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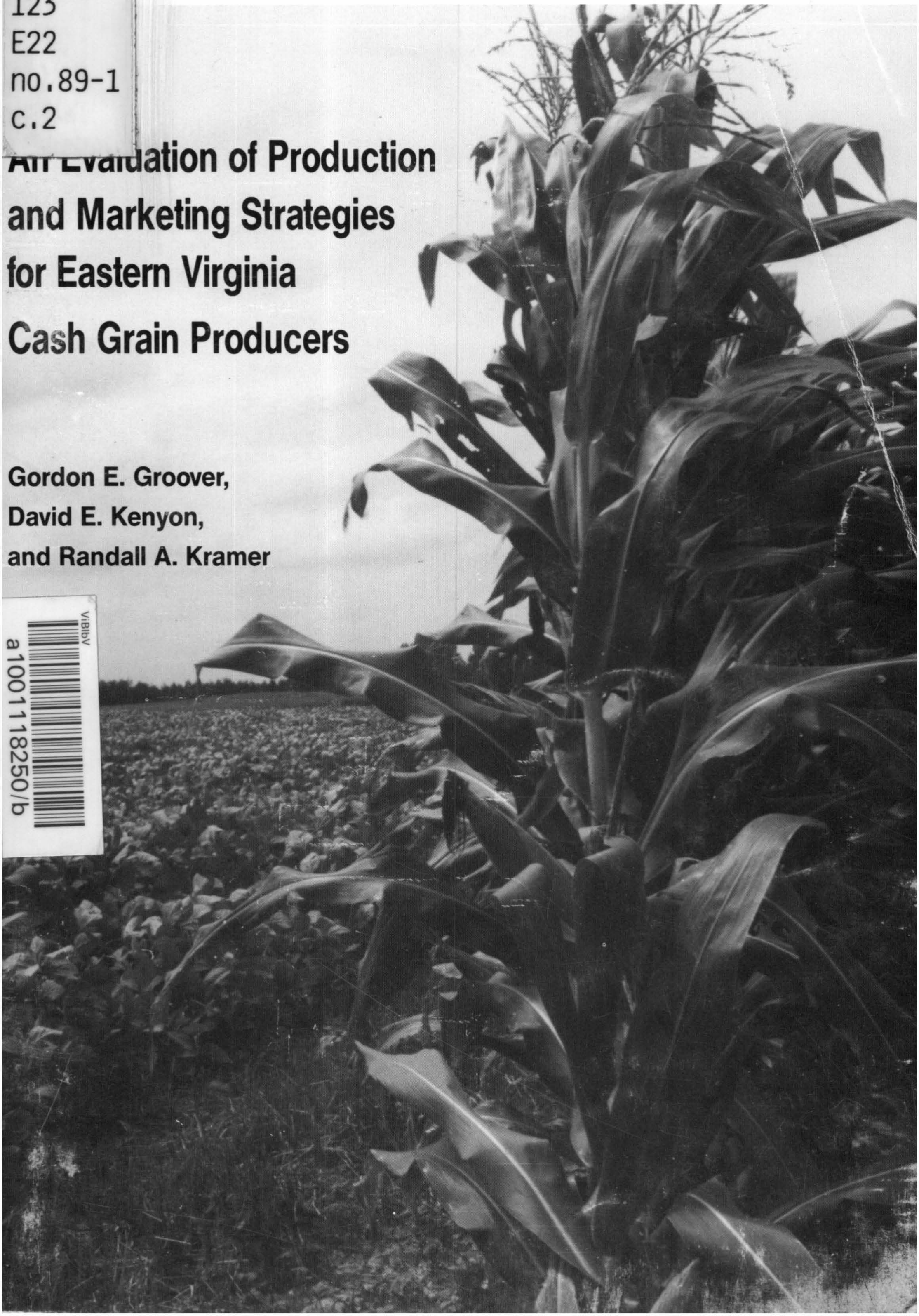
Bulletin 89-1
ISSN 0096-6088



An Evaluation of Production and Marketing Strategies for Eastern Virginia Cash Grain Producers

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The Virginia Agricultural and Mechanical College came into being in 1872 upon acceptance by the Commonwealth of the provisions of the Morrill Act of 1862 "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." Research and investigations were first authorized at Virginia's land-grant college when the Virginia Agricultural Experiment Station was established by the Virginia General Assembly in 1886.

The Virginia Agricultural Experiment Station received its first allotment upon passage of the Hatch Act by the United States Congress in 1887. Other related Acts followed, and all were consolidated in 1955 under the Amended Hatch Act which states "It shall be the object and duty of the State agricultural experiment stations . . . to conduct original and other researches, investigations and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including the researches basic to the problems of agriculture and its broadest aspects and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contributions by agriculture to the welfare of the consumer . . . "

In 1962, Congress passed the McIntire-Stennis Cooperative Forestry Research Act to encourage and assist the states in carrying on a program of forestry research, including reforestation, land management, watershed management, rangeland management, wildlife habitat improvement, outdoor recreation, harvesting and marketing of forest products, and "such other studies as may be necessary to obtain the fullest and most effective use of forest resources."

In 1966, the Virginia General Assembly "established within the Virginia Polytechnic Institute a division to be known as the Research Division . . . which shall encompass the now existing Virginia Agricultural Experiment Station . . . "

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Virginia Agricultural Experiment Station Bulletin 89-1

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24061

October 1989

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no. B9-1
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Acknowledgements

The authors would like to acknowledge the helpful comments and suggestion of Eluned Jones, Jim Pease, and Darrell Bosch who reviewed this document. The authors would also like to thank Howard McDowell for his critical comments and suggestions which helped focus this research project.

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Chapter 1. Introduction

Production Characteristics of Eastern Virginia Crop Farms

Eastern Virginia crop farms are characterized by a two-year crop rotation of corn and/or full-season soybeans, and wheat or barley double-cropped with soybeans. In 1982 the sixteen eastern Virginia counties[1] reported 435,162 acres planted in corn, soybeans, and small grains (Dunkerley p. 36-47). This acreage was 89 percent of the area's total cropland acreage or 92 percent of the harvested acres (U.S. Department of Commerce). A typical crop rotation for this geographic area is described in Table 1.

The 2,008 farms in the sixteen Eastern Virginia counties are classified into the following categories based on size: 1) 1,022 farms with 1 to 179 acres or 51 percent of the total farms, 2) 547 farms with 180 to 499 acres or 27 percent of the total farms, 3) 285 farms with 500 to 999 acres or 14 percent of the total farms, 4) 122 farms with 1000 to 1,999 acres or 6 percent of the total farms,

[1] The following counties were classified by the Virginia Crop Reporting Service as eastern Virginia counties Accomack, Charles City, Essex, Gloucester, James City, King and Queen, King George, King William, Lancaster, Mathews, New Kent, Northhampton, Northumberland, Richmond, and Westmoreland.

Table 1. A Typical Crop Rotation for Eastern Virginia

Fall	Spring	Fall	Spring/Summer
Harvest soybeans and leave field fallow with mulch from previous crops	Turn plow, disk twice and plant corn or full-season soybeans.	Harvest corn or full-season soybeans, chisel plow, disk twice, and plant small grain.	Harvest small grain, and no-till plant soybeans in small grain stubble.

and 5) 32 farms with greater than 2,000 acres or 2 percent of the total farms (1982 Census of Agriculture).

The agricultural extension agents in the Eastern Virginia Counties classify farms having 1 to 499 acres as part-time, requiring less than one full-time equivalent person. Comparing the agents' classification to the 1982 Census data, seventy-eight percent of the farms in this sixteen-county area are operated by part-time farmers. Farms having more than 500 acres are classified as full-time. The agents further classify the full-time farms as: one-person-equivalent farms with 750 acres of cropland, two-person-equivalent farms with 1200 acres of cropland, and three-person-equivalent farms with 1500 acres of cropland.

Extension agents in the sixteen county area report that farms owning or having access to grain storage will store wheat or barley for only a limited period of time. The major factors limiting the storage of small grains are difficulty in controlling grain storage pests during the summer months, and unwillingness of country elevator managers to purchase small grains after mid-August. The limiting factor for managers of country elevators is the need for storage space for corn and soybeans during the September-to-December harvest period. However, small grains can be sold year-round at the larger regional Virginia markets, e.g., Richmond and Norfolk. The corn harvest begins in late August, a month earlier than the start of the soybean harvest. Generally, sufficient grain is sold by farmers at harvest to retire operating notes and make payments on other borrowed capital. Remaining corn and soybeans are often stored until small grain harvest the following spring.

