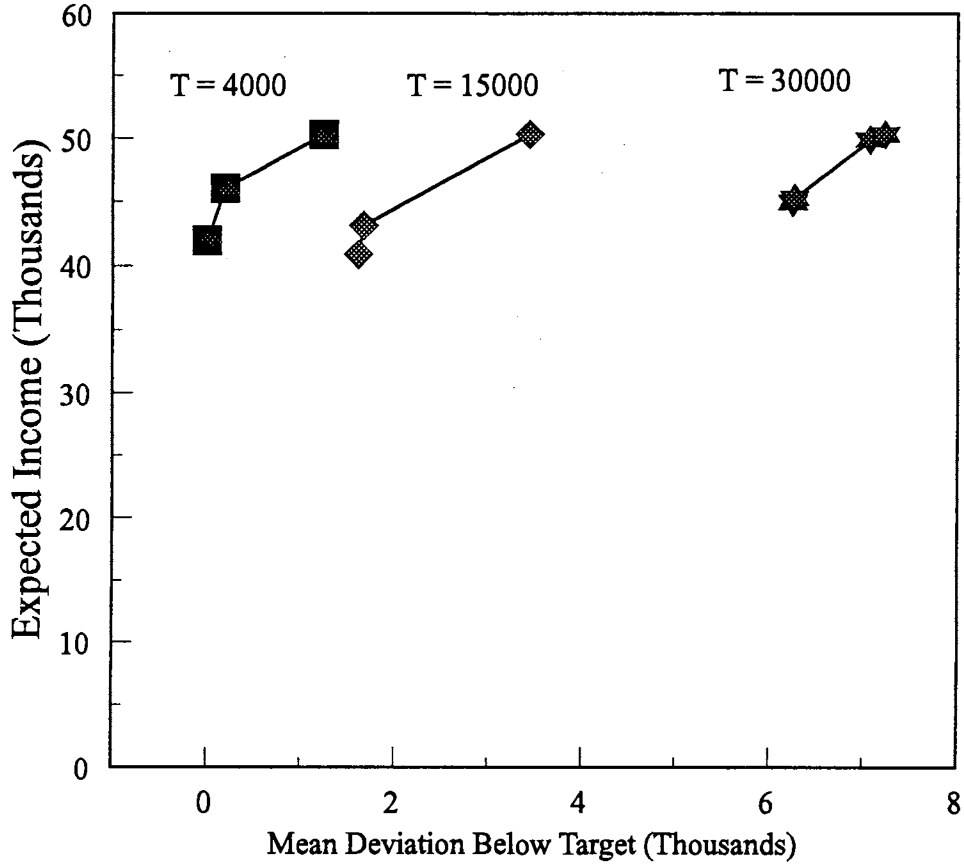


Figure 5. E-MDBT Frontiers (Scenario 4)

Table 32. Target MOTAD Farm Plans for the Wheat Grain and Forage Farm Which has Nonerodible Land and Participates in the Government Programs.

Plan[a]	Target Return	Expected Deviation	Expected Return	Average Deficiency Payments	Average 0/92 Payments	Activities Levels					
						----acres----				----head----	
		----$----				Plow-15cm	GGPL15	GGOSW	SGGOPL15	STKWW	STKGZ
R	16,500	0	57,323[b]	8,372			542[c]		28	257	28
	17,000	0	57,055	8,372			542	8	28	249	36
	17,000	58	57,323	8,372			542		28	257	28
S	18,000	0	56,594	8,372			522	21	27	237	48
	18,000	158	57,323	8,372			542		28	257	28
	19,000	0	56,134	8,372			510	33	27	225	60
	19,000	258	57,323	8,372			542		28	257	28
	20,000	0	55,673	8,372			497	47	26	212	73
	20,000	358	57,323	8,372			542		28	257	28
T	22,000	0	52,792	8,372		48	409	90	23	149	111
U	22,000	83	54,753	8,372			473	72	25	188	97
	22,000	732	57,323	8,372			542		28	257	28
	30,000	1,834	53,550	8,097	253		441	106	23	156	129
	30,000	1,838	54,129	8,372			456	90	24	171	114
	30,000	1,879	55,528	8,372			493	51	26	208	77
	30,000	2,332	57,323	8,372			542		28	257	28
	45,000	7,546	56,236	8,372			512	31	27	227	58
	45,000	7,599	57,323	8,372			542		28	257	28

