Station Bulletin 578—1987 (Item No. AD-SB-3255)

A Risk Analysis of Farm Program Participation

Harry M. Kaiser and Jeffrey Apland

Department of Agricultural and Applied Economics

Minnesota Agricultural Experiment Station

University of Minnesota

CONTENTS

Harry M. Kaiser is an assistant professor in the Department of Agricultural Economics, Cornell University and Jeffrey Apland is an associate professor in the Department of Agricultural and Applied Economics, University of Minnesota. The authors wish to thank several individuals who provided assistance in this study. W. W. Nelson and Tony Straesser generously compiled field time data used in this research and Fred Benson provided valuable assistance in constructing the machinery sets for the model. Vernon Eidman and Robert King provided useful advise during various phases of the research. The reviews by Richard Boisvert, Dan Halbach, Kent Olsen, and Ford Runge are also appreciated. Remaining errors are the responsibility of the authors.

Funding for this project came from the University of Minnesota Agricultural Experiment Station. Partial support for the computer work came from Academic Computing Services and Systems of the University of Minnesota.

A RISK ANALYSIS OF FARM PROGRAM PARTICIPATION

Farm decisions are influenced by risk from many sources. Government policies, either directly or indirectly, often affect how risky farming will be. As with production, marketing, and finance decisions, farmers may make decisions about commodity program participation based on their expectations of average returns and risk.

For example, Scott and Baker found that participation in the 1972 farm program was optimal for risk-averse Illinois farmers, and Persaud and Mapp concluded that selected provisions of the 1977 Act were effective in reducing risk for Oklahoma producers. Additionally, Musser and Stamoulis found that participation in the 1978 farm program was optimal for Georgia crop farmers exhibiting any degree of risk aversion. Kramer and Pope demonstrated that participation in the 1979 program by California crop growers was optimal only for extremely risk-averse agents.

This bulletin reports the results of a study on how participation in commodity programs established by the 1981 and 1985 farm acts performed as a risk management option relative to nonparticipation strategies used by corn and soybean producers in southern Minnesota. A mathematical programming model was used to generate and compare risk-efficient plans for two scenarios: nonparticipation and participation in the commodity programs. Provisions of the 1983 and 1986 commodity programs were used to examine the differences in the benefits of commodity program participation between years. Two case farms, which have characteristics of typical cash crop farms in this region, were used in the analysis so that the sensitivity of results to different yield data sets could be examined. Income risk was incorporated into the model by treating field time, yields, and prices as stochastic variables.

There are four main sections to this bulletin. In the first section, the major provisions of commodity programs regarding corn and soybeans are discussed and results of previous research on risk analyses of program participation are reviewed. This is followed by a description of the empirical model used to generate results for the analysis. In the third major section, the results are reported and analyzed. The paper concludes with a summary which reiterates the highlights of the research and discusses some of the implications with respect to farm risk management.

REVIEW OF U.S. FARM PROGRAMS

One justification for government farm commodity programs which has been cited is the high degree of vulnerability of the farm sector to factors beyond its control (Robison and Barry). Exogenous factors like disease, drought, pests, and interruptions in foreign markets cause a great deal of production and market instability for agricultural commodities. Farm programs which offer price and income support can help managers cope with this inherent instability.

The Food Security Act of 1985 is the most recent piece of major legislation enacted by Congress to guide farm policy over the next five years. As currently written, the Act is quite similar to its predecessor -- the Agriculture and Food Act of 1981. The policy structures of both Acts with respect to corn and soybeans are virtually identical, i.e., acreage reduction, target price-deficiency payment, and price-support programs are integral components of both pieces of legislation. The major difference is the level of policy parameters associated with these programs.

Participation in commodity programs is voluntary. In order to receive the benefits of these programs, farmers must enroll in any acreage reduction program (ARP) in effect. These set-aside programs require that a specific portion of crop acreage be withheld from production and devoted to conservation uses. The requirements of the ARP are of critical importance to farmers in determining whether or not to participate since they result in lost production, the major cost of participation. Under the 1981 and 1985 Acts, the Secretary of Agriculture was given the option to further reduce supply by offering additional paid land diversion programs (PLD) to participants. Unlike ARPs, producers participating in PLD programs receive payments for the land that they take out of production.

Producers who comply with these requirements are eligible for price and income support. Price support loans are used to set floors on market prices. Participants may receive a non-recourse loan by placing their crop as collateral into Commodity Credit Corporation (CCC) approved storage facilities. The loan is equal to the county loan rate multiplied by the quantity of the crop placed in storage. At a later time, farmers may choose either to repay the loan plus interest, or to forfeit the ownership of the stock to the government in lieu of repayment.

Target prices are used in conjunction with deficiency payments. Producers are eligible for income support whenever the national average market price over the first five months of the marketing year falls below the target price. The deficiency payment rate is equal to the difference between the target price and the higher of the loan rate or the national average market price. Deficiency payments are based on program yields established by the Agricultural, Stabilization, and Conservation Service (ASCS) county committee for each participating farmer.

Although there are no production control programs for soybeans, corn is subject to an ARP, which was equal to 10 percent of corn base acreage under the 1981 Act and is equal to 20 percent in the 1986 Act. In 1983, to combat a growing corn surplus, a 10 percent PLD program was mandated for program participants in addition to the 10 percent ARP. Also, a voluntary payment-in-kind (PIK) was established to reduce government stocks.[1] Although no PIK programs are included in the 1985 Act, it is possible that this type of program will be implemented in the future if government stocks continue to rise.

Review of Farm Level Studies

The central focus of most of the farm-level risk analyses of commodity programs has been to examine the expected income-risk trade-offs under participation and nonparticipation and to identify which classes of farmers, based on their risk attitudes, would participate in the programs. A variety of models have been used to estimate risk-efficient sets of farm plans under participation and nonparticipation in the programs. Most of the approaches have their roots in expected utility theory (EV, MOTAD, and stochastic dominance). All the studies reviewed below considered price and production variability as the sources of risk faced by farmers. The results, although somewhat mixed, have suggested that there are strong economic incentives for moderately to extremely risk-averse producers to use farm programs to manage income risk.

In an earlier study of alternative production and participation strategies under risk, Scott and Baker used quadratic programming (QP) to estimate efficient expected income-variance of income (EV) sets for an Illinois case farm. They found that participation in the 1972 Feed Grain Program and diversification of crop enterprises significantly reduced the variance of income, but at a cost of lowering expected income. The desirability of each of the strategies analyzed differed by level of risk aversion. For instance, their results indicated that a risk-neutral farmer would have found nonparticipation and specialization in one crop (corn) optimal since this plan had the highest expected income, but the highest variance of income as well. A moderately risk-averse farmer would have found growing both corn and soybeans coupled with participation in the minimum set-aside program optimal. Farmers with high aversion to risk would have found diversification of crop enterprises to include some wheat and oats, as well as corn and soybeans, and participation in the maximum set-aside program optimal.

Persaud and Mapp, and Mapp, et al., reached similar conclusions regarding the Food and Agriculture Act of 1977. They used a minimization of total absolute deviations (MOTAD) model, to estimate risk-efficient strategies for a southwestern Oklahoma farm. Their analysis suggested that while participation in the wheat program was optimal, using crop insurance neither decreased gross margin variability nor increased gross average margins. An interesting aspect of Persaud and Mapp's study is that a variety of marketing activities were evaluated instead of using one aggregate marketing strategy to represent marketing alternatives in the model. While participation in the 1977 commodity program was part of one efficient strategy, some strategies without participation were equally effective in stabilizing gross margins and raising expected income through marketing decisions. Their results suggest that analyses which have not considered a reasonable set of alternative marketing activities may produce misleading results.

Musser and Stamoulis (1980, 1981) provided stronger evidence of the risk efficiency of the 1977 program. They used QP to calculate efficient E-V sets for participation and nonparticipation in the program for a Georgia crop farm. The results suggested that the 1977 program reduced the variance of income and increased expected income relative to nonparticipation. However, unlike Persuad and Mapp's analysis, Musser and Stamoulis did not use a detailed set of marketing activities in their model.

Kramer and Pope used stochastic dominance with respect to a function (Meyer) to look at the net benefits of participation in the 1977 program for a California crop farm. They generated net revenue probability distributions for a number of participation scenarios and one nonparticipation situation, which was used as the base situation for comparisons. Their results demonstrated that nonparticipation dominated participation in the 1977 Act for all classes of farmers exhibiting risk-loving, risk-neutral, and moderately risk-averse behavior -- a result contrary to previous studies reviewed. However, when some of the program parameters were altered, e.g., reducing the set-aside provision by one-half or increasing the target price by 10 percent, more groups found participation optimal.

To summarize, most of the these studies have indicated that farmers exhibiting any degree of aversion to risk should have had economic incentives to use commodity programs in the 1970s and early 1980s to manage income risk. Yet, available data on past participation rates by state and nationwide does not support this strong conclusion. For example, only 31 percent of all U.S. corn farmers participated in the 1978 corn program (Johnson and Clayton, 1982). There are four factors that may explain why actual participation rates were lower in the 1970s than what some of these studies have concluded is optimal, assuming that most farmers are risk-averse.

First, these studies have had to oversimplify actual participation requirements, omitting some of the program provisions out of necessity, as well as leaving out unquantifiable factors such as farmers' social and political attitudes regarding these programs. To the extent that the omitted provisions and/or farmer attitudes are disincentives to participation, the model results will not mirror actual practice.