The Nature of the Problem In Virginia

Since the mid-1970s U.S. agricultural producers have experienced wide variations in prices.[2] While price variability has increased, Virginia producers also have experienced increasing yield variability for many of the major commodities. Adverse conditions such as floods, droughts, and crop disease on a local or regional basis, led to yield fluctuations affecting the producers' supply of marketable agricultural commodities. Virginia farmers experienced four state-wide droughts in the last decade, in 1977, 1980, 1983 and 1986. In 1981 and 1982 Virginia corn growers experienced two of the highest yielding years of the last two decades. Over these same periods the variability of corn grain yields on a state wide basis increased by fifty-one percent (Table 2.). Comparing the periods of 1964 to 1974 with 1975 to 1984, the variability of Virginia's net farm income has increased forty-three percent (table 2). Although nominal mean net farm income increased, net farm income in three of the last six years (1979, 1980 and 1983) was below the mean for the period of 1964 to 1974 (Table 2.).

Problem Statement

Virginia farmers experienced stable or increasing yield and price trends during the 1960s and early 1970s. However, price and yield variability has increased since the middle 1970s. Farmers facing increasing variability of prices and yields have incentives to reevaluate their production, marketing, and financial management strategies. While farmers are aware of the general concept of risk in making day-to-day management decisions, they may not be aware of factors that affect

[2] For example, corn market prices and industry gross revenue experienced a marked increase in instability in the 1970 and early 1980 as compared to the 1960 (an increase of 186 and 167 percent respectively) (Myers and Runge).

Table 2. Virginia Net Farm Income and Corn Yield Variations

Year	Va. Corn[a] Yield, Bu./Ac	Va. Net Farm[b] Income (Nominal $)
1964	56	119.779
1965	68	122.917
1966	46	118.594
1967	73	107.443
1968	71	116.134
1969	77	141.468
1970	68	158.757
1971	68	141.519
1972	83	203.400
1973	86	333.958
1974	80	302.660
1975	88	300.009
1976	78	296.309
1977	55	222.119
1978	83	294.974
1979	83	138.580
1980	55	126.321
1981	90	260.512
1982	101	366.855
1983	48	102.933
1984	104	771.602
Summary of the Two Decades		
Mean 1964-84	74.3	226.1
C.V.% 1964-84[c]	21.6	67.3
Mean 1964-74	70.5	169.7
C.V% 1964-74[c]	16.6	46.2
Mean 1975-84	78.5	288.0
C.V.% 1975-84[c]	25.0	66.3
Percentage Increase In C.V. 1964-74 to 1975-84	50.6	43.4

[a]Source "Virginia Agricultural Statistics" September, 1985.
[b]Source "Economic Indicators of The Farm Sector, March, 1986.
[c]The coefficient of variation is defined as the $\frac{\sigma}{E(x)}$

of risk in making day-to-day management decisions, they may not be aware of factors that affect farm-level risk. Furthermore, they may not be able to devise viable production and marketing strategies in response to risk. These strategies considered by farmers need to take into account the effects of factors such as:

1. government policies,
2. land productivity and level of inputs used, and
3. types of marketing decisions e.g., cash, futures and forward contracts.

In Virginia, studies have been conducted to consider marketing risk and strategies designed to increase returns while holding variation in prices to a minimum. However, studies which combine the production and marketing strategies under a portfolio approach have been limited. Portfolio analysis is the allocation of resources across an array of choice possibilities such that the decision maker's expected utility or income is maximized. (Anderson, Dillion, and Hardaker p. 190). In this study, expected utility is assumed to depend only on expected net returns and variance of returns.[3].

Eastern Virginia farmers face wildly varying levels of soil productivity, rainfall, management, and numerous marketing alternatives. These variations among factors of production and marketing alternatives lead to a wide variation in returns between enterprises and farms Farmers appear willing to sacrifice expected net returns for reduction in variability of returns and vice versa (Mapp, Hardin, Walker, and Persaud). Thus, a study appears warranted to develop a tool to assist farmers in evaluating production and marketing strategies in a portfolio approach.

Objectives

The overall objective of this study is to evaluate the level and variability of expected returns for different production and marketing strategies. Strategies to be considered include:

1. diversifying crop production e.g., full-season corn and soybeans or a combination of double-cropped wheat and barley with soybeans and full-season corn and soybeans,
2. marketing all grains and oil seeds at harvest in the cash market,
3. hedging a percentage or all of expected production using futures or forward contracts,
4. storing corn and soybeans until spring small grain harvest, and

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[3] The assumptions of portfolio analysis are based on the premise that the decision maker's utility function is quadratic or that returns from a risky portfolio are judged to follow a normal distribution (Anderson, et al.)

5. storing grains and oil seeds past the harvest glut.

Additional objectives for this study are: 1) to evaluate the effects of agricultural commodity programs, and changes in relative land productivity potential, on the above strategies, and 2) to develop a tool which will assist farmers in understanding trade-offs between returns and risk.

Procedures

Portfolio analysis provides the conceptual framework for analysis of risk strategies. The problem's complex nature and the need to explain observed phenomena to farmers suggest use of the MOTAD (minimization of total absolute deviations) method of linear programming (Anderson, Dillon, and Hardaker, p. 231). The decision to use MOTAD over other portfolio analysis techniques such as quadratic programming was based on the following:

1. data requirements are considerably less for MOTAD than for quadratic programming,
2. linear programming models are readily understood by extension farm management field staff, and
3. linear programming algorithms are more widely available and less difficult to use than are quadratic programming algorithms (Barry p. 74).

A MOTAD model was developed using actual farm level yield data for the period 1975 to 1987 and secondary data obtained from the Virginia Crop Reporting Service Bulletin No. 52, 1982 Census of Agriculture, and expert opinion. Solutions were generated showing the trade-offs between expected returns and variability of returns for the five production and marketing alternatives listed in the overall objective.

Chapter 2. The Empirical Model

Introduction

This chapter deals with the practical consideration of developing a model for a representative eastern Virginia cash grain farm. The theoretical background and basic assumptions required to develop the model and preparation of yield and variable costs data are discussed, followed by an explanation of the method used to calculate gross return deviations and objective function values. The chapter concludes with formulation of the empirical model[4].

Theoretical Background

In 1971 Hazell proposed a linear alternative to the quadratic programming method developed by Markowitz (1952) based on the expected income-variance (E-V) criterion of quadratic

[4] The complete description of the empirical model discussed in this chapter can be found in Appendix A.

programming. The assumptions are: that a farmer's preferences between farm plans are based solely on expected income and associated variance, and that the farmer is risk averse. These assumptions allowed Hazell to develop a set of farm plans where income variance (V) is minimized for each level of expected income (E), leading to an efficient set of farm plans.

Hazell approaches utility maximization as a quadratic programming problem that minimizes income variance (V) while parameterizing the level of expected income (conceptually this is equivalent to the Freund approach of maximizing expected returns, if one parameterized the risk aversion level). Hazell proposed the following model as an alternative to quadratic programming:

$$\text{Min} \sum_{h=1}^{s} y_{h}-$$

such that

$$\sum_{j=1}^{n}(c_{hj} - g_j)x_j + y_{h}- \geq 0 \qquad (\text{for all } h, h = 1,...,s)$$

and

$$\sum_{j=1}^{n} f_j x_j = \lambda \qquad (\lambda = 0 \text{ to unbounded}),$$

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

$$x_j, y_{h}- \geq 0 \qquad (\text{for all } h,j)$$

where: $y_{h}-$ = absolute value of negative income deviations, c_{hj} = observed gross return of the j^{th} activity for the h^{th} observation, g_j = the mean return for the j^{th} activity, x_j = level of the j^{th} activity, f_j = expected gross margin for the j^{th} activity, a_{ij} = technical requirements of the j^{th} activity for the i^{th} resource or constraint, and b_i = i^{th} constraint level.