[a] The plans selected for stochastic dominance analysis.
[b] LP solution.
[c] The model is based on the assumptions of a 5 percent set-aside requirement (28 acres) and a 15 percent mandatory flexible acres requirement. Also, 80 percent of the base (456 acres must be harvested for grain to qualify for the full deficiency payment ($8,372).

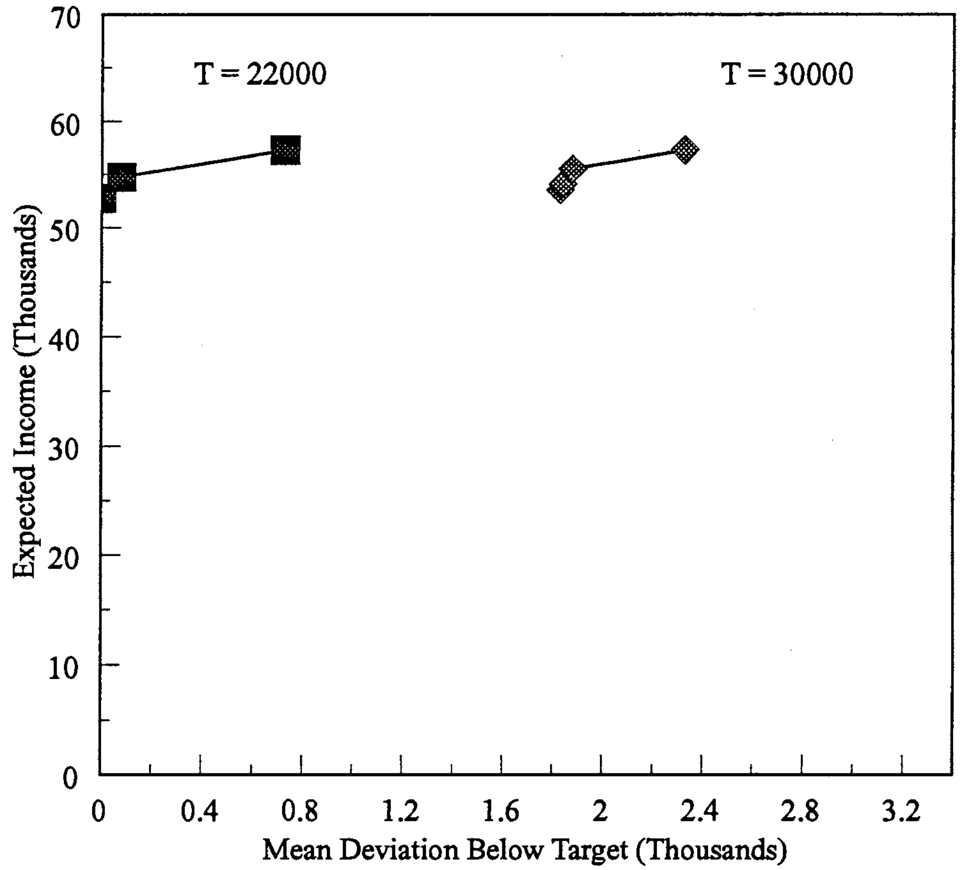


Figure 6. E-MDBT Frontiers (Scenario 5)

<u>Scenario 6.</u> Results for Scenario 6 are summarized in Table 33. These results were generated for a producer who farms land classified as highly erodible and who chooses to participate in government programs. Eleven unique plans are presented in the table. Expected incomes range from $52,552 for the profit maximizing LP solution, to $42,776 for a diversified plan generated with the restriction of zero deviation from a target income level of $19,000. In general, the Disk system is optimal for land which is seeded to produce grain, and the Sweep system for land seeded to be grazed out.