Second, the fact that agricultural policy and specific provisions changed from year to year implies uncertainty which may discourage some farmers from participation. However, this aspect of the decision problem is not reflected in these models due to the difficulty of quantifying it. Because of abrupt and unexpected policy changes, such as the 1980 Soviet grain embargo, some farmers may have found other risk managing alternatives (i.e., those that are not as dependent upon government actions) more attractive.

Third, farmers may have found participation less attractive because the free market orientation during the 1970s lowered target and support prices relative to market prices. Gardner (1978) has suggested that commodity programs where price supports are close to free market price levels such as sugar and peanuts have not been effective in reducing price variability significantly.

Finally, the majority of these studies have isolated government farm programs as the only strategy used to manage income risk. By comparing nonparticipation and participation in the absence of production and marketing risk management strategies, the optimality of joining government programs may have been overstated.

EMPIRICAL MODEL

The studies reviewed in the preceding section have provided useful information on how commodity programs affect farm behavior and organization under risk. However, there are two common limitations in past research on these programs. First, all of the studies have assumed a static, nonsequential decision process. As a result, the sets of optimal decision activities derived from the models are not adaptive throughout the planning period. Farm production and marketing decision-making is an adaptive process involving a sequence of decisions made over time. For example, a corn producer can price grain after harvest when information critical to marketing decisions is available.

A second shortcoming in most previous studies has been the lack of detail in specifying marketing strategies in the model. With the exception of Persaud and Mapp, these studies have represented the agent's marketing options by a single aggregate marketing activity. The implicit assumption used in previous research is that farmers sell their entire crop at one time. Moreover, the modeling of marketing strategies in this manner could exaggerate the impact of commodity programs on raising income and/or reducing income variability.

The model developed for this study incorporates a sequential decision process and includes a variety of marketing instruments used by Minnesota corn and soybean producers. Because of the market orientation of U.S. commodity programs, inclusion of a variety of marketing instruments may be critical to an economic analysis of farm decision-making with respect to program participation. Three sources of income risk are considered: 1) risk resulting from price variability, 2) risk due to yield variability, and 3) risk accruing from fall field time variability.

The Model

A discrete stochastic sequential programming (DSSP) model was used in this study (Cocks). By using DSSP, decision-making was treated as a multi-stage process with a mixed information structure characterized by discrete random problem parameters (Rae, 1971(a), 1971(b)). In the model, farm production and marketing decisions were assumed to be made in three stages. Production decisions were assumed to be made at the beginning of stage I (pre-harvest periods) and stage II (harvest periods). Marketing decisions were assumed to occur in stage III (post-harvest periods).

The production operations and flow resource constraints in the model were based on 11 intra-year time periods which are shown in Table 1. Stage I of the decision process included production periods 1 through 6. Stage I operations included spring plowing, disking, herbicide application, planting, and post-planting operations. Stage II operations included harvesting and fall plowing, which take place in periods 7 through 11. The constraining resources for both stages were full and part-time labor by time period, tractor and harvester time by time period, crop acreage, and on-farm storage capacity.

There were six marketing techniques for corn and six for

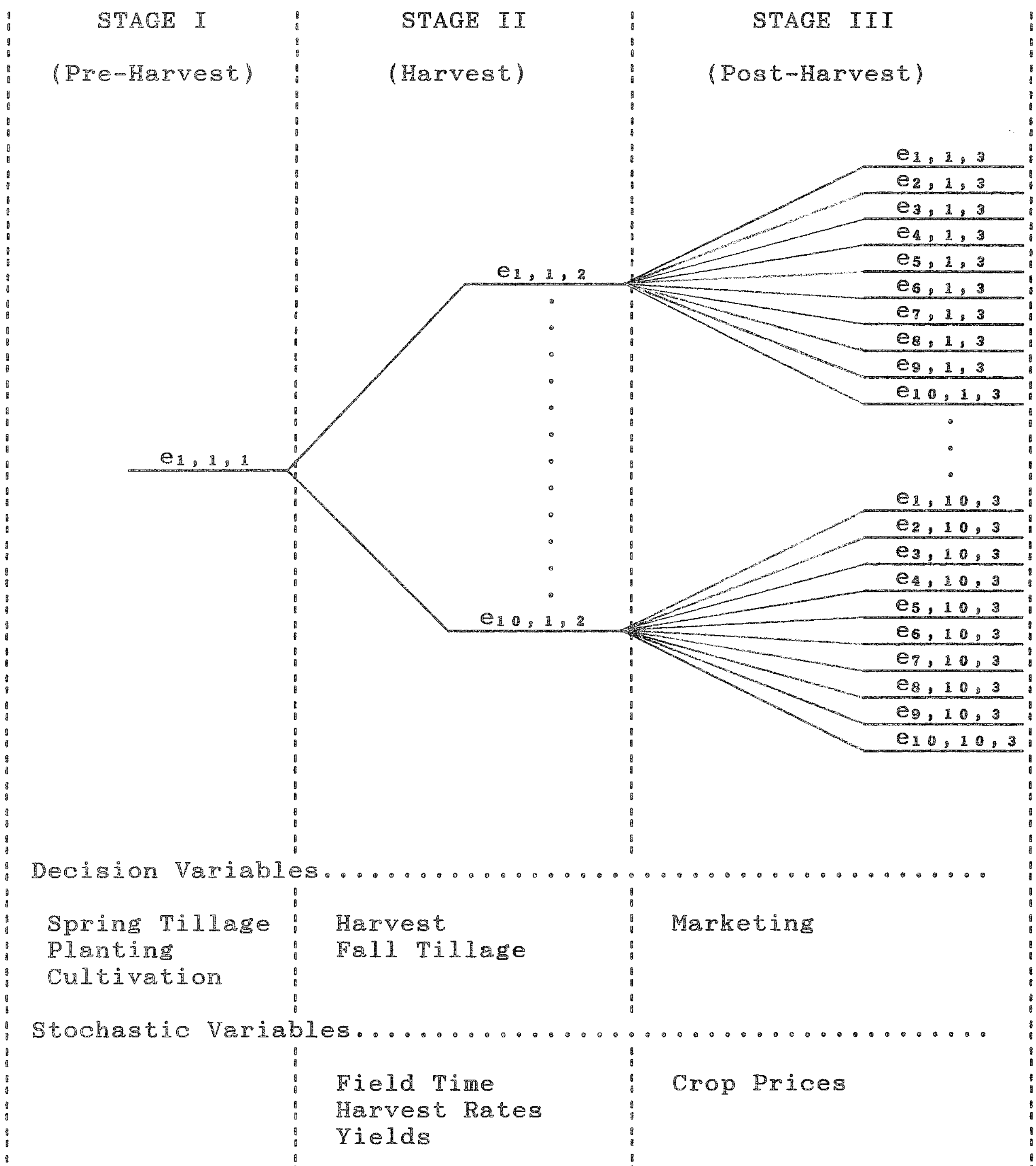
Table 1. Calender of Production Operations.

Stage	Period	Days	Plow	Disk 1	Disk 2	Corn Plant	Corn Harv	Soybeans Plant	Soybeans Harv
I	1 APR07-APR22	16	X	X					
	2 APR23-MAY01	9	X	X	X	X			
	3 MAY02-MAY11	10	X	X	X	X		X	
	4 MAY12-MAY21	10		X	X	X		X	
	5 MAY22-MAY31	10		X	X	X		X	
	6 JUN01-JUN08	8		X	X			X	
II	7 SEP15-SEP30	16	X						X
	8 OCT01-OCT16	16	X				X		X
	9 OCT17-OCT31	15	X				X		X
	10 NOV01-NOV15	15	X				X		
	11 NOV16-NOV30	15	X						

soybeans, which were based on common marketing practices in the region (Gois). These included a cash market sale at harvest, a storage hedge placed at harvest and lifted in May, and four alternative post-harvest cash market sales activities. Under the harvest sales activities, it was assumed that soybeans were sold in mid-October and corn was sold in mid-November. The storage hedge activity consisted of two sets of transactions for corn and soybeans. First, July futures contracts were sold at harvest and the contracted grain was placed in on-farm storage. Then, in May, the July contracts were purchased back and the grain was sold in the cash market to lift the hedge. The post-harvest sales activities involved selling the stored crop in the months that traditionally have higher prices than in the fall. The four months selected in this study for post-harvest sales were mid-February, April, May, and June. At the beginning of stage III, the producer had to decide, based on earlier production decisions and events in stage II, how much of each crop would be sold under each of the marketing activities.