Hazell suggests that expected income-mean absolute deviations (E-A)[5] efficient solutions are consistent with E-V solutions. He argues that the E-A method is an approximate substitute for the E-V method used in quadratic programming based on sample properties. If income is normally distributed, then its standard deviation can be estimated with the statistic $d(\pi s/2(s-1))^{1/2}$ where s

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[5] A is a linear unbiased estimator of the population mean absolute income deviations (A):

$$A = \frac{1}{s} \sum_{h=1}^{s} \left| \sum_{j=1}^{n} (c_{hj} - g_j) x_j \right|$$

is the number of observations in the sample, $\pi = \frac{22}{7}$, and d is the estimated mean absolute deviation. Hazell states that this statistic also is an estimator[6] of the standard deviation of a population that is only approximately normally distributed. Since $(\pi s/2(s-1))^{1/2}$ is a constant and A is an estimator of the mean absolute deviation, the MOTAD method generates linear approximations to quadratic risk models.

In two studies where quadratic programming and MOTAD were compared (Hazell and Barry) little difference was reported in the results. Hazell reported that in comparing quadratic and MOTAD model solutions, "a surprising similarity of result" was obtained (p. 61). In another study, Barry (p. 144) reported small differences between the approaches but explained the difference based on rounding error and concluded that both techniques are acceptable methods of risk programming.

In summary, Hazell provided an alternative method for estimating quadratic programming solutions. The conceptual basis for the linear alternative to quadratic programming referred to as MOTAD is consistent with the theoretical work of Freund and Markowitz. Therefore, research based on the MOTAD technique can be considered an approximation of quadratic programming.

Basic Assumptions and Yield Data

The data used in this study were obtained from a large cash grain farm in the northeastern area of the state. The data set consists of a 10-year series of individual crop and field-specific yields. The data source consisted of historical yield data for specific crops and fields for the time period 1975 to 1985.[7] Individual yields for each field were combined to obtain a farm average for each crop by year. The type of yield data and the short run planning nature of the model required the authors to make several assumptions. These assumptions provided a means to fulfill the objective of

[6] $d(\pi s/2(s-1))^{1/2}$ is only 94% as efficient a sample variance.

[7] No additional information will be disclosed about the farm to protect the anonymity of the producer.

investigating the effects of soil type on production, marketing, and financial decisions. The first assumption is that the major influence on crop yield is soil type of course, management, weather, pests, distance to the farm headquarters and other factors could also effect yield but, these factors were not considered. The second assumption is that yield is an indicator of land productivity. This assumption could lead to problems in measuring overall soil productivity because of the farm's crop rotation. For example, one field may have corn the first year and wheat double cropped with soybeans the second year. Such a practice could result in difficulty in interpreting the results of the model since crop yields for each year could have been obtained from any field on the farm. The third assumption is that short-run planning decisions are not affected by fixed costs. This assumption is dependent on fixed costs remaining constant and not varying with crop rotations.

The decision to model current government commodity programs made it necessary to obtain yield data for years 1986 and 1987. Actual farm yields for each crop could not be obtained for these two years. Therefore, a forecasting procedure was developed to provide a proxy for the two missing years. The yields forecast for the years 1986 and 1987 were generated by regressing the individual farm yields on the state, district and the county yield data obtained from Virginia Agricultural Statistics. The resulting model with the highest $\bar{R}^2$ was used to predict the appropriate yield (Groover, p. 29-30). The $\bar{R}^2$ ranged from 0.9366 to 0.2527. Slope coefficients for the models were significant at the 1 percent level in all but two cases. These were significant at the 10 percent level.

Using yield as an indicator of soil type, the data were divided into two classes, I and II. This was accomplished by calculating the mean for each crop and each field over the period 1975 to 1987. Class I soils were defined as all observations above the mean and Class II soils as the observations below the mean. The data were tested for any trend influence over the period of study. A trend was found to be significant only for wheat on class I soils (Groover, p. 31).

Mean yields over 1975-1986 for each crop and soil type were used to provide farm-level yield expectations in calculating the expected per acre gross returns. This approach to obtaining farm-level yield expectations seems reasonable given the limited information available to provide yield expectations. For an alternative approach to forming yield expectations based on subjective probability distributions, see Pease (1987).

The relative variability of yield for each soil class was measured by the coefficient of variation (C.V.). In Table 3 the mean yield and coefficient of variation (C.V.) for selected crops are generally consistent with a prior expectations based on agronomic results; i.e., lower yielding soils have lower mean yields and higher variability.

Table 3. Mean Yields and Coefficients of Variation for Selected Crops, 1975-86

	Class I Soil		Class II Soil	
Variable	Mean	C.V. %	Mean	C.V. %
Corn	109.73	30.27	77.57	41.65
Soybeans	31.00	32.87	16.34	45.27
Wheat	46.21	12.29	33.66	16.81
Barley	74.11	20.82	58.11	27.92
Soybeans D/C Wheat	31.55	25.07	21.71	31.83
Soybeans D/C Barley	35.62	18.57	28.65	28.85

However, double-cropped soybeans have a higher mean yield and lower C.V. than those of full-season soybeans. This result may be explained in two ways (Hawkins). First, full-season soybeans are planted between corn planting and small grain harvest. This narrow planting window may force the full-season soybeans into pod filling at the driest part of the season. Second, double-cropped soybeans may be benefit from late summer moisture due to later planting dates.

Variable Costs

All technical coefficients used to determine production expenses were obtained from Northeast Extension Farm Management crop budgets (Perkinson, 1987). These budgets reflect expected costs before planting. Variable costs were considered to be known with certainty, on the premises that a majority of the variable costs are committed by planting time and that harvest expenses are a relatively small proportion of total variable costs.

Northeast Extension budgets are developed by soil and yield class. The budget for the yield class closest to the mean yield was chosen. Yield-dependent costs were adjusted to reflect expected yield for example, per bushel hauling charges. The costs entered in the objective function do not include labor, interest, and rent or land charge. Interest charges on pre-harvest expenses are a separate technical coefficient for each crop activity with interest charged for six months. There are no labor charges since labor availability is not an important constraint for Northeast farmers.

Calculation of Gross Return Deviations and Objective Function Values

Each production activity based on soil type transfers a one-acre quantity to the marketing activities of the model. These marketing activities are broken down into five sections: 1) cash sales at harvest, 2) hedged sales before harvest, 3) cash sales of grain stored past harvest, 4) grain stored and hedged past harvest, and 5) participation in government programs. The resolution of one conceptual problem was required before the objective function and the deviation matrix could be specified. This problem is how best to measure income expectations and risk in the MOTAD framework.

Typically most MOTAD models are backward looking in terms of risk measurement (Norton, et.al 1980, Schurle and Erven 1979, Mapp, et.al 1979, and Hazell 1971). A historical returns series is obtained from an inflation-corrected price series and from a detrended yield series. This series of returns is then used as a proxy for the subjective probability distribution an individual producer faces. In many instances the mean returns from these series are assumed to be the expected returns a decision maker will receive in the planning period. This common approach in quadratic and MOTAD models has serious shortcomings as a means of representing farmers expectations.

McSweeny, Kenyon, and Kramer (1987) argue that a mean squared forecast error (MSFE) is a better approximation of the process by which farmers are hypothesized to estimate parameters of their subjective probability distributions. The MSFE method attempts to explain the risk the farmer experiences in terms of "disappointments" between what was expected and what actually occurred. Just and Rausser (1981) show that futures markets provide as good or better forecast of expected prices as econometric models. McSweeny, Kenyon and Kramer argue that futures prices adjusted for local market conditions provide a realistic estimate of expected prices at the farm level. Their general approach is used in this study.

The MSFE was originally developed in a quadratic programming framework. Therefore, to apply the mean squared forecast error method to a MOTAD model required modification of the method of calculating deviations and will be referred to as the mean forecast deviation (MFD). Hazell (1971) in the original article on MOTAD used the following general procedure to calculate deviations where p_{ij} and q_{ij} are the price and quantity of the i^{th} activity sold in the j^{th} year, i= 1...m, j= 1...n, and the observed gross return for the i^{th} activity in the j^{th} year is $c_{ij} = p_{ij}q_{ij}$. Given that $\sum_{j=1}^{n} c_{ij}/n = \bar{c}_i$ is the mean observed gross return for the i^{th} activity, then $(c_{ij} - \bar{c}_i) = d_{ij}$, where d_{ij} is the deviation from the mean of the i^{th} activity for the j^{th} year.