Four of the Scenario 6 plans include the use of the 0/92 provision of the government program. For example, consider the plan which generates the target income of $17,000 with zero expected deviation. The expected return is $46,581. Total government payments for the plan are estimated to be $8,201, with $1,995 resulting from the 0/92 payment. While all of the land is seeded to wheat, only 338 of the 570 acres are harvested for grain.

With 5 percent set aside and 15 percent mandatory flexible acres, deficiency payments can be made on a maximum of 456 acres for a farm which has 570 acres of wheat base (570 acres minus 5 percent set aside and 15 percent mandatory flexible acres). (The maximum deficiency payment is $18.36 per acre for the 456 qualifying acres for a total of $8,372 for the farm.) To qualify for full payment the wheat must be harvested for grain. In the case of the plan generated for the $17,000 target income with zero expected deviation, the full deficiency payment is made for the 338 acres which are harvested for grain. The payment is 338 times $18.36 ($6,206). The remaining 118 acres are enrolled in the 0/92 program. They may not be harvested for grain but may

Table 33. Target MOTAD Farm Plans for the Wheat Grain and Forage Farm Which has Erodible Land and Participates in the Government Programs.

Plan	Target Return	Expected Deviation	Average Expected Return	Average Deficiency Payments	0/92 Payments	CHSEL	GGDI	Activity Levels GGOSW	SCH	SGGODI	STKWW	STKGZ
	$					acres					head	
	11,000	0	52,552[b]	8,372			542[c]			28	257	28
	13,000	0	50,652	8,372			475	70		25	190	95
	13,000	202	52,552	8,372			542			28	257	28
W	15,000	0	48,523	7,399	896		403	145		22	118	165
Z	15,000	143	50,111	8,372			456	90		24	171	114
	15,000	402	52,552	8,372			542			28	257	28
X	17,000	0	46,581	6,206	1,995		338	214		18	53	232
	18,000	343	50,111	8,372			456	90		24	171	114
	17,000	602	52,552	8,372			542			28	257	28
Y	19,000	0	42,776	6,848	1,404	115	258	178	6	14	33	191
	19,000	543	50,111	8,372			456	90		24	171	114
	19,000	776	52,307	8,372			533	9		28	248	37
V	19,000	868	52,552	8,372			542			28	257	28
	30,000	2,430	49,766	8,152	186		445	102		23	160	125
	30,000	2,448	50,111	8,372			456	90		24	171	114
	30,000	2,536	51,145	8,372			492	52		26	207	78
	30,000	3,068	52,552	8,372			542			28	257	28
	40,000	6,179	52,552	8,372			542			28	257	28

[a] The plans selected for stochastic dominance analysis.
[b] LP solution.
[c] The model is based on the assumptions of a 5 percent set-aside requirement (28 acres) and a 15 percent mandatory flexible acres requirement. Also, 80 percent of the base (456 acres) must be harvested for grain to qualify for the full deficiency payment ($8,372).

be winter grazed and grazed out. The per acre payment for these 118 acres is 92 percent of that received for harvested acres. For the plan it is 92 percent of $18.36 times 118 acres ($1,995).

The Disk system should be used on the 338 acres which are harvested for grain. And, consistent with results discussed for other scenarios, the land seeded for grazeout should be tilled with the Sweep system since it is the least expensive tillage method and forage yield is assumed to be equivalent across all tillage systems. All 570 acres should be winter grazed with 285 stockers. Fifty-three should be sold in March and the remaining 232 concentrated on 232 acres for graze out. Figure 7 present the E-MDBT for some target income levels in this scenario.

Stochastic Dominance Analysis

The application of stochastic dominance to evaluate alternative production strategies has become widely established. By construction, farm plans generated by Target MOTAD will be members of the second-degree stochastic dominance (SSD) efficient set (Tauer). For example, all the farm plans which are reported in Table 33 are members of the SSD set for producers in the region who produce wheat for grain and forage and who farm erodible land. In this section stochastic dominance with respect to a function (SDRF) is employed to further evaluate the risk efficiency of the plans generated in the Target MOTAD analysis. In addition, participation plans are directly evaluated with nonparticipation plans for both land not classified as highly erodible as well as for land classified as highly erodible.