Figure 1 shows a decision tree which illustrates the decisions, events, and information structure used in this problem. To reduce the size of the model, stage I was modeled deterministically. This allowed a more detailed specification of critical harvest and post-harvest states of nature. Production risk was captured through 10 discrete states of nature on yields, field time, and harvest field rates in stage II. It was assumed that the producer had complete knowledge of the past and present when stage II production decisions were made. That is, at the

Figure 1: Decision Tree for the Empirical Model.



beginning of stage II when harvesting and fall tillage decisions must be made, the farmer has complete information on which harvest state of nature would occur. Ten discrete price states were defined for stage III for each of the 10 harvest states resulting in 100 joint events in total. Each price state consisted of a net price for each marketing activity in the model. It was assumed that the producer had complete knowledge of stage II and harvest price events at the beginning of stage III, but only probabilistic knowledge of the post-harvest price states. A general formulation of the empirical model follows:

Maximize:

$$E - \alpha r \sum_{i=1}^{n} \sum_{j=1}^{m} d_{ij} \qquad (1)$$

Subject to:

$$Y_{ij} + C_{11}X_{11} + C_{12}X_{12} + C_{21}X_{21i} + C_{22}X_{22i} - P_{ij}M_{ij} = 0 \quad (i=1...n;j=1...m) \qquad (2)$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} a_i e_j Y_{ij} - E = 0 \qquad (3)$$

$$Y_{ij} - E + d_{ij} \geq 0 \quad (i=1...n;j=1...m) \qquad (4)$$

$$A_{11}X_{11} + A_{12}X_{12} \leq b_1 \qquad (5)$$

$$L1X_{12} \leq b_2 \qquad (6)$$

$$A_{21i}X_{21i} + A_{22i}X_{22i} \leq b_{3i} \quad (i=1...n) \qquad (7)$$

$$- HiX_{21i} + M_{ij} \leq 0 \quad (i=1...n) \qquad (8)$$

$$SM_{ij} \leq b4 \quad (i=1...n;j=1...m) \qquad (9)$$

$$- B_1X_{11} + B_2X_{12} \leq 0 \qquad (10)$$

$$- IX_{12} + B_3X_{21i} \leq 0 \quad (i=1...n) \qquad (11)$$

$$- B_4X_{21i} + B_5X_{22i} \leq 0 \quad (i=1...n) \qquad (12)$$

$$B_7X_{11} - \sum_{i=1}^{n} a_i B_6 X_{22i} \leq 0 \quad (i=1...n) \qquad (13)$$

$$Y_{ij}, d_{ij}, X_{11}, X_{12}, X_{21i}, X_{22i}, M_{ij} \geq 0 \quad (i=1...n; j=1...m) \qquad (14)$$

Where:

Y_{ij} = net revenue, harvest state i, post-harvest state j;

d_{ij} = negative deviation from expected net revenue, harvest state i, post-harvest state j);

X_{11}, X_{12} = spring tillage and planting vectors, stage I;

X_{21i}, X_{22i} = harvesting and fall tillage decision vectors, stage II, harvest state i;

M_{ij} = marketing decision vector, harvest state i, post-harvest state j;

$C_{11}, C_{12}, C_{21}, C_{22}$ = variable cost vectors for field operations in stages I and II;

P_{ij} = net price vector of marketing activities, harvest state i, post-harvest state j;

A_{11}, A_{12} = matrices of resource requirements for stage I field operations;

A_{21i}, A_{22i} = matrices of resource requirements for stage II field operations, harvest state i;

H_i = vector of crop yields, harvest state i;

S = vector of zeros and ones for storage requirements of marketing activities;

b_1 = vector of stage I resource endowments;

b_2 = total crop land endowment;

b_{3i} = vector of stage II resource endowments, harvest state i;

b_4 = on-farm storage capacity;

$B_1, ..., B_7$ = sequence preserving matrices;

I = identity matrix;

L_1, L_2 = vector of ones;

a_i = probability of harvest state i;

e_j = probability of post-harvest state j, given harvest state i;

$\alpha = (2/s)(\pi s/2(s-1))^{0.5}$, where s = number of joint events (Hazell);

r = risk aversion coefficient.

The objective function (1) is expected net revenue (E) adjusted for risk. By (3), E is equal to the sum of the 100 joint net revenue events (Y_{ij}) weighted by their respective probabilities ($a_i e_j$). Risk is measured as the standard deviation of net revenue as estimated by total negative deviation from the mean times the coefficient α. Constraint (2) defines net revenue activities Y_{ij} and constraint (4) defines negative deviation activities d_{ij} for each joint event.

Constraints (5) and (6) restrict the use of farm land, labor, and machinery resources for each operation in stage I to endowed levels. By constraint (7), the use of stage II resources under each of the 10 states of nature cannot exceed endowed levels. The right-hand side of the flow resource constraints for both stages are equal to the number of field days available times the hours per field day times the number of workers/machines for each production period. Constraints (8) and (9) are output and grain storage constraints which restrict the total amount of grain sales to the total output produced and limit the amount of grain sold from storage to no more than on-farm storage capacity. Constraints (10) through (13) are sequencing restrictions, which are constructed to preserve the proper sequence of field operations in the model. These constraints assure that spring tillage occurs prior to planting, planting activities are matched to harvesting activities, and harvesting is performed prior to fall plowing.

The Data[2]

Two farms were selected from the Minnesota Farm Management Association (MFMA) records to obtain time-series yield data. The farms were chosen on the basis of two considerations. First, only corn-soybean farms were considered because farms with other enterprises (e.g., livestock) may have a distinctly different set of production and marketing practices than cash grain farms. Second, it was necessary to look at only those farms with records on yields going back to the early 1970s in order to obtain the necessary time-series data required for the analysis.

Based on these considerations, yield data for two farms were used. Farm 1 was located in Jackson County and had 612 tillable acres in 1983, while Farm 2 was located in Nobles County and had 409 tillable acres for the same year. The actual corn and soybean yields for the two farms along with county averages are shown in Table 2. The yields for both farms were higher, on average, than the two-county average of all farms. As would be expected, the riskiness of yields, as measured by the coefficient of variation, was greater for the two farms (except the soybean yields for Farm 2) than the county average.

The machinery and equipment sets used in the model were

Table 2. Actual Farm Level and County Average Corn and Soybean Yields, 1969 to 1983.

	Corn			Soybeans		
Year	Farm 1	Farm 2	County[a] Average	Farm 1	Farm 2	County[a] Average
1969	104.0	81.7	95.0	27.1	31.1	29.5
1970	106.5	104.3	90.5	36.0	32.7	30.0
1971	101.4	92.3	82.5	33.2	28.5	26.5
1972	136.7	112.8	101.5	37.2	39.4	33.0
1973	73.7	98.5	95.5	17.4	34.0	28.0
1974	68.7	63.3	57.3	29.6	30.9	23.2
1975	70.0	78.6	80.5	32.7	36.1	32.5
1976	67.3	50.0	56.6	36.6	25.0	22.9
1977	124.8	114.0	96.8	44.7	37.4	34.8
1978	129.0	107.1	108.6	53.0	37.6	38.5
1979	148.0	116.6	105.0	34.7	31.5	33.5
1980	114.5	107.7	103.0	40.5	35.1	33.5
1981	147.4	148.0	123.5	48.0	39.3	35.1
1982	132.6	95.6	120.5	47.5	37.7	37.8
1983	50.5	82.5[aa]	84.0	18.9	30.6	31.0
Mean	105.0	96.9	93.4	35.8	33.8	31.3
Std Dev	32.1	23.8	19.3	10.2	4.2	4.7
Coef of Var	30.6	24.6	20.7	28.5	12.4	15.0

SOURCE: Minnesota Farm Management Association Records, 1969-83 and Minnesota Agricultural Statistics, 1970-84.

[a] County average is for both Jackson and Nobles counties.

[aa] Estimate.

typical of farms of comparable size in southern Minnesota. Both farms used a conventional tillage system. Field rates and other technical parameters used in the empirical model were taken from Benson and Gillard. Labor requirements for all operations were assumed to be 110 percent of the machine-time requirements (except 210% for harvest since it was assumed that two workers were required for this operation).

The variable costs for the 1983 analysis were adapted from Minnesota Farm Management Association records and Benson and Gillard. These costs included fuel, lubrication, and repairs for machinery and equipment as well as seed, herbicide, insecticide, fertilizer, interest on cash expenses, variable drying costs, and insurance. Since data were not available for 1986, the 1983 costs were adjusted by using the February 1986 and February 1983 indices of prices paid by farmers (Agricultural Prices, March 1983 and 1986). The operating costs (except drying) were assumed to be known by the farmer at the beginning of the decision process. Drying cost was a function of the moisture content of the corn at harvest and the yield. Since yield and moisture content varied by planting and harvesting date, and by state of nature, the drying costs per acre were stochastic. Variable drying costs per acre were calculated based on a fixed rate per bushel and per percentage point of moisture removed.

Data on the number of field days by period were based on records from the Southwest Experiment Station in Lamberton, Minnesota, for 1974-1983 (Nelson and Straesser). Field days represent the number of days per period that farmers can perform field operations. The hours per field day were based, in part, on the number of hours from sunrise to sunset in this region. A maximum of 11 hours was assumed and the number of daylight hours was rounded down to the next lowest hour for each time period.

The discrete random variables defining the harvest states of nature included corn and soybean yields, field days in stage II production periods, and field rates. For these random variables there were ten states of nature. The discrete values of these variables were based on actual observations for the ten-year sample period, 1974 to 1983, and it was assumed that the farmer perceived each state to be equally likely.

Corn and soybean yields were actual farm-level observations for the sample period (see Table 2). The ten-year yield series for corn and soybeans were regressed on a time variable for each farm to determine whether a trend existed. None of the coefficients on the time variables in the linear trend functions were statistically significant. Consequently, all base yield states were equal to actual values for this period.

For each state of nature, the base yields for corn and soybeans were adjusted for each combination of planting and harvesting period to reflect the effects of timeliness on yields. A moisture content level for corn was set for each planting/harvest period combination to estimate the per acre variable drying cost. These yield coefficients and the moisture content at harvest were adapted from a previous study (Fuller and Hasbargen). It was assumed that all corn planted up to May 21 (i.e., end of period 4) used a full season variety and that corn planted after May 21 (i.e., period 5) used a short-season variety.

The 10 field day states of nature in each stage II production period were the actual number of days available for field work in this region over the sample period. Field rates for harvesting corn and soybeans were a function of yield levels. As yields increase due to more favorable weather or more timely production practices, the time necessary to harvest one acre increases also. To account for this, harvester field rates were adjusted by linear interpolation according to the yields occurring for each planting/harvest period combination and each state of nature. This linear function was based on the suggestions of an agricultural engineer (True).