The MFD adapted for MOTAD requires the calculation of observed and forecasted deviations. The MFD method is based on the following assumptions where p_{ij} and q_{ij} are the actual price and quantity, P_{ij} and Q_{ij} are the forecasted price and quantity of the i^{th} activity for the j^{th} year, i= 1...m, j= 1...n, the actual gross return for the i^{th} activity and the j^{th} year is $c_{ij} = p_{ij}q_{ij}$, and the forecasted gross return for the i^{th} activity and the j^{th} year is $C_{ij} = P_{ij}Q_{ij}$. Let $e_{ij} = (c_{ij} - C_{ij})$, where e_{ij} is the forecast error between actual and observed gross returns for the i^{th} activity and the j^{th} year. Then $D_{ij} = (e_{ij} - \bar{e}_i)$, where D_{ij} is the mean forecast deviation (MFD) for the i^{th} activity and the j^{th} year, and $\bar{e}_i = \sum_{j=1}^{n} e_{ij}/n$ where, $\bar{e}_i$ is the mean difference between the observed and the actual gross returns of the i^{th} activity. Thus, the use of the MFD method provides an alternative to the standard method of calculating deviations for MOTAD models.[8]

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8 The authors recognize the problem associated with the required assumption of normality for quadratic programming and MOTAD models. However, based on properties of the Central Limit Theorem (Hazell 1971), the mean forecast deviations can be assumed to be approximately normally distributed.

The MFD also provides a solution to the problem of whether to inflate, deflate or use nominal dollars for prices in the model. A basic assumption of the traditional MOTAD model is that expected prices are a function of previous prices. In periods of high inflation the argument for removing the inflationary trend is sound. However, in periods of relative stability following periods of inflation (late 1980s) use of real prices as expectations for current prices can lead to unrealistic results. Use of an inflated or deflated price series would have led to overstatement of the returns and deviations in the model. By using the MFD method, the deviation matrix is a function of forecast errors. Therefore, deflating of prices would not be appropriate. The MFD method provides a practical and realistic approach to incorporating risk and expectations in a MOTAD framework.

Gross Return Calculations for Cash Sales

The gross returns and objective function values for each of the cash alternatives were obtained from the following general equations:

$$e_{ij} = (c_{ij} - C_{ij})$$

$$C_{ij} = (F_{ij} + EB_{ij})EY_{ijk}{}^{9},$$

$$c_{ij} = p_{ij}y_{ijk}\ ,$$

$$i = 1...m\ ,\ j = 1...n,\ \text{and}\ k = I,II$$

where: C_{ij} is expected returns per acre, c_{ij} is observed returns per acre, e_{ij} is the error between the expected and the actual returns, F_{ij} is the average weekly futures price during the first week of February for the i^{th} crop and the j^{th} year, EB_{ij} is the 3 year average expected basis (cash price - futures price), EY_{ijk} is the expected yield[10] for the k^{th} yield class where k = I for class I soils and k = II

[9] The objective function value is a special case of this equation i.e., $j = 1987$.

[10] Expected yields are based on mean yields for the 12-year yield series.

for class II soils, y_{ijk} is the actual yield for the k^{th} yield class, and p_{ij} is the actual price when the grain is sold in the cash market.

Futures prices F_{ij} were obtained from the Chicago Board of Trade's Statistical Annual. These prices reflect the February price of a futures contract that is closest to, but not before, the time period of the actual cash sale. For example, for cash corn sold at harvest, the price of one December contract was used for corn trading during the first week of February. The three-year average basis (EB_{ij}) was obtained by subtracting the cash market price from the appropriate futures contract price when the crop is sold. The last three years' basis are averaged to provide an estimate of the next year's basis. The expected yield (EY_{ijk}) is the mean yield for the period 1975-86 for each crop. Cash price p_{ij} is the weekly average price for the Norfolk, Virginia market. These prices were obtained from the Farm Price Weekly published by the Virginia Crop Reporting Service. Actual yields y_{ijk} are the observed yields for each crop for each year.

The equations discussed above were used for determining the deviations and expected prices for corn, soybeans, wheat, and barley sold in the cash market. All planning decisions are made during the first week of February. Expected gross returns (C_{ij}) are defined as the product of futures prices (F_{ij}) adjusted for expected basis (EB_{ij}). The futures contract used to obtain the futures price (F_{ij}) were 1) corn: December, 2) soybeans: November, 3) wheat: March, and 4) barley: March corn futures contract. The futures price was adjusted for local market conditions by the addition of an expected basis. Basis was calculated for pre-harvest and post-harvest time periods. The markets and time periods used in calculating basis were: 1) pre-harvest corn: the Norfolk cash price in the last week of September minus the December futures contract during that same week, 2) pre-harvest soybeans: the Norfolk cash price in the fourth week of October minus the November futures contract during that same week, 3) pre-harvest wheat: the Norfolk cash price in the third week of June minus the July futures contract during that same week, 4) pre-harvest barley: the Norfolk cash price in the first week of June minus the September corn futures contract during that same week, 5) post-harvest corn: the Norfolk cash price in the first week of January, March and June minus the futures price for March and July during the same respective periods, and 6) post-harvest soybeans: the Norfolk cash price in the first week of January, March and June minus the futures price for January, March and July during the same respective periods. Expected prices used to determine gross returns were obtained by adding the last three-year average basis to the current period futures price.

Actual prices p_{ij} received from the cash sale of corn, soybean, wheat and barley were obtained from the Norfolk market. Multiplying there prices times the actual per acre yields y_{ij} gives the actual gross returns c_{ij} for each crop.

The assumptions used above created two problems. First, there is no futures contracts traded for barley which can be used in hedging a Virginia crop. Second, a typical eastern Virginia crop rotation is greater than eighteen months, however, a number of the futures contacts required for forecasting prices in the model are not traded that far in advance.

The barley-cropping enterprise involves both issues; therefore, barley will be addressed first. The problem of which futures contract to use in forecasting the price of barley was resolved by using corn contracts as a proxy for barley. The choice of corn as the proxy for barley is an obvious choice in that both crops are feed grains and are close substitutes in livestock rations. However, the assumption that the corn price will adequately reflect the market conditions for barley is not so easily resolved. Regressing the price of the July corn futures contract (the closest corn contract to the barley harvest) during the first week of June (1972-86) on the June cash price of barley in Norfolk yielded the following equation:

$$Barley = 0.026496 + 0.627636(Corn)$$

$$\overline{R}^2 = 0.6640, \quad t = 5.354.$$

The slope coefficient is significant at the 1 percent level. A more detailed study of the relationship between the Virginia barley markets and the futures contracts for corn would be desirable, but is beyond the scope of this research. The $\overline{R}^2$ does allow for a reasonable prediction of barley price. Therefore, the July corn futures contract was used as a proxy for barley price.

The model decision time is the first week of February for a barley crop not sold until the first week of June the following year. Therefore, another procedure was needed, given that no consistent trading of July corn contracts for next year has occurred during the the first week of February of the current year. However, the March corn contract next year is traded the first week of February. The March contract does provide a contract price reflecting the expectations of the following year's crop. In February, price expectations relative to March or July may not differ greatly. To estimate the July barley futures price, a historical relationship between March and July corn futures prices was computed during the the first week of August. The previous three-year average spread between the March and July contracts was added to the March futures contract price to estimate the July futures price. The resulting futures price (F_{ij}) was adjusted for (EB_{ij}) to determine expected gross returns.

A similar problem in estimating expected cash prices is observed for corn, soybeans and wheat. However, the problem arises for corn and soybeans only when the grain is stored past March of the following year. The situation for wheat is the same as for barley in that there are no wheat contracts consistently traded in February for delivery the following summer. Thus, a historic spread was calculated for corn, soybeans, and wheat using the March and July contracts as of the first week of August. These spreads were used to provide the expected futures price (F_{ij}) used in the gross returns calculations. The difference between actual gross returns c_{ij} and expected gross returns C_{ij} generates the forecast error e_{ij} used in determining the deviation matrix D_{ij} .