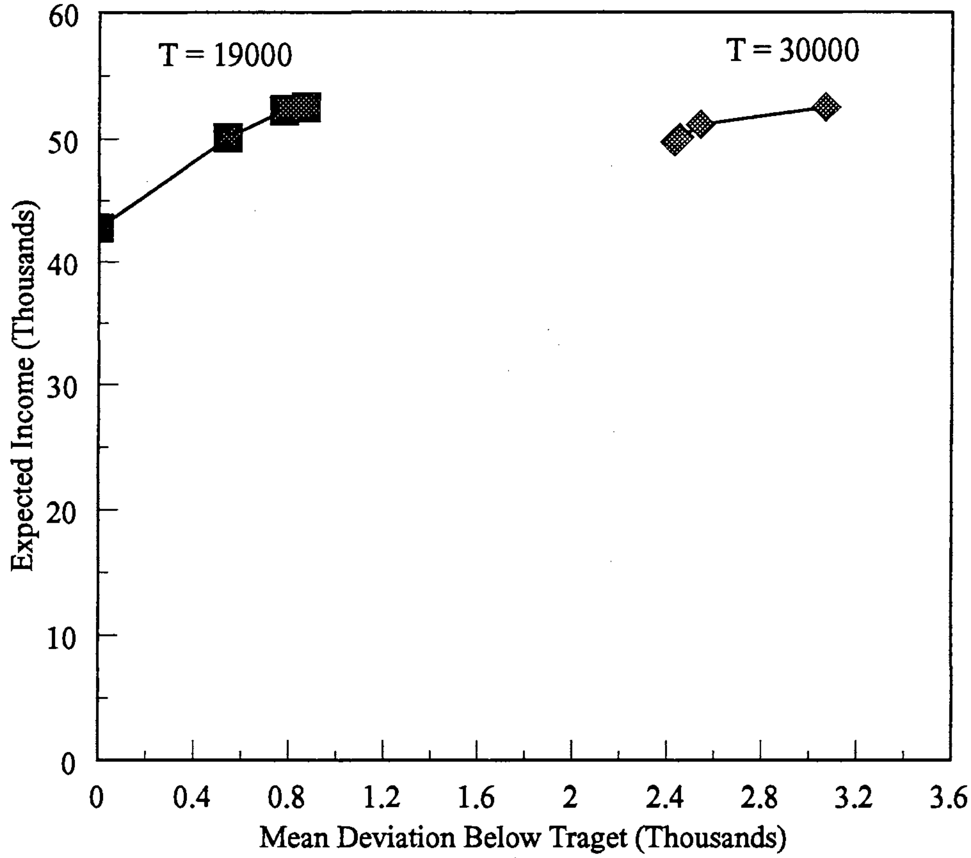


Figure 7. E-MDBT Frontiers (Scenario 6)

As described in Chapter III, SDRF is an efficiency criterion which orders uncertain choices for decision makers whose absolute risk-aversion function lies within specific lower and upper bounds. It establishes necessary and sufficient conditions for the distribution of outcome defined by the cumulative distribution function (CDF) F(Y) to be preferred to that defined by the an alternative CDF G(Y) by all individuals whose absolute risk aversion functions lie everywhere between lower and upper bound $r_1(Y)$ and $r_2(Y)$ (King and Robison).

For this analysis, risk aversion intervals (-0.0008 to -0.0001), (-0.0001 to 0.0001), (0.0001 to 0.0004), and 0.0004 to 0.001) were selected to represent risk-^[preferring, risk-neutral, slightly risk-averse, and strongly risk-averse decision makers. A software package developed by Cochran and Raskin was used to conduct the analysis.