The discrete random variables defining the post-harvest events consisted of net selling prices for each of the marketing activities in the model. There were 10 price states specified for each of the 10 harvest events, thus making 100 joint events in total. It was assumed that the farmer knew the outcome of the harvest cash price state, but only had probabilistic knowledge of the 10 post-harvest price states at the beginning of stage III.

Stage III price states were generated using procedures similar to those used by King and Lybecker. Corn and soybean monthly cash and futures prices were collected for the 1974-75 through 1984-85 marketing years (All American Cooperative, Stewartville; Chicago Board of Trade). Monthly prices (for the months corresponding to the marketing activities) were generated in index form by dividing the price associated with each marketing activity by the preceding April cash price for each marketing year.[3] Prices were transformed in this way to represent expected price distributions before planting decisions were made.

Although the harvest price states were based on actual observations of the index from the time series, the post-harvest price distributions were simulated. To generate values for the post-harvest price states, it was assumed that the producer based his post-harvest price expectations on a model which uses the harvest cash price and market indicators associated with each harvest state. The market indicators considered were: USDA forecasted carryover stocks, ratios of expected supply/expected disappearance, expected exports, monthly cash prices before harvest, changes in these prices, futures price at harvest, and other lagged prices. For each post-harvest marketing activity, the post-harvest price was regressed (using ordinary least squares) on the harvest price and a market indicator to fit the various models. All the variables were in natural logarithms and all prices were in index form. The logarithm model was used because it had the best fit in terms of the adjusted R-squared of all forms considered, which included linear models.

The five corn and five soybean price-expectations models selected are presented in Tables 3 and 4. The dependent variables in these models were: the February, April, May, and June cash price, and the July futures contract price in May. These equations were estimated using the same 10 years of observations used to define the harvest price states of nature.

Table 3. Post-Harvest Corn Price Expectation Models.*

I.	$LPC_5 = -0.671 + 0.788\ LPC_2 + 0.091\ LCX$ (-1.17) (7.34) (1.19)	R**2 = 0.8551
II.	$LPC_7 = -1.450 + 0.741\ LPC_2 + 0.202\ LCX$ (-2.06) (5.61) (2.15)	R**2 = 0.7674
III.	$LPC_8 = -1.580 + 0.686\ LPC_2 + 0.222\ LCX$ (-2.39) (5.52) (2.58)	R**2 = 0.7646
IV.	$LPC_9 = -1.410 + 0.622\ LPC_2 + 0.200\ LCX$ (-1.66) (3.91) (1.77)	R**2 = 0.6025
V.	$LFC_8 = -2.190 + 0.623\ LPC_2 + 0.318\ LCX$ (-2.75) (4.16) (2.99)	R**2 = 0.6733

Where: LPC_i = log of normalized cash corn price, i=2 => November, i=5 => February, i=7 => April, i=8 => May, i=9 => June

LFC_8 = log of normalized July futures price in May

LCX = log of expected corn exports, reported by the USDA, in October

R**2 = Adjusted R Squared

* Numbers in parentheses are t-values.

Table 4. Post-Harvest Soybean Price Expectation Models.[a]

I.	$LPS_5 = -0.068 + 0.805\ LPS_1 - 0.817\ SPC$ $(-2.07)\quad(8.25)\qquad(-3.10)$	R**2 = 0.8844
II.	$LPS_7 = -0.004 + 0.768\ LPS_1 - 1.250\ SPC$ $(-0.070)\quad(4.61)\qquad(-2.77)$	R**2 = 0.7195
III.	$LPS_8 = 0.008 + 0.723\ LPS_1 - 1.600\ SPC$ $(0.180)\quad(5.61)\qquad(-4.58)$	R**2 = 0.8253
IV.	$LPS_9 = 0.003 + 0.638\ LPS_1 - 1.270\ SPC$ $(0.050)\quad(4.58)\qquad(-3.37)$	R**2 = 0.7402
V.	$LFS_8 = 0.067 + 0.683\ LPS_1 - 1.590\ SPC$ $(1.630)\quad(5.69)\qquad(-4.91)$	R**2 = 0.8359

Where: LPS_i = log of normalized cash soybean price, i=1 => October, i=5 => February, i=7 => April, i=8 => May, i=9 =>June

LFS_8 = log of normalized July futures price in May

SPC = normalized October cash price minus September cash price

R**2 = Adjusted R Squared

[a] Number in parentheses are t-values.

Hence, for each of the 10 models there were 10 error terms. The explanatory variables in the selected corn-price expectation models were the harvest cash price and expected corn exports reported by the USDA at harvest time. Coefficients on these two variables were positive for all five equations, as expected. The independent variables in the soybean price expectation models were the harvest cash price and the change in the cash price from September to October. All estimated coefficients on the harvest price variable were positive, while the coefficients on the price change variable were negative.

The 10 error terms from each regression were added to the predicted value of the model to create the post-harvest price states for each harvest stage state of nature. For example, the predicted value (in natural logarithm form) of the February indexed cash corn price under harvest state 1 was 0.212. The 10 error terms from this regression were added to this number to generate 10 states of nature conditional upon harvest state 1. This process was repeated for the rest of the 10 harvest states to obtain 10 conditional post-harvest states for each of the post-harvest marketing activities. The exponential of the natural logarithm was used to convert the prices into gross indexed prices.

Finally, the resulting indexed prices were converted into current price states by multiplying them by the April 1983 (April 1986 for the analysis of the 1986 program) cash prices. These prices were $2.92 and $5.92 per bushel in 1983 and $2.07 and $5.00 per bushel in 1986 for corn and soybeans, respectively.

Prices for the marketing activities requiring storage and sales at a later time than harvest were discounted for shrinkage and interest costs to reflect the opportunity cost of storage.[4] It was again assumed that the farmer believed each of the post-harvest states had an equal probability of occurrence. The yield and harvest price states of nature are shown in Table 5. For post-harvest price states, see Kaiser.

The Participation Case

Up to this point, the discussion has focused on the nonparticipation scenario for both farms. The model has been presented in terms of the production and marketing options available to the two farms. Program parameters of the 1983 and 1986 commodity programs pertaining to corn and soybeans were selected for this study. Provisions of the 1983 program included a 10 percent corn acreage reduction program (ARP), corn and soybeans price supports of \$2.49 and \$4.81 per bushel, respectively, and a corn target price of \$2.86 per bushel. Provisions of the 1986 program included a 20 percent ARP, corn and soybean price supports of \$1.74 and \$4.66 per bushel (estimated by Nobles County ASCS office), and a corn target price of \$3.03 per bushel.

The corn ARP was incorporated by changing the land constraint (equation (5)) to the following:

$$L_1 X_c \leq (1-ARP)CA^s \quad (15)$$

$$L_2 X_s \leq SA^s \quad (16)$$

where: L_1, L_2 = vectors of ones;

Table 5. Yield and Harvest Cash Price States of Nature.

	Yields*				Harvest Cash Prices			
	Farm 1		Farm 2		1983		1986	
Harvest State	Corn	Soy-beans	Corn	Soy-beans	Corn	Soy-beans	Corn	Soy-beans
	bu/ac				dollars/bushel			
1	68.7	29.6	63.3	30.9	4.09	9.59	2.90	8.10
2	70.0	32.7	78.6	36.1	2.42	5.98	1.72	5.05
3	67.3	36.6	50.0	25.0	2.39	6.10	1.70	5.15
4	124.8	44.7	114.0	37.4	2.37	6.10	1.68	5.15
5	129.0	53.0	107.1	37.6	2.54	6.93	1.80	5.85
6	148.0	34.7	116.6	31.5	2.77	8.41	1.97	7.10
7	114.5	40.5	107.7	35.1	3.97	10.77	2.82	9.10
8	147.4	48.0	148.0	39.3	2.01	6.04	1.43	5.10
9	132.6	47.5	95.6	37.7	2.60	6.33	1.84	5.35
10	50.5	18.9	82.5	30.6	3.12	7.28	2.21	6.15
Mean	105.3	38.6	96.3	34.1	2.83	7.35	2.00	6.21
Coef of Var	33.4%	26.4%	28.2%	12.5%	24.6%	23.0%	24.6%	23.0%

* These are average annual yields, which are multiplied by planting/harvest period coefficients to reflect timeliness of planting and harvesting operations in the model.

X_c, X_s = vectors of planting activities for corn and soybeans, respectively:

CA*,SA* = optimal corn and soybean acreage planted under nonparticipation for each risk coefficient.

Under the ARP provision, the amount of corn planted could not exceed (1-ARP) times the nonparticipation corn base for each risk aversion level. Soybean acreage could not exceed 100 percent of the soybean base acreage.[5] This procedure was used so that the acreage base for each participation run reflected the corresponding risk posture of the farmer.

Under both programs, a soil-conserving crop was to be planted, but not harvested, on the set-aside acres. In order to account for this provision, it was assumed that both farms planted oats on the idle acreage, which is a common practice among participating Minnesota farmers. The cost of growing oats as a conserving crop included the costs of disking, planting, mowing, and seed for growing oats and was based on estimates from Hasbargen. In the participation scenario, the model was solved without these costs and then the costs were subtracted from the expected net revenue. This procedure was used because these costs can be viewed as fixed costs, unique to the participation case, and therefore would not affect the decision variables in the model.

Producers satisfying the ARP for corn are eligible for corn and soybean price supports. Producers may place any portion of their crop in CCC-approved storage and receive a nonrecourse loan equal to the loan rate times the amount of crop transferred to the government any time between October 1 and June 1. To incorporate this provision of the programs, all cash market price states of nature lower than the loan rate were truncated at the loan level. Through this procedure, it is implicitly assumed that farmers only take out loans when the market price falls below the support price.