Gross Return Calculations for Hedged Sales

Gross returns and objective function values for each of the hedged alternatives were obtained from the following general equations:

$$e_{ij} = (c_{ij} - C_{ij}) ,$$

$$C_{ij} = (F^{S}_{ij} + EB_{ij})EY_{ijk}$$[11],

$$c_{ij} = ((F^{S}_{ij} - F^{C}_{ij}) + p_{ij})y_{ijk} ,$$

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[11] The objective function value is a special case of this equation; i.e., $j = 1987$.

$i = 1...m$, $i = 1...n$, and $k = I,II$

where: c_{ij} is the observed returns per acre, C_{ij} is the expected returns per acre, e_{ij} is the error between the expected and the actual returns per acre, F^S_{ij} is the average futures price during the first week of February for the i^{th} crop and the j^{th} year ($S =$ the starting futures contract), EB_{ij} is the 3-year expected average basis (cash price - futures price), EY_{ijk} is the expected yield[12] for the k^{th} yield class where k = I for class I soils and k = II for class II soils, F^C_{ij} is the weekly average futures price at the time the futures position is closed out ($C =$ the closing futures contact), p_{ij} is the actual cash price at the time of sale, and y_{ijk} is the actual yield for the k^{th} yield class where k = I for class I soils and k = II for class II soils.

The actual gross return equation c_{ij} reflects actual results of trading a futures contract. All hedging strategies assume 100-percent of expected production is hedged at price level F^S_{ij}. This approach does not consider that futures contracts for grain are available only in multiples of 1000 bushels. Gain or loss in the futures market is added to actual market price received when the grain is sold in the cash market. This leads to the net price received from hedging that includes basis error.

A large number of hedging strategies could have been considered. The need to model production strategies, other marketing strategies, and government program activities required that the hedging activities be limited. Several typical strategies used by producers were analyzed. All decisions were assumed to be made during the first week of February: 1) pre-harvest corn: hedge placed during the first week of February, April and June, and removed at harvest (fourth week September); 2) pre-harvest soybeans: hedge placed during the first week of February, April and June, and removed at harvest (fourth week October); 3) post-harvest corn: hedge placed during the last week of September, removed the first week of January, March and June and; 4) post-harvest soybeans: hedge placed during the fourth week of October, removed the first week of January, March and June[13].

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[12] Expected yields are based on mean yields for the 12-year yield series.

[13] A spread was used between the March and July corn and soybeans contracts to obtain an expected price

Futures price was adjusted for local market conditions by the addition of a local basis. Basis is the historical difference between the cash and the futures market prices at the time of cash sale. The average of the three preceding year's basis was used in the expected gross returns calculation as the appropriate basis. The expected prices used to determine the gross returns were obtained by adding the three-year average basis to the futures price.

Gain or loss from futures trades was added to actual cash prices received in the Norfolk market at the appropriate time of sale. Gross returns per acre were obtained by multiplying the actual price received per acre times the actual yield. The difference between the actual gross returns c_{ij} and the expected gross returns C_{ij} generates the forecast error e_{ij} used in determining the deviation matrix D_{ij} .

Government Commodity Programs

Several assumptions were made to investigate the effects of the government commodity programs on the production and marketing decisions of eastern Virginia producers. First, it was assumed that government programs remain constant in the model (i.e., that producer's expectations about the government programs are known during a given cropping season). Second, it was assumed that requirements for program participation can easily be meet (e.g., no problems with absentee landlords on leased land). Third, it was assumed that crop rotational constraints will represent the actual base acreage of the model farm.

The information and data used in these models were obtained from conversations with state and national Agricultural Stabilization and Conservation Service (ASCS) employees (Huber and Weston 1987), The Food Security Act of (Stucker, 1985) and Provisions of the Food and Security

for the June hedge. The section Gross Return Calculations for Cash Sales contains a detailed discussion on how spreads were calculated.

Act (Glaser, 1985). The general format of the equations used to represent the commodity programs was based on the work by McSweeny and Kramer (1986).

The net government payment received by a producer is composed of PART1 (loan rate), PART2 (primary deficiency payment), PART3 (final deficiency payment), and PART4 (paid diversion). The following equations were used in calculating the net government payment for each of the program crops:

$$PART1 = \max(LP_{ij}, LLR_i)Y_{ij}$$

$$PART2 = (TP_i - \max(USP_{ij}, NSLR_i))\bullet PY_i\bullet(1 - SA_i)$$

$$PART3 = (NSLR_i - \max(USAP_{ij}, NELR_i))\bullet PY_i\bullet(1 - SA_i)$$

$$PART4 = (PY_i\bullet PDR_{ij})\bullet PD_i$$

where: LP_{ij} is the local price of the i^{th} crop for the j^{th} year, LLR_i is the local loan rate of the i^{th} crop, Y_{ij} is the actual farm yield for the i^{th} crop and the j^{th} year, TP_i is the target price for the i^{th} crop, USP_{ij} is the U.S. 5 month average price of the i^{th} crop and j^{th} year, $NSRL_i$ is the National Statutory Loan Rate for the i^{th} crop, PY_i is the individual program yield for i^{th} crop, SA_i is the set-aside acreage for the i^{th} crop, $USAP_{ij}$ is the U.S. 12 month average price of the i^{th} crop and j^{th} year, $NELR_i$ is the National Effective Loan Rate for the i^{th} crop, PDR_{ij} is the Paid Diversion Rate in dollars per unit sold for the i^{th} crop and j^{th} year, and PD_i is the Paid Diversion percent for the i^{th} crop of the farm's base acreage.

Table 4 contains the parameters used in calculating the gross returns per acre for government program participation. These assumptions were used to calculate the gross returns per acre as if the 1987 government programs had been in place over the time period 1975 to 1987.

In general, the current government program is based on three major components: nonrecourse loans (PART1), deficiency payments (PART2 and PART3), and paid diversion (PART4). Nonrecourse loans are a price support mechanism that allows producers to store their crop for later sale. The net price the farmer receives is the greater of the local cash price at harvest (LP_{ij}) or the local loan rate (LLR_i). The LLR_i is the national loan rate adjusted for local conditions and reduced by 4.3 percent based on provisions of Gramm-Rudman Act. The provisions of nonrecourse loans apply to all crops in this model.

Table 4. Assumptions Used In Calculating Government Program Returns

Item	Corn	Soybeans	Wheat	Barley
February 1987 Expected Harvest Price[a]	1.73	4.80	2.37	0.76
Target Price for 1987	3.03	n/a	4.38	2.60
National Statutory Loan Rate for 1987	2.28	n/a	2.85	1.68
National Effective Loan Rate for 1987	1.82	n/a	2.28	1.49
Local Loan Rate for 1987	1.99	4.61	2.28	1.42
Paid Diversion for 1987	2.00	n/a	n/a	1.60
Set-aside percent of base for 1987	0.20	n/a	0.275	0.20

[a]The expected cash harvest prices for the respective crops are provided as a comparison to the target prices and loan rates.

Deficiency payments (PART2 and PART3) to producers growing eligible crops (corn, barley, sorghum and wheat) are determined by the difference between the target price and the higher of the market price or the U.S. loan rate. The target price was established by law in the 1985 Farm Bill for wheat, feed grains, rice, and cotton. The market price is an average of a number of major United States markets over a specified number of months. The producer can receive only the deficiency payment when a proportion of the eligible acreage is left out of crop production for that season (set-aside acreage). Recent legislation has divided the deficiency payment into two parts: a primary deficiency payment and a final deficiency payment. For a detailed discussion of the model parameters see Groover, p. 44.

Participation in current government commodity programs requires that the producer have a base acreage for each crop. Base acreages are determined by historical cropping practices reported to the local ASCS office. Due to cultural or agronomic reasons, producers establish rotational constraints that limit the amount of any one crop grown in a year. Given these two considerations, maximum crop acreage constraints were established for the model. They are as follows: corn 200 acres; full season soybeans 150 acres; wheat double-cropped with soybeans 250 acres; barley double-cropped with soybeans 250 acres; and a maximum of 750 acres of total crop land. These maximums were based on conversations with extension agents (Johnson, 1986) and extension specialists (Brann, 1987) familiar with counties in the study area.