Four farm plans were selected arbitrarily from those generated for Scenarios 1, 2, 3, 4, 5, and 6. The selected plans are denoted in Tables 27, 28, 29, 31, 32, and 33. For every comparison and all risk intervals, plans which did not include the stocker production activities were dominated by plans which did include stocker production. Thus, the discussion of the SDRF analysis includes few, if any, references to the dominated plans A, B, C, D, E, F, G, and H, which do not include stocker production activities.

SDRF Plans for Nonerodible Land

The results of the analysis for comparing nonparticipation plans M, N, O, and P from Table 31 and participation plans for nonerodible land, R, S, T, and U from Table 32 are presented in Table 34. Plan M is the only member of the risk-preferring set. A

Table 34. Results of the Stochastic Dominance with Respect to a Function Analysis for a Farm with Land Not Classified as Highly Erodible.

Risk Aversion Interval	Dominant Strategy[a]
-0.0008 to -0.0001 risk preferring	M
-0.0001 to 0.0001 risk neutral	M, R, S, and U
0.0001 to 0.0004 slightly risk averse	U and T
0.0004 to 0.001 strongly risk averse	T

[a] See Tables 31 and 32 for detail.

Table 35. Results of Stochastic Dominance with Respect to a Function Analysis for a Farm with Land Classified as Highly Erodible.

Risk Aversion Interval	Dominant Strategy[a]
-0.0008 to -0.0001 risk preferring	V
-0.0001 to 0.0001 risk neutral	M, N, P, V, W, X, and Z
0.0001 to 0.0004 slightly risk averse	X and Y
0.0004 to .001 strongly risk averse	Y

[a] See Tables 31 and 33 for detail.

farmer who prefers risk should not participate in the government program, till with Plow-15, seed all land to wheat, fully stock for winter grazing, and harvest the grain. Four of the eight plans are members of the risk neutral set.

Plan U and T are the only member of the SDRF slightly risk averse sets. Plan U, which is described in Table 32, is a diversified plan generated for Scenario 5 (nonerodible participation). A producer who followed plan U would (a) fully participate in the government program; (b) seed the entire farm to wheat; (c) stock the entire acreage for winter grazing; (d) use a moldboard plow on land seeded for grain harvest; (e) use the relatively inexpensive Sweep system on the land seeded for grazeout; (f) grazeout 97 acres (17 percent of the land) with 97 head; and (g) harvest 473 acres for grain.

SDRF Plans for Erodible Land

The results of the analysis for comparing nonparticipation plans M, N, O, and P from Table 31 and participation plans for erodible land, V, W, X, and Y from Table 33 are presented in Table 35. Plan V is the only member of the risk-preferring set. A farmer who prefers risk and farms erodible land should participate in the government program, till with the Disk system, seed all land to wheat, fully stock for winter grazing, harvest 95 percent of the wheat base, and graze out the required 5 percent set aside.

Seven of the eight plans are members of the risk neutral set. Plan O which is not included in the set has an expected income of $41,933 which is $4,107 less than the next lowest expected income plan.

Plan X and Y are the only member of the SDRF slightly risk averse sets. Plan X, which is described in Table 33, is a diversified plan generated for Scenario 6 (participation with erodible land). A producer who followed plan X would (a) fully participate in the government program; (b) seed the entire farm to wheat; (c) use the Disk system on land seeded for grain harvest; (d) use the relatively inexpensive Sweep system on the land seeded for grazeout; and (e) harvest 338 acres (60 percent); and (f) participate in 0/92 program.

CHAPTER VI

CONCLUSION AND SUMMARY

This chapter includes a summary of the thesis. The summary is presented in terms of a brief review of the material presented in the preceding chapters. The review is followed by a summary of the overall conclusions of the study. The chapter concludes with a listing of noted limitations and shortcomings of the analysis.

Thesis Summary

The first chapter includes a description of Oklahoma's agricultural sector, its importance to the State's economy, and its contribution to gross state product. Winter wheat is by far the most important field crop produced in the State. In addition to its importance for producing high quality hard red winter wheat grain, wheat is a vitally important forage crop.

Livestock may be pastured on nutritious wheat forage during the winter months. If grazing is terminated in late winter, typically early March, the wheat will produce a normal grain crop. Many farmers in Oklahoma use standing winter wheat forage for the production of stocker cattle, especially young beef steers.