Deficiency payments for corn are made whenever the higher of the loan rate or the five-month (October to February) national average cash price is lower than the target price. Deficiency payments are made independently of marketing decisions formulated by the farmer. The deficiency payment rate per bushel of corn is equal to the following:

$$DP_i = \begin{cases} TP - \max[PS_c, E(P_{ci})], & \text{if} > 0 \\ 0, & \text{otherwise} \end{cases} \qquad (17)$$

where: DP_i = deficiency payment rate per bushel, state i;
TP = national target price for corn;
PS_c = local price support level,
$E(P_{ci})$ = 5 month national average price, state i.

The total payment is equal to (17) times the program yield times the number of acres planted to corn.

Although the target price, program yield, and price support levels were nonstochastic, total deficiency payments were represented by 10 stage-two states of nature associated with 5-month national average price events. To incorporate deficiency payments into the model, deficiency payments were included in the constraints defining net revenue outcomes. The program yields were set at actual levels established for both farms. The target price for each state was calculated using a procedure similar to that used for the other price states. First, national average target prices were indexed by dividing by the April national average cash price for corn for each of the 10 years in the time series. Then, the resulting indexed prices were converted to 1983 levels by multiplying them by the 1983 April (and 1986 March) national average cash price for corn. The resulting target prices were used in equation (17) to arrive at deficiency payment rates for each harvest event.

THE RESULTS

In this section, two sets of results are reported. First, nonparticipation and participation scenarios under 1983 program provisions, prices, and costs for Farms 1 and 2 are presented and discussed. Then, an analysis of nonparticipation and participation under 1986 provisions, prices, and costs for Farm 1 is provided.

The procedures used for both situations involved the following steps. The model was first solved for the nonparticipation case with the risk coefficient r parametrically adjusted from 0.0 to 2.0 in increments of 0.5. Each of these solutions provided base acreages of corn and soybeans for an agent with the associated risk posture. Then, two versions of the participation model were solved for each r value to examine the relative risk efficiencies of participation and nonparticipation.

For the 1983 participation model, corn acreage was limited to 90% of the base acreage of corn taken from the nonparticipation solutions for each level of risk aversion. The first version of the participation model maximized E subject to an upper bound on D at the nonparticipation level. The second version of the model minimized D subject to a lower bound on E at the nonparticipation level. This approach was used because initial solutions under the participation scenario using E - arD as the objective function gave some solutions with a lower E and lower D, or a higher E and higher D than under nonparticipation. It therefore would have been necessary to rely on a strict interpretation of the objective function as expected utility in order to compare participation and nonparticipation results. The two solutions of the revised participation model made it possible to evaluate what opportunities, if any, there were to either increase E or decrease D by participating in the program.

Two sets of solutions were solved for the 1986 participation model. In the first set, corn acreage was limited to 80% of the base acreage of corn taken from the 1986 nonparticipation solutions for each level of risk aversion. The two versions of the model were solved to find the maximum E and minimum D due to program participation. In the second set of 1986 participation solutions, corn acreage was limited to 80% of the base acreage of corn taken in the 1983 nonparticipation solutions for each level of risk aversion. Again, E and D were constrained to 1986 nonparticipation optimal levels to find whether participation was E-D dominant to nonparticipation in 1986.

1983 Nonparticipation Results

The set of efficient farm plans under nonparticipation for

Farms 1 and 2 are summarized in Table 6. For Farm 1, expected net revenue under nonparticipation ranged from $109,498 to $45,771 as the risk coefficient (r) was increased from 0.0 to 2.0. The corresponding standard deviations of net revenue were $52,987 and $3,913 for this risk interval. For Farm 2, expected net revenue under nonparticipation ranged from $62,607 in the risk-neutral case to $39,735 in the highest risk-aversion case. The standard deviation within this risk interval ranged from $24,225 to $1,818. The ED frontiers are shown graphically for both farms in Figure 2.

For both farms, corn yields were more variable than soybean yields in terms of the coefficient of variation of per acre yields. Corn acreage tended to decline as the risk coefficient was increased. For example, the percentage of land planted to corn went from 63% to 23% between r values of 0.0 and 2.0 for Farm 1. For Farm 2, acres devoted to corn fell from 62% to 37% of total acres for the same risk-coefficient range.

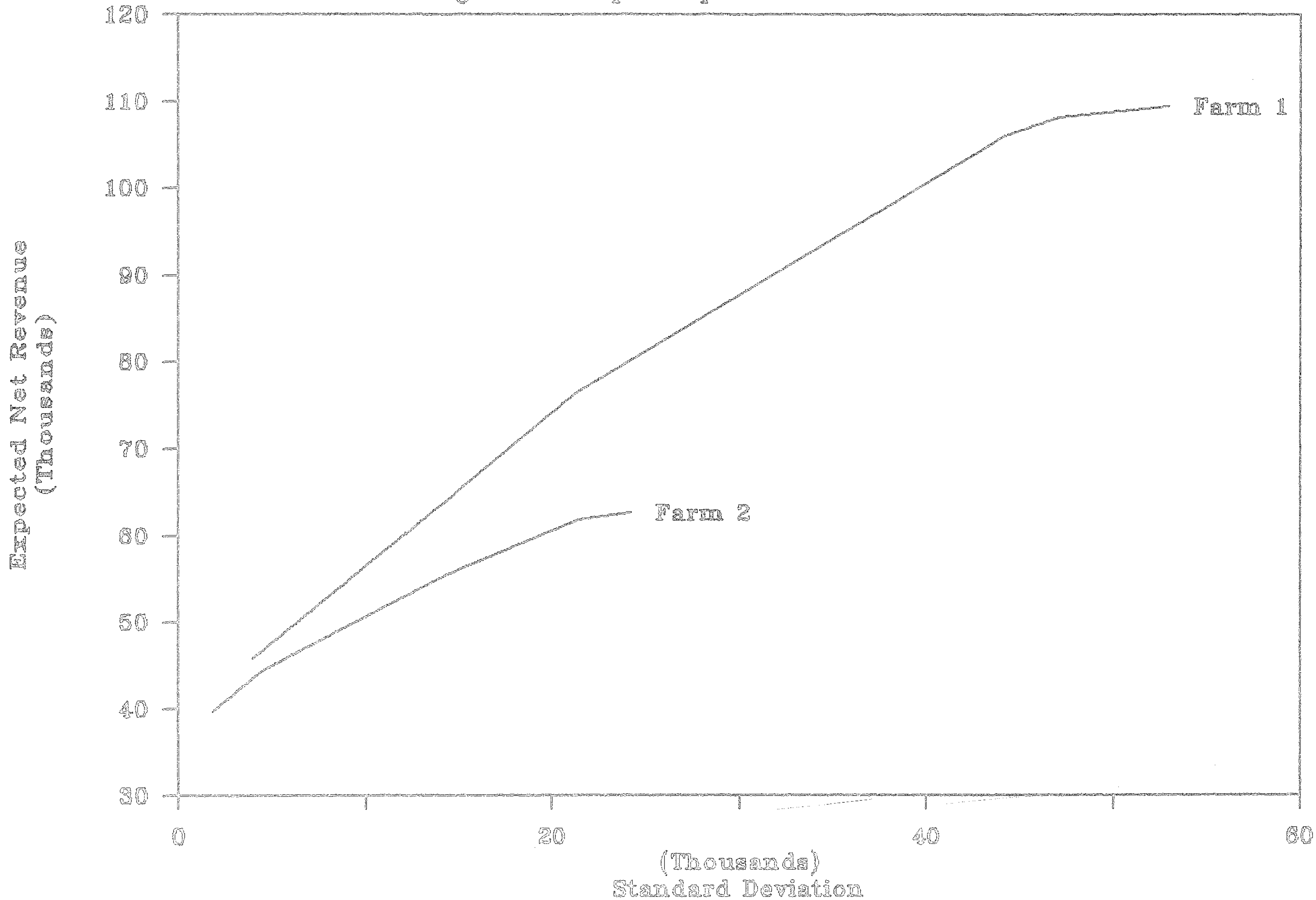
A summary of optimal solutions for the marketing activities is reported in Table 6, also. The marketing activity levels are reported here in acres so that the results for corn and soybeans may be combined. Cash market sales at harvest and the storage hedge both dominated the post-harvest sales for farm 1 for all risk averse cases -- the storage hedge was dominant in the risk neutral case. As the risk coefficient was increased, a smaller portion of total production for Farm 1 was sold in the post-harvest cash market -- the combined use of post-harvest sales activities went from 36% to 23% of total production between r

Table 6. Farm 1 and Farm 2 Programming Solutions for the Nonparticipation Scenario, 1983.

Risk Coef (r)	Expected Net Revenue	Standard Deviation	Production: Corn	Production: Soybeans	Marketing Strategies*: Harvest Cash Sale	Marketing Strategies*: Storage Hedge	Marketing Strategies*: Post Harvest Sale
Farm 1							
0.0	$109,498	$52,987	386ac.	226ac.	233	158	221
0.5	108,326	47,080	299	313	201	223	188
1.0	106,205	44,264	257	355	162	293	157
1.5	76,167	21,189	274	338	165	270	145
2.0	45,771	3,913	143	469	201	272	139
Farm 2							
0.0	$62,607	$24,225	252ac.	157ac.	146	111	152
0.5	61,759	21,410	192	217	118	128	163
1.0	55,487	14,342	152	257	103	130	176
1.5	44,313	4,413	152	257	122	157	156
2.0	39,735	1,818	152	257	114	194	105

* The marketing activities are averaged over the ten harvest states of nature, stated in acres and both crops are combined.