The 12-month average price is denoted as USAP. This price series was not available prior to 1979 and had not been published at the time of this study (Mellon 1987). Provisions of the 1985 Farm Bill required that a 12 month average price be calculated. However, to obtain a proxy for the missing four years (1975-1978), the 12-month average price (1979-1986) was regressed against the USDA 5-month average price and the USDA 12-month season average. The model resulting in the highest $\overline{R}^2$ was selected for predicting USAP. The models used are as follows:

$Wheat = 0.1157 + 0.9854$ (5 Month Average Price)

$\overline{R}^2 = 0.9933, \quad t = 29.771$

$Barley = 0.0860 + 0.9651$ (12 Month Season Average Price)

$\overline{R}^2 = 0.9942, \quad t = 32.101$

$Corn = -0.2525 + 1.0584$ (12 Month Season Average Price)

$\overline{R}^2 = 0.9903, \quad t = 24.793$

All slope coefficients for the models were significant at the 1 percent level.

The actual and expected gross returns and resultant deviations were calculated from the following general equations:

$$e_{ij} = (c_{ij} - C_{ij}) \, ,$$

$$C_{ij} = (EPART1_{ij} + EPART2_{ij} + EPART3_{ij} + EPART4_{ij})EY_{ijk}{}^{14},$$

$$c_{ij} = (PART1_{ij} + PART2_{ij} + PART3_{ij} + PART4_{ij})y_{ijk} \, ,$$

$$i = 1...m \, , j = 1...n, \text{ and } k = I,II$$

where: c_{ij} is the observed returns per acre, C_{ij} is the expected returns per acre, e_{ij} is the error between the expected and the actual returns per acre, $EPART1_{ij}$, $EPART2_{ij}$, $EPART3_{ij}$, and $EPART4_{ij}$ are the expected level of government payments as of the first week of February, EY_{ijk} is the expected yield[15] for the k^{th} yield class where k = I for class I soils and k = II for class II soils, $PART1_{ij}$, $PART2_{ij}$, $PART3_{ij}$, and $PART4_{ij}$ are the actual level of government payments, and y_{ijk} is the actual yield for the k^{th} yield class where k = I for class I soils and k = II for class II soils.

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14 The objective function value is a special case of this equation; i.e., $j = 1987$.

15 Expected yields are based on mean yields for the 12-year yield series.

During the first week of February, the local price (LP_{ij}), 5-month average price (USP_{ij}), and the 12-month average price ($USAP_{ij}$), are unknown. Therefore, a producer making a decision as of the first week of February would have to form expectations with respect to these prices. The method used to forecast these prices is similar to the method used for forecasting cash prices and the same futures contract months used for each commodity.[16].

The expected gross returns from the government programs use the expected values defined above to determine C_{ij}. The values for the actual gross returns c_{ij} are calculated from the actual local prices in Norfolk and the 5-month and 12-month average prices. The difference between the gross returns generates the forecast error used in determining the deviation matrix D_{ij}.

The Empirical Model

The tableau in Table 5 is a schematic outline of the model formulated to analyze the farm-level problem, where: $E(R)$ = expected return for each selling activity, $E(GP)$ = expected government payment, $E(V)$ = expected variable costs for each crop, B = other input costs (e.g., capital and storage costs), C = level of annual debt service, L = fixed level of land resource, G = level of production from each crop activity in per acre units, A = maximum crop acreage constraints imposed by rotational and commodities programs considerations, F = storage and operating capital costs for production and marketing activities, M = individual crop deficiency payment (sum of the primary and final deficiency payment), H = maximum level of crop deficiency payments ($50,000), S = the maximum level of annual fixed debt, D = the gross return deviations for the j^{th} year, GP = government program deviations for the j^{th} year, and λ = the maximum level of negative deviation parametrically changed from zero to the profit maximizing level.

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[16] Wheat and barley required the use of a spread between the March and July contracts. The section Gross Return Calculations for Cash Sales contains a discussion on how spreads were calculated.

Table 5. Schematic Layout of the Model Tableau

	Production Activities	Sales Activities: Marketing Activities (Futures, Cash)	Sales Activities: Government Programs	Storage and Oper. Capital Costs	Fixed Debt Costs	Negative Deviation Control	RHS
OBJ FNC	$-VX_1$	$E(R)X_2$	$E(GP)X_3$	$-BX_4$	$-X_5$	0	
Max Crop Acreage	1	0	0	0	0	0	$\leq A$
Max Acreage	1	0	0	0	0	0	$\leq L$
Production to Marketing Transfers	$-1_{-1} \ddots -1$	$1_1 \ddots 1$	$1_1 \ddots 1$	0	0	0	≤ 0
Storage and Oper. Capital Controls	F_{ij}	F_{ij}	0	-1	0	0	≤ 0
Government Program Controls	0	0	M_{ij}	0	0	0	$\leq H$
Fixed Debt/Ac.	0	1	0	0	0	0	$\leq S$
Deviation Controls 1975-1986	0	$\pm D_{ij}$	$\pm GP_{ij}$	0	0	$1_1 \ddots 1$	≥ 0
Deviation Controls	0	0	0	0	0	$1_1 \ddots 1$	$\leq \lambda$

The empirical model was formulated to analyze a series of production, marketing, and government program activities. The matrix consisted of 41 rows and 123 columns with 1588 total elements. The activity naming convention used in the model is explained in Table 6. Table 7 contains a listing 1987 expected returns and standard deviations for each corresponding e_i. The objective function values are gross returns only. The non-stochastic variable cost for each of these activities are listed in the second section of Table 7. The variable costs for storage and set-aside maintenance are not included in these costs. Appendix A contains a schematic and a detailed listing of the model activities.

A variance-covariance and correlation[17] matrix was generated for the mean forecast errors to provide insights into the relationships among activities in the model. The size of the matrices (8464 relationships) prohibits their inclusion in this report. However, Table 8 contains the activities with negative correlations. All other relationships were positive. The size and sign of the correlation provides insight into the nature of the activities in the model. A negative correlation would imply a risk reducing interaction, a positive relationship would increase risk, and a correlation of zero would be risk neutral. For example, the correlation between CLCAS1 (soybeans on class I soils with post-harvest cash sales in January) and the government program activities CLGPWSND (soybeans and wheat double cropped on class II soils with no additional paid diversion) is -0.50154. This implies that the interaction between CLGPWSND and CLCAS1 will reduce the level of negative deviations relative to other activities with positive or zero relationships.

[17] The variance-covariance and correlation matrix was generated using the PROC CORR procedure of the SAS program.

Table 6. Crop Activity Naming Convention

The following procedure was be used to name crop activities in the model. MPS allows only 8 character names. Each of the 8 characters were defined as follows:

Character	Names and symbols used
First	C = column or R = row
Second	Yield: H = high or L = low
Third	Type of sale: C = Cash, F = futures or G = government program
Fourth	Season of sale: P = Pre-harvest, A = After-harvest
Fifth & Sixth	Crops grown: C = Corn, S = Full season soybeans, BS = Barley/soy double cropped, or WS = Wheat/soy double cropped
Seventh & Eight	Month of sale: 1 = Jan ... 12 = Dec. Unless character 3 is G = Gov then 7 and 8 are PD = Paid diversion or ND = No paid diversion.

Table 7. Objective Function and Standard Deviation Values For Selected Activities

Activities[a]	Objective Function[b]	Standard Deviation[c]
CHFPC2	215.07	108.81
CHFAC1	209.59	89.47
CLFPC2	152.03	101.07
CLFAC1	148.15	85.50
CHFPS2	146.03	95.5
CHFAS1	153.78	72.62
CLFPS2	76.97	65.52
CLFAS1	81.06	48.91
CHFPWS2	265.94	85.54
CHFAWS1	273.83	58.80
CLFPWS2	187.73	71.52
CLFAWS1	193.16	52.52
CHFPBS2	224.12	81.89
CHFABS1	233.02	56.28
CLFPBS2	179.12	83.67
CLFABS1	186.29	65.03
CHCPC2	215.07	108.81
CHCAC1	209.59	89.47
CLCPC2	152.03	101.07
CLCAC1	148.15	85.50
CHCPS2	146.030	68.00
CHCAS1	153.78	72.18
CLCPS2	76.97	48.93
CLCAS1	81.06	108.96
CHCPWS2	265.94	62.67
CHCAWS1	273.83	88.57
CLCPWS2	187.73	55.38
CLCAWS1	193.16	54.99
CHCPBS2	224.12	55.11
CHCABS1	233.02	55.26
CLCPBS2	179.12	63.56
CLCABS1	186.29	65.05
CHGPCND	311.29	103.19
CLGPCND	247.29	96.85
CHGPSND	146.03	51.42
CLGPSND	76.97	30.58
CHGPWSND	330.33	57.32
CLGPWSND	252.11	42.84
CHGPBSND	323.19	55.57
CLGPBSND	267.63	50.96

Non-Stochastic Variable Cost

Activities	Var. Costs	Activities	Var. Costs
CHC	-193.22	CLC	-141.62
CHS	-108.49	CLS	-103.64
CHWS	-192.98	CLWS	-178.33
CHBS	-184.29	CLBS	-174.98

[a]See Table 6 for definitions of activities names.
[b]Units $/acre. Values based on 1987 prices.
[c]The standard deviations were calculated from the twelve years of deviations used in the model.