Government programs have been an important factor in the production of wheat for forage and grain. Over most of the history of federal price support programs, farmers have been required to idle, or set aside, some of their cropland to qualify for price supports and deficiency payments. Grain may not be harvested from the set aside acres. However, Oklahoma producers have been permitted to seed the set aside to wheat and graze it during the winter and spring.

By 1995, farmers who farm highly erodible land will be required to fully implement soil conserving production practices to maintain eligibility for federal deficiency payments and other federal programs. This requirement will impact many producers, most of whom have prepared compliance plans which express their intentions to adjust tillage practices as necessary to fulfill statutory surface residue requirements. The consequences of adjusting tillage practices to achieve conservation compliance have not been determined. The impacts on participation rates, wheat production, stocker production, farm income, and income variability have not been fully explored.

The overall objective of the research reported in this thesis was to determine risk efficient tillage, government program participation, and stocking strategies for a representative Oklahoma farm on which winter wheat is produced for both grain and forage.

Chapter II includes a review of selected literature regarding the economics of the alternative tillage systems; impact of government programs on the economics of production alternatives; methods used to determine efficient farm plans given government programs; and the history of government programs which are relevant to wheat production in Oklahoma.

Chapter III includes a discussion of the concept of risk and the theoretical aspects of risk programming. Several risk programming models were discussed. The Target MOTAD model as developed by Tauer was presented as an appropriate method for conducting the analysis.

Model and data development were described in Chapter IV. The chapter contains a description of the experiment which generated wheat grain yield data for six alternative production systems. Results of the experiment were also presented.

Information regarding equations which were estimated to determine if a time trend could be detected in the experiment station, county, and state average yields was presented. No significant trends were detected in any of the three sets of yields. It was determined that the experiment station yields were not correlated with market prices. Data requirements of the representative farm model and the procedure used to adjust wheat and livestock prices for inflation were described.

Costs of production and gross margins for alternative activities were estimated and presented. Government commodity program parameters were presented. Modeling of the government programs and its integration with alternative wheat and wheat-stocker strategies were explained.

Results of the risk programming analysis are presented in Chapter V. Farm plans are presented which would be appropriate strategies for producers who are risk neutral as well as for producers who are risk averse. Plans were prepared for those who farm erodible as well as nonerodible land. The major finding of the study are as follows:

1. A farmer who prefers risk should not participate in the government program, till with moldboard plow, seed all land to wheat, fully stock for winter grazing, and harvest the grain.

2. To maximize utility a risk averse producer who farms nonerodible land should: (a) fully participate in the government program; (b) seed the entire farm to wheat;

(c) stock the entire acreage for winter grazing; (d) use a moldboard plow on land seeded for grain harvest; (e) use a relatively inexpensive tillage system on the land seeded for grazeout; (f) grazeout the set aside land; and (g) harvest the rest for grain.

3. A risk averse producer who farms erodible land should: (a) fully participate in the government program; (b) seed the entire farm to wheat; (c) stock the entire acreage for winter grazing; (d) use the Disk system on land seeded for grain harvest; (e) use the relatively inexpensive Sweep system on the land seeded for grazeout; (f) harvest for grain the minimum (eighty percent) acreage required to qualify for full deficiency payment; and (g) grazeout the set aside (5 percent) and mandatory flexible acres (fifteen percent).

Limitations of the Study

1. Forage yield data were not available from the experiment station study.
2. Winter grazing was assumed to have no impact on wheat grain yields and was assumed to be constant across all tillage systems.
3. Stocker weight gain was assumed to be constant across all tillage systems and across all states of nature.
4. A constant stocking density of 0.5 animals per acre was assumed for winter grazing and 1.0 animal per acre for grazeout.
5. Machinery fixed costs used to estimate the gross margins were based on the assumption that the cropping system for which the machinery complement was prepared was used on the entire 570 acre farm. Machinery fixed costs may be

understated for those plans which call for the use of more than one tillage system.

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