Figure 2: Nonparticipation ED Frontiers



values of 0.0 and 2.0. For Farm 2, marketing by harvest cash sale and storage hedge went from 63% at r=0.0, decreased slightly, then increased to 74% of total production at r=2.0. For both farms, the greatest use of harvest cash market sales occurred in the risk-neutral case.

Marketing results under nonparticipation are reported for Farms 1 and 2 in Tables 7 and 8, respectively. Marketing activity levels are reported by harvest state of nature for a risk-neutral (r=0.0) and a risk-averse case (r=1.5). Optimal marketing activities varied substantially depending upon the harvest state of nature. For example, in the risk-neutral case, if harvest state 6 occurs, the optimal marketing strategy for Farm 1 was to sell 29,134 bushels of corn in November in the cash market, 32,467 bushels of corn would be hedged, and 7,533 bushels of soybeans would be sold from storage in the cash market in May. On the other hand, if harvest state 9 occurred, 15,248 bushels of corn would be sold in the November cash market, 40,000 bushels of corn would be sold in May in the cash market, and 10,311 bushels of soybeans would be sold in October in the cash market.

As previously discussed, the use of the storage hedge is greater for the risk averse agent than the risk-neutral agent. In the risk-neutral case for Farm 1, the storage hedge activity was used in 4 of the 10 harvest states for corn and 2 of the 10 harvest states for soybeans. This marketing activity represented 30.2% of corn production and 18.2% of soybean production on average over the 10 harvest states. In the risk averse case for Farm 1, the storage hedge was used in 7 of the 10 harvest states

Table 7. Marketing Activities for Farm 1, Risk-Neutral and Risk-Averse Cases.

Risk Coef (r)	Crop	Marketing Activity[8]	Bushels by State of Nature 1	2	3	4	5	6	7	8	9	10	Average
0.0	Corn	NCS	0	0	0	21,625	13,666	29,134	16,653	21,276	15,248	21,058	13,866
		SH	28,800	0	0	0	40,000	32,467	31,207	0	0	0	13,247
		FCS	0	0	0	0	0	0	0	0	0	0	0
		ACS	0	0	0	0	0	0	0	0	0	0	0
		MCS	0	0	0	0	0	0	0	0	40,000	0	4,000
		JCS	0	29,121	27,985	30,302	0	0	0	40,000	0	0	12,741
		Total --	28,800	29,121	27,985	51,927	53,666	61,601	47,860	61,276	55,248	21,058	43,854
	Soybeans	OCS	0	7,099	0	0	11,506	0	0	10,420	10,311	4,103	4,344
		SH	6,426	0	0	0	0	0	8,792	0	0	0	1,522
		FCS	0	0	0	0	0	0	0	0	0	0	0
		ACS	0	0	0	0	0	0	0	0	0	0	0
		MCS	0	0	7,946	0	0	7,533	0	0	0	0	1,548
		JCS	0	0	0	9,698	0	0	0	0	0	0	970
		Total --	6,426	7,099	7,946	9,698	11,506	7,533	8,792	10,420	10,311	4,103	8,383
1.5	Corn	NCS	0	0	0	11,637	0	14,609	6,308	13,335	8,686	15,104	6,968
		SH	20,936	0	0	25,881	38,651	29,717	27,704	22,063	10,050	0	17,500
		FCS	0	0	0	0	0	0	0	0	20,819	0	2,082
		ACS	0	0	0	0	0	0	0	0	255	0	26
		MCS	0	0	0	0	0	0	0	0	0	0	0
		JCS	0	20,948	20,083	0	0	0	0	8,728	0	0	4,976
		Total --	20,936	20,948	20,083	37,518	38,651	44,326	34,012	44,126	39,810	15,104	31,551
	Soybeans	OCS	0	10,512	0	0	16,210	0	0	0	0	6,033	3,276
		SH	8,808	0	0	0	0	0	12,296	9,209	8,876	0	3,919
		FCS	0	0	0	0	0	0	0	0	0	0	0
		ACS	0	0	0	0	0	0	0	0	0	0	0
		MCS	0	0	11,786	8,599	0	10,283	0	0	0	0	3,067
		JCS	0	0	0	5,520	0	0	0	0	0	0	552
		Total --	8,808	10,512	11,786	14,119	16,210	10,283	12,296	9,209	8,876	6,033	10,813

[8] Marketing activity codes are the following:

OCS = October Cash Market Sale
SH = Storage Hedge (See text for a detailed description)
NCS = November Cash Market Sale
FCS = February Cash Market Sale
ACS = April Cash Market Sale
MCS = May Cash Market Sale
JCS = June Cash Market Sale

Table 8. Marketing Activities for Farm 2, Risk-Neutral and Risk-Averse Cases.

Risk Coef (r)	Crop	Marketing Activity[a]	Bushels by State of Nature 1	2	3	4	5	6	7	8	9	10	Average
0.0	Corn	NCS	0	0	0	11,827	4,193	11,690	9,684	15,293	1,101	22,554	7,634
		SH	17,373	0	0	0	25,000	20,172	19,620	0	0	0	8,217
		FCS	0	0	0	0	0	0	0	0	0	0	0
		ACS	0	0	0	0	0	0	0	0	0	0	0
		MCS	0	0	0	0	0	0	0	0	25,000	0	2,500
		JCS	0	21,540	13,614	19,277	0	0	0	25,000	0	0	7,943
		Total --	17,373	21,540	13,614	31,104	29,193	31,862	29,304	40,293	26,101	22,554	26,294
	Soybeans	OCS	0	5,534	0	0	5,763	0	0	6,024	5,687	4,691	2,770
		SH	4,737	0	0	0	0	0	5,380	0	0	0	1,012
		FCS	0	0	0	0	0	0	0	0	0	0	0
		ACS	0	0	0	0	0	0	0	0	0	0	0
		MCS	0	0	3,832	0	0	4,829	0	0	0	0	866
		JCS	0	0	0	5,723	0	0	0	0	0	0	572
		Total --	4,737	5,534	3,832	5,723	5,763	4,829	5,380	6,024	5,687	4,691	5,220
1.5	Corn	NCS	0	0	0	3,085	0	0	1,360	6,282	0	13,598	2,433
		SH	10,668	0	8,317	9,552	10,283	19,365	16,330	0	0	22	7,454
		FCS	0	0	0	0	820	0	0	0	0	28	85
		ACS	0	0	0	0	0	0	0	0	7,386	0	739
		MCS	0	0	0	0	6,587	0	0	0	8,596	0	1,518
		JCS	0	13,095	0	6,356	0	0	0	18,174	0	0	3,763
		Total --	10,668	13,095	8,317	18,993	17,690	19,365	17,690	24,456	15,982	13,648	15,990
	Soybeans	OCS	0	8,951	0	0	5,781	0	0	0	8,941	5,376	2,905
		SH	7,499	0	0	0	1,099	0	8,670	6,826	0	38	2,413
		FCS	0	0	0	0	0	0	0	0	0	0	0
		ACS	0	0	0	0	0	0	0	0	0	0	0
		MCS	0	0	6,211	0	0	5,636	0	0	0	0	1,185
		JCS	0	0	0	9,093	0	0	0	0	0	0	909
		Total --	7,499	8,951	6,211	9,093	6,880	5,636	8,670	6,826	8,941	5,414	7,412

[a] Marketing activity codes are the following:

OCS = October Cash Market Sale
SH = Storage Hedge (See text for a detailed description)
NCS = November Cash Market Sale
FCS = February Cash Market Sale
ACS = April Cash Market Sale
MCS = May Cash Market Sale
JCS = June Cash Market Sale

for corn and 4 of the 10 harvest states for soybeans, about double compared to the risk-neutral case. On average, this strategy represented 55.5% and 36.2% of total sales for each crop, respectively.

Similar results occurred for Farm 2. In the risk-neutral case for Farm 2, the storage hedge was used in 4 out of the 10 harvest states of nature for corn and 2 of 10 for soybeans. This represented 31.3% and 19.4% of corn and soybean total sales, respectively. In the risk-averse case, the storage hedge was used in 7 out of 10 states for corn and 5 of 10 states for soybeans. This accounted for 46.6% and 32.6% of corn and soybean total sales, respectively. Based upon the average number of marketing instruments used under a particular state of nature, the marketing plans in the risk-averse cases were slightly more diversified. However, the most notable adjustments to reduce risk involved the shift from corn to soybean production and the increased use of the storage hedge.