Table 8. Negative Correlation Coefficients Between Error Terms For Selected Model Activities

Model Activities[a]

CLCAS1	CHGPBSND	CLGPBSND	CHGPBSPD	CLGPBSPD	
Corr Coef	-.12852	-.03537	-.12852	-.03537	
CLCAS1	CLGPCND	CHGPSND	CLGPSND	CHGPWSND	CLGPWSND
Corr Coef	-.00531	-.22929	-.00806	-.47890	-.50154
CLCAS1	CLFAC1	CLCAC3			
Corr Coef	-.00438	-.04488			
CHFAC1	CLCPBS2	CLCABS1	CLGPSND	CHGPSND	
Corr Coef	-.01981	-.00719	-.00719	-.01981	
CHCAC6	CHGPWSND				
Corr Coef	-.04613				
CHCAWS1	CHGPWSND	CLGPWSND			
Corr Coef	-.15361	-.11648			

[a]See Table 6 for definitions of terms used in this table.

Chapter 3. Model Results

Introduction

This chapter presents and discusses the results of the programming analysis results of four different farm situations. After a general discussion, each set of results is depicted graphically as E-A efficient farm plans. The time frame of the risk-programming model is the first week of February, 1987. Therefore, all results are based on price and quantity expectations for that time period.

The four scenarios analyzed were: 1) 750 acres of class I soils (HIGH), 2) 750 acres of class II soils (LOW), 3) 375 acres of class I and 375 acres of class II soils (HILOW), and 4) no participation in the government commodity programs (HLNOG). The results were obtained by first solving a profit-maximizing model. The results were accomplished by setting the value for λ, the constraint on the level of deviations, to an arbitrarily high value. The resulting profit-maximizing value for λ was used to establish the upper range for the E-A frontiers. The interval of income deviations was established between \$10,000 and \$175,000. This interval was divided into 10 equal parts allowing for an increase in the level of risk by \$16,500 per solution. Eleven separate solutions for each scenario was the result. The profit-maximizing solution was reached by the tenth run of each scenario. Therefore, deviation levels are the same across all solutions which facilitates comparison. The identical levels of deviations could not be maintained when the government programs were dropped from the model because the deviations levels increase substantially. The deviation interval used in the no-government program scenario (HLNOG) ranged from $10,000 to $220,000 with a change of $21,000 for each solution.

Discussions of the overall results are presented in the next section and center around the E-A frontiers for each scenario. Table 6 contains the procedure used to name each of the production, marketing and government program activities. Reference to this table will provide the reader with a quick summary of each activity.

All Class I Soils (HIGH)

The results for high yielding soils are summarized in Table 10. The E-A efficient farm plans demonstrate the trade-offs a producer would make for different levels of risk aversion. The results range from strongly risk averse to risk neutral at the profit-maximizing level. The profit-maximizing solution is farm plan number 11. The best alternative at all levels of risk aversion includes participation in the government commodity programs.

The crops grown at all levels of risk aversion are high-yielding corn grain and soybeans doubled-cropped with wheat and barley. The absence of full-season soybeans from the solutions seems plausible given the comparatively lower yield and higher variation observed in the yield data (see Table 3.). Production increases as the level of deviations are allowed to increase (risk aversion decreases). The acreage of corn grain increases over all farm plans and reaches the acreage constraint at farm plan 11. All corn grain produced is placed in the government program with the additional paid diversion acreage of 15 percent (CHGPCPD). Thus, for all levels of risk aversion, the paid diversion program offers the best alternative for corn grain.

Table 9. E-A Efficient Farm Plans Based on High Yielding Soils (HIGH)

Activities	Farm Plans 1	2	3	4	5	6	7	8	9	10	11[1]
Net income ($)	5731	15187	24643	34099	43555	53011	62360	68744	74223	77630	77630
Deviations ($)	10000	26500	43000	59500	76000	92500	109000	125500	142000	158500	164284
Production activities[2] (acres)											
CHC	6	15	24	34	43	53	63	101	142	182	200
CHWS	21	55	89	123	158	192	220	150	150	150	141
CHBS	16	43	70	96	123	150	180	250	250	250	250
Total acres farmed	43	113	183	254	324	394	463	501	542	582	591
Government program activities (acres)											
CHGPCPD	6	15	24	34	43	53	63	101	142	182	200
CHGPWSND	21	55	89	123	158	192	220	150	150	150	141
CHGPBSPD	16	43	70	96	123	150	180	250	250	91	250
CHGPBSND	0	0	0	0	0	0	0	0	0	159	0
Total acres of set-aside	13	35	57	80	102	124	146	164	178	168	159

[1]Profit maximizing solution.
[2]See Table 6 for activity definitions.

The acreage of soybeans doubled-cropped with wheat increases with decreasing risk from farm plan 1 to 7. Starting with farm plan 8, the acreage devoted to this crop sequence declines and reaches a low of 141 acres at the profit-maximizing solution. The wheat/soybean enterprise is entered into the only government program alternative available (CHGPWSND). Thus, this activity is directly related to the production activity.

The acreage of barley/soybeans increases as the level of deviations are allowed to increase. The barley/soybean activity reaches and remains at the rotational constraint beginning with farm plan number 8. All barley is entered in the government program alternative including the additional paid diversion acreage (CHGPBSPD) except for farm plan 10. In farm plan 10, 159 acres are removed from the paid-diversion option (CHGPBSPD) and placed in the no-diversion option (CHGPBSND). This is reversed in farm plan 11. In reality a farmer cannot choose to only enter a part of their acreage in the paid diversion and part in the set-aside. In the sensitivity analysis both of these alternatives are in the basis and have zero shadow prices. This implies that a change in the acreage in the set-aside at 20 or at 35 percent would not affect the objective function.

In summary, the government programs provide the best combination of expected returns and minimum deviations for the 1987 crop year based on expectations in February 1987. In farm plans approaching risk neutrality (farm plans 9-11), little net income is gained by adding the last marginal corn acreage or participating in the paid diversion program for barley.

All Class II Soils (LOW)

The results for low yielding soils are summarized in Table 10. The E-A efficient farm plans demonstrate the trade-offs a producer would make, given various levels of risk aversion. The results range from strongly risk averse to risk neutral at the profit-maximizing level. The profit-maximizing solution is farm plan number 10. A general observation is that participation in the government programs is the preferred alternative at all levels of risk aversion.

Table 10. E-A Efficient Farm Plans Based on Low-Yielding Soils (LOW)

	Farm Plans									
Activities	1	2	3	4	5	6	7	8	9	10[1]
Net income ($)	4538	12025	19511	26998	34310	40281	45827	50705	55033	55504
Deviations ($)	10000	26500	43000	59500	76000	92500	109000	125000	142000	144547
Production activities[2] (acres)										
CLC	3	8	13	19	23	52	95	138	189	200
CLS	1	1	2	2	6	7	0	0	0	0
CLWS	13	34	55	76	112	150	150	150	130	119
CLBS	34	91	147	204	250	250	250	250	250	250
Total acres farmed	51	134	217	301	391	458	495	538	569	569
Government program activities (acres)										
CLGPCPD	3	8	13	19	23	52	92	114	134	137
CLGPCND	0	0	0	0	0	0	3	24	55	63
CLGPWSND	13	34	55	76	112	150	150	150	130	119
CLGPBSPD	34	91	147	204	250	250	250	250	250	250
Total acres of set-aside	17	44	71	99	126	147	161	173	181	181
Cash and futures activities (acres)										
CLCAS1	1	1	2	2	6	7	0	0	0	0

[1]Profit maximizing solution.
[2]See Table 6 for activity definitions.