1983 Participation Results

Table 9 presents the expected net revenue, standard deviation, crop mix, and deficiency payment by risk-aversion level for both farms under nonparticipation and participation in the 1983 commodity programs. Figure 3 shows the nonparticipation ED frontier for Farm 1 and the participation solutions for r=0.0 and r=1.5. For both farms, a general pattern emerged with respect to the effects of program participation on expected net revenue and risk. Generally, as risk aversion increased, the potential for

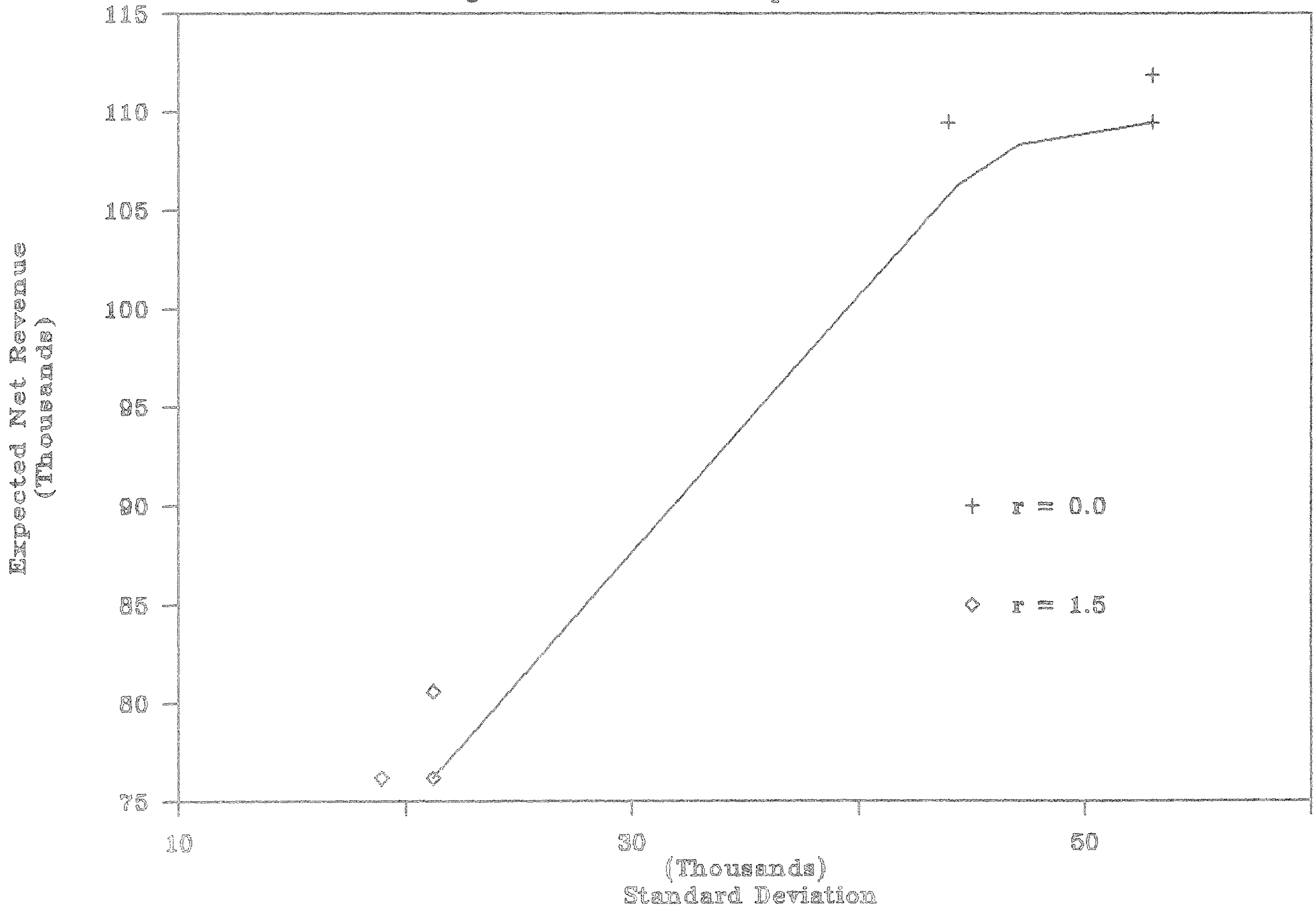
Table 9. Nonparticipation and Participation DSSP/ED Programming Solutions by Nonparticipation and Participation in the 1983 Farm Program, Farms 1 and 2.

	- Nonparticipation -		Participation						
Risk Coef (r)	Expected Net Revenue	Standard Deviation	Solution 1[a] E	(Difference)[aa]	Solution 2[a] D	(Difference)[aa]	Acres Corn	Acres Soybeans	Average Deficiency Payment
Farm 1									
0.0	109,498	52,987	111,868	(2,370)	43,935	(-9,052)	386	226	2,136
0.5	108,326	47,080	111,033	(2,707)	38,567	(-8,513)	299	313	4,256
1.0	106,205	44,264	109,351	(3,146)	36,581	(-7,683)	257	355	3,654
1.5	76,167	21,189	80,601	(4,434)	18,939	(-2,250)	274	338	3,908
Farm 2									
0.0	62,607	24,225	66,661	(4,054)	17,519	(-6,706)	252	157	3,591
0.5	61,759	21,410	65,254	(3,495)	15,274	(-6,136)	192	217	2,737
1.0	55,487	14,342	60,813	(5,326)	8,165	(-6,177)	152	257	2,167
1.5	44,313	4,413	51,001	(6,688)	1,138	(-3,275)	152	257	2,167

[a] Solution 1 gives the maximum E subject to D less than or equal to D', where D' is the optimal standard deviation for the nonparticipation case. Solution 2 gives the minimum D subject to E greater than or equal to E', where E' is the optimal expected net revenue for the nonparticipation case.

[aa] The numbers in parentheses give the changes in expected net revenue and standard deviation, respectively, from the nonparticipation case.

Figure 3: Farm 1 Participation Results



increasing average net revenue by participating in commodity programs increased. Also, as risk aversion increased, the potential for decreasing risk through program participation declined. This pattern was broken slightly in the Farm 2 results (see Table 9).

For Farm 1, participation dominated nonparticipation at each level of risk aversion considered. Risk-neutral producers (r=0) with characteristics similar to Farm 1 would have benefited because E could be increased by $2,370 by participating in the commodity programs. As solution 2 indicates, a significant decrease in risk was possible -- $9,052. Moderately risk-averse agents (r=1) would have preferred participation over nonparticipation because it resulted in either a $3,146 increase in E with the same level of D, or a $7,683 decrease in D with the same level of E relative to nonparticipation. At r=1.5, the farmer would have found participation superior to nonparticipation due to a $4,434 increase in E with the same level of risk, or a $2,250 decrease in D with the same level of expected income.

Similar to Farm 1, participation dominated nonparticipation for Farm 2 at all levels of risk aversion considered. Risk neutral producers with characteristics similar to Farm 2 would have benefited from participation since it resulted in an increase in expected net revenue of $4,054 over the nonparticipation scenario. Moderately risk-averse agents (r = 1) would have found participation optimal because it resulted in either a $5,326 increase in E with the same level of D, or a $6,177 decrease in D with the same level of E as in the nonparticipation results. Highly risk-averse farmers (r = 1.5) with the same attributes as Farm 2 would have benefited the most out of all three groups from participation. For these producers, participation resulted in either a $6,688 increase in E with the same level of D, or a $3,275 decrease in D with the same level of E as in the nonparticipation case. Since different yield time series were used for Farm 2, the results provide a sensitivity analysis with respect to yield distributions. The results suggest that changing the yield distribution did not make nonparticipation more E-D efficient than participation in the 1983 program.

Although participating farms were required to reduce their corn bases by 10% to be eligible for the 1983 program, the loss of income due to this acreage reduction was more than offset by the benefits of higher prices and government income payments. As Table 10 shows, deficiency payments to both farms were made in 5 out of the 10 harvest states of nature because the corn target price was greater than the higher of the loan or market price under these five states of nature. For Farm 1, deficiency payments averaged 2.0%, 3.8%, 3.3%, and 4.9% of expected net revenue for r values equal to 0, .5, 1, and 1.5, respectively. Average deficiency payments for Farm 2 were 5.4%, 4.2%, 3.6%, and 4.3% of expected net revenue for the same range of risk coefficients.

The fact that government payments were made in 5 of the 10 harvest events combined with market prices being truncated by the price support levels caused expected net revenue to be higher

Table 10. Deficiency Payments by Harvest State of Nature and Risk-Aversion Coefficient for Farm 1 and Farm 2, 1983.

Risk Coef (r)	Deficiency Payment by Harvest State of Nature: 1	2	3	4	5	6	7	8	9	10	Average Deficiency Payment
Farm 1...											
0.0	0	3,661	1,983	5,492	0	0	0	8,695	1,526	0	2,136
0.5	0	7,295	3,952	10,943	0	0	0	17,326	3,040	0	4,256
1.0	0	6,265	3,393	9,397	0	0	0	14,879	2,610	0	3,654
1.5	0	6,699	3,628	10,048	0	0	0	15,909	2,791	0	3,908
2.0	0	3,498	1,895	5,248	0	0	0	8,309	1,458	0	2,041
Farm 2...											
0.0	0	6,156	3,335	9,234	0	0	0	14,621	2,565	0	3,591
0.5	0	4,692	2,541	7,038	0	0	0	11,143	1,955	0	2,737
1.0	0	3,715	2,013	5,573	0	0	0	8,824	1,548	0	2,167
1.5	0	3,715	2,013	5,573	0	0	0	8,824	1,548	0	2,167
2.0	0	3,715	2,013	5,573	0	0	0	8,824	1,548	0	2,167

and/or the standard deviation to be lower compared with nonparticipation in the program. These results imply that risk neutral and risk averse farms having characteristics similar to these farms would have found participation in the 1983 commodity program desireable.

<u>1986 Participation Results</u>

In order to analyze how participation incentives have changed since 1983, the model was solved for Farm 1 using 1986 prices, costs, and program parameters. Since market prices were much lower in 1986 than in 1983, one might expect that the benefits of participation were even more attractive in 1986 than in the 1983.

Table 11 presents the expected net revenue, standard deviation, crop mix, and deficiency payments by r for the 1986 nonparticipation and two participation scenarios -- one using acreage constraints derived from 1986 base levels and a second using 1983 bases. The 1983 bases were used to examine the plausible case of a farm which had participated in commodity programs since 1983.

Participation in the 1986 program again dominated nonparticipation for risk-neutral and risk-averse producers. Moreover, the incentives to participate were greater in 1986 than they were in 1983. Under the 1986 base-acreage scenario, risk-neutral farmers had stronger incentives than in 1983 because E was $12,664 greater under participation relative to nonparticipation. Moderately risk-averse farmers (r = 1) had greater

Table 11. Nonparticipation and Participation DSSP/ED Programming Solutions by Nonparticipation and Participation in the 1986 Farm Program, Farm 1.

	- Nonparticipation -		——— Participation (1986 Base Acres*) ———							——— Participation (1983 Base Acres*) ———						
	Expected															
Risk	Net	Standard					--Acres--		Average					--Acres--		Average
Coef	Revenue	Deviation	-Solution 1**-		-Solution 2**-			Soy-	Deficiency	-Solution 1**-		-Solution 2**-			Soy-	Deficiency
(r)	(E)	(D)	E	(Diff)***	D	(Diff***)	Corn	beans	Payment	E	(Diff***)	D	(Diff***)	Corn	beans	Payment
0.0	68,862	35,502	81,526	(12,664)	18,758	(-16,744)	135	443	10,945	86,434	(17,572)	18,413	(-17,089)	309	226	25,053
0.5	68,584	34,243	82,371	(13,787)	18,348	(-15,895)	150	424	12,162	85,893	(17,309)	17,250	(-16,993)	239	313	19,378
1.0	67,310	32,926	81,526	(14,216)	17,977	(-14,949)	135	443	10,945	85,209	(17,899)	16,860	(-16,066)	206	355	16,702
1.5	45,028	15,432	59,984	(14,956)	7,903	(-7,529)	79	503	6,405	64,742	(19,714)	5,656	(-9,776)	219	338	17,526

* The 1986 base acre results are based on the 20% corn ARP applied to the optimal acreage from the 1986 nonparticipation case. The 1983 base acre results are based on the 20% corn ARP applied to the optimal acreage from the 1983 nonparticipation case.

** Solution 1 gives the maximum E subject to D less than or equal to D', where D' is the optimal standard deviation for the nonpartcipation case. Solution 2 gives the minimum D subject to E greater than or equal to E', where E' is the optimal expected net revenue in the nonparticipation case.

*** The numbers in parentheses give the changes in expected net revenue and standard deviation, respectively, from the nonparticipation case.

incentives compared to 1983 results because participation resulted in either a $14,216 increase in E, or a $14,949 decrease in D relative to nonparticipation. Finally, extremely risk-averse agents (r = 1.5) could have increased E by $14,956 or reduced D by $7,529 through participation in the 1986 program. Due to the relatively low market price for corn, the 1986 bases included large acreages of soybeans. However, had crop rotation benefits been built into the model, the magnitude of this shift would likely have been reduced.

When the participation model was solved constraining base acreage to 1983 optimal levels, similar results prevailed. Under this scenario, risk-neutral farmers could have increased E by $17,572 relative to nonparticipation. Moderately risk-averse producers could have increased E by $17,899 or reduced D by $16,066 relative to nonparticipation. Finally, extremely risk-averse agents could have increased E by $19,714 or reduced D by $9,776 through participating in the 1986 program. As with the 1983 results, as risk aversion increased, the potential to increase average net revenue by participating in commodity programs increased while potential to reduce risk declined.

While deficiency payments in the 1983 scenario were made in 5 of the 10 harvest states of nature, government payments were made in 9 of the 10 states in both 1986 scenarios (see Table 12). Deficiency payments, averaged over the 10 harvest states of nature, were significantly higher in 1986 than in 1983. For instance, in the 1986 base acreage case, the average payment for the risk-neutral case was $10,945 in 1986 compared to $2,136 in

Table 12. Deficiency Payments (1986) by Harvest State of Nature and Risk-Aversion Coefficient for Farm 1, 1986 and 1983 Base Acreage Scenarios.

Risk Coef (r)	Deficiency Payment by Harvest State of Nature 1	2	3	4	5	6	7	8	9	10	Average Deficiency Payment
Acreage Constrained to 1986 Nonparticipation Base...											
0.0	229	15,713	14,340	17,086	12,662	7,017	0	19,374	13,882	9,153	10,945
0.5	254	17,459	15,933	18,984	14,069	7,797	0	21,527	15,425	10,170	12,162
1.0	229	15,713	14,340	17,086	12,662	7,017	0	19,374	13,882	9,153	10,945
1.5	134	9,195	8,391	9,998	7,409	4,106	0	11,337	8,124	5,356	6,405
Acreage Constrained to 1983 Nonparticipation Base...											
0.0	524	35,965	32,822	39,107	28,981	16,062	0	44,345	31,774	20,950	25,053
0.5	405	27,817	25,387	30,248	22,416	12,423	0	34,299	24,576	16,204	19,378
1.0	349	23,976	21,881	26,071	19,321	10,708	0	29,563	21,183	13,967	16,702
1.5	371	25,489	23,262	27,717	20,540	11,384	0	31,429	22,520	14,848	17,756

1983. Average deficiency payments were 13.4%, 26.5%, 23.0%, and 33.4% of expected net revenue for r values of 0, .5, 1, and 1.5, respectively. In the 1983 base-acreage case, average deficiency payments were 29.0%, 22.6%, 19.6%, and 27.1% for r values of 1, .5, 1, and 1.5, respectively. The stronger economic incentives to participate in 1986 therefore were due to lower market prices and a higher deficiency payment rate for corn relative to 1983, even though the corn ARP was twice as large and price supports were lower in 1986.

SUMMARY AND IMPLICATIONS

This study investigated the effectiveness of participation in farm commodity programs relative to other production and price risk management strategies used by corn-soybean farmers in southern Minnesota. The decision of whether or not to participate in commodity programs is an important one to farmers in this region, considering the tremendous price and production risk they face.

A discrete stochastic sequential programming (DSSP) model with a MOTAD-type objective function was used in the analysis. The sequential nature of the problem was captured in a three-stage decision process. Discrete states of nature were defined for the harvest and post-harvest stages of the decision process. These states included stochastic prices, yields, field time, and field rates. Two situations were investigated. The first involved analyzing the benefits of participation in the 1983 program for two case farms with different acreages, machinery complements, and yield distributions. The second examined participation in the 1986 program using one of the case farms. Efficient sets of expected income-standard deviation of expected income were derived by adjusting the risk-aversion coefficient in the model. Participation was found to be E-D dominant to nonparticipation for all scenarios investigated.

An important implication of this study is drawn from the conclusion that risk-neutral, as well as risk-averse, producers would have been better off under program participation compared to nonparticipation. The results demonstrate that the net benefits of the 1983 and 1986 programs included income enhancement as well as income stabilization. Although a different model was used than in previous studies, these findings are consistent with the majority of those reviewed above, particularly the findings of Musser and Stamoulis. A unique result of this analysis, however, had to do with the nature of the benefits of program participation for agents with various risk postures. As aversion to risk increased, the potential for reducing risk by participating in the programs declined and the potential for increasing average income grew.

Not surprisingly, the results confirm suggestions that the incentives to participate in the 1986 program were greater than those for the 1983 program. This was true even though the corn ARP was larger and price supports were lower in 1986 than in 1983. The primary reason for this was the lower market prices in 1986 combined with a higher target price for corn. The fact that market prices are substantially lower, target prices higher, and participation incentives stronger in 1986 relative to 1983 implies that the budgetary costs of commodity programs will likely be higher in 1986 than in previous years. Furthermore, there is no indication that prices will improve over the next couple of years, perhaps resulting in even greater incentives to participate. It appears, therefore, that policy-makers will be confronted with the difficult task of adjusting program parameters to reduce or hold constant government outlays.

Two important attributes of farm decision-making were incorporated into the model used in this study. A sequential decision process was modeled and a varied set of marketing activities were included. For future research, it would be useful to extend the list of marketing activities further. Forward contracting before, during, and/or after harvest are pricing alternatives that should be explored. Forward contracting offers a farmer price certainty and therefore may be quite attractive to risk-averse groups. This model could also be used to investigate options marketing. Although this study did not include all possible types of marketing strategies available to farmers, it did include several commonly used cash-marketing activities as well as less commonly used hedging activities.

FOOTNOTES

[1] PIK was a voluntary land set-aside program. Producers participating in the PIK program were required to be enrolled in the ARP and PLD programs. Under the PIK program, producers received payment in commodities in lieu of monetary payments. The basic purpose of this program was to reduce government stocks and raise farm prices.

[2] All data used in this study are reported in Kaiser (1985).

[3] The marketing year was assumed to begin at harvest in mid-October and extended to mid-June of the following year. All harvest and post-harvest prices of marketing activities for each of the 10 years were divided by the preceding April cash price to make seasonal fluctuations comparable.

[4] The formula used to estimate these costs in terms of price per bushel is the following:

$$SC = (L)(P) + (n)(S)(P) + (P)[(1 + i/12)^n - 1]$$

where: SC = on-farm storage cost in dollars per bushel of holding corn n months;
L = shrink due to handling in (bushels);
P = price of corn or soybeans per bushel at harvest;
n = number of months grain is held in storage;
S = shrinkage per month;
i = interest rate used in discounting.

[5] Actually, soybean acreage could be greater than 100 percent of the nonparticipation soybean base under these provisions as long as total acreage of corn and soybeans is reduced by (1-ARP) times the farmer's corn base. However, this would be atypical because the farmer's corn base would then be smaller in the following year. Thus, constraints (15) and (16) were used since they better reflect actual practices of participating farmers.

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