The crops produced under the assumption of low-yielding soils are corn grain, full season soybeans, and soybeans double-cropped with wheat and barley. The corn grain (CLC) enterprise enters the first farm plan and increases to the rotational constraint. The 200-acre maximum is reached at the profit-maximizing solution (plan 10). The corn grain is entered in the government program at the full 35 percent paid diversion (CLGPCPD). The 35 percent paid diversion holds until the seventh plan, where all additional land is taken out of the paid diversion and entered only in the 20 percent set-aside (CLGPCND). This change in paid diversion implies that as the level of risk aversion declines, the benefit to entering the paid diversion program also declines. This change also coincides with reaching the maximum constraint on corn acreage, thus, by changing government program participation, a 15 percent increase in corn land can be obtained.

A small acreage of low-yielding full-season soybeans (CLS) enters the model at high levels of risk aversion (farm plans 1 to 7). The soybeans are stored from harvest to January and sold in the cash market (CLCAS1). Implying that storage of soybeans past the harvest period would provide greater income at lower levels of risk. However, this does not completely explain why this activity has entered the model. Table 3 indicates full-season soybeans on class II soils have the lowest relative yield and highest coefficient of variation of any crop. This might imply that full-season soybeans would be one of the last crops to enter a solution. However, due to the negative correlation between full-season soybeans sold in January (CLCAS1) and wheat soybeans double-cropped on class II soils entered in the government program without paid diversion (CLGPWSND) (see Table 8), the full season soybeans do enter the solution.

Low-yielding wheat doubled-cropped with soybeans (CLWS) is consistently part of each of the 10 farm plans. The only government program activity available for wheat double-cropped with soybeans is CLGPWSND. The acreage is increased from plans 1 to 6. In plans 6 to 8 the acreage remains constant at 150 acres. However, as the level of risk aversion approaches risk neutrality, the acreage of wheat/soybeans declines. The reduction in this activity coincides with the change in the acreage of corn grain entered in the government program. Thus, at the profit maximizing levels, corn grain is marginally more profitable than wheat/soybeans.

The acreage of barley-doubled cropped with soybeans (CLBS) exceeds the number of acres of all other crops for every farm plan on class II soils. Thus, this alternative offers the best mix of income and income variability. This enterprise enters the first farm plan and reaches the rotational constraint in farm plan 5 and remains constant into the profit-maximizing solution. The barley and soybeans are in the set-aside (CLGPBSPD) along with the additional paid diversion at all levels of risk aversion.

In summary, corn, wheat, barley and double cropped soybeans enter the model at all levels of risk aversion. The government programs offer the highest level of expected income at all levels of risk aversion. Full-season soybeans enter the solutions only at lower levels of risk aversion. In farm plans approaching risk neutrality, little additional income is gained from the addition of the last marginal acres to fully utilize the farm's 750 acres (farmed and set-aside).

Equal Amounts of Class I and II Soils (HILOW)

The HILOW scenario assumes the farm has 375 acres of class I and 375 acres of class II soils. The HILOW results are summarized in Table 11 and demonstrate the trade-offs a producer would make as risk aversion declines. The risk-neutral farm plan is the profit-maximizing solution (plan number 10). The general finding is that the government programs offer the best alternatives at all levels of risk aversion.

The mixture of soil types leads to a different cropping system as compared to either the HIGH or LOW frontiers. Corn grain (CLC) and full season soybeans (CLS) are grown only on class II soils. Barley doubled-cropped with soybeans (CLBS and HBS) is produced on both soil types. However, wheat double-cropped with soybeans (CHWS) is produced only on class I soils. The corn grain entered in the paid diversion (CLGPCPD) part of the commodity program increases as the level of deviations is increased. Only in plans 8 to 10 is additional land entered in the commodity program with no paid diversion (CLGPCND). This would imply that as land becomes

Table 11. E-A Efficient Farm Plans Based on High and Low Yielding Soils (HILOW)

	Farm Plans									
Activities	1	2	3	4	5	6	7	8	9	10[1]
Net income ($)	5877	15574	25271	34968	43722	51481	58207	63313	68190	70841
Deviations ($)	10000	26500	43000	59500	76000	92500	109000	125000	142000	144547
Production activities[2] (acres)										
CLC	3	7	11	15	42	49	68	111	154	200
CLS	4	10	16	22	5	0	0	0	0	0
CHWS	34	90	146	203	149	144	150	150	150	138
CHBS	9	25	40	56	137	142	136	136	136	166
CLBS	0	0	0	0	0	69	114	114	114	84
Total acres farmed	50	131	213	295	333	403	468	511	554	588
Government program activities (acres)										
CLGPCPD	3	7	11	15	42	49	68	100	122	142
CLGPCND	0	0	0	0	0	0	0	11	32	58
CHGPWSND	34	90	146	203	149	144	150	150	150	138
CHGPBSPD	9	25	40	56	137	142	136	136	136	0
CLGPBSPD	0	0	0	0	0	69	114	114	114	84
CHGPBSND	0	0	0	0	0	0	0	0	0	166
Total acres of set-aside	14	36	58	80	104	130	152	166	178	162
Cash and futures activities (acres)										
CLCAS1	4	10	16	22	5	0	0	0	0	0

[1]Profit maximizing solution.
[2]See Table 6 for activity definitions.

limited and the level of risk aversion decreases, there is less incentive to participate in the paid diversion program.

The full-season soybeans produced at the higher levels of risk aversion on limited acreage are sold in the cash market. These are similar to the results observed with the low-yielding soils. The reason for this activity entering is based on the negative covariance between CLCAS1 and CHGPWSND (see Table 8). Thus, the storage of soybeans from late October to January (CLCAS1) provides the only cash or futures activity to enter a farm plan in conjunction with the government programs.

The wheat/soybean combination is entered in the government program with a set-aside acreage of 27.5 percent (CHGPWSND). The acreage entered in the commodity program reaches a peak in farm plan 4 and then gradually declines. However, the decline in acreage at the profit-maximizing level implies that as land becomes limited, profits can be increased by substituting wheat/soybeans for barley/soybeans on class I soils.

The barley/soybeans enterprise provides interesting results. The acreage of barley/soybeans reaches the rotational constraint by farm plan 7 and does not drop below that level. At most levels of risk aversion, this crop combination on class I soils is entered in the government program at the full diversion of 35 percent (CHGPBSPD). However, approaching risk neutrality (plans 9 to 10) when land becomes limited, there is a shift to diverting only 20 percent of the crop acreage of barley and soybeans (CHGPBSND). At the profit-maximizing level, additional acreage of class II soils is brought into barley/soybean production (CLGPBSPD). This combination of high-yielding barley and wheat with soybeans maximizes the acreage of high yielding crops with the largest expected returns. This is accomplished by reducing the class I wheat/soybeans in favor of barley/soybeans due to the difference in the level of set-aside required to participate (27.5% set-aside for wheat verses 20% set-aside for feed grains).

In summary, the government programs provide the highest level of income for the least amount of risk as compared to all cash or futures alternatives based on February 1987 expectations. The production of wheat and barley double-cropped with soybeans offers the best alternatives for class I soils. The production of corn grain on class II soils provides a stable crop component at all levels of risk aversion. At profit-maximizing levels the cropping alternatives look quite similar to a standard crop rotation in eastern Virginia.

No Government Program Participation (HLNOG)

The results of the analysis excluding participation in the government commodity programs provide information as to which cash and futures strategies are feasible. In the previous four frontiers, based on 1987 expected prices, the government programs were too dominant to allow any inferences about other marketing strategies. The decision was made to remove these alternatives to allow direct comparison between the cash and futures strategies unencumbered by the government programs. This may provide insights into expected producers' behavior in future years as market prices rise relative to government loan rates and target prices. The E-A efficient farm plans generated under the above assumption are presented in Table 12.

The results are based on 375 acres of soil class I and 375 acres of soil class II. The removal of the government programs did not lead to drastically different cropping patterns as compared to the farm plans with government program participation. The crops grown on class I soils are wheat (CHWS) and barley (CHBS) double cropped with soybeans and full season soybeans (CHS). The only crop grown on class II soil is corn grain (CLC). A general observation is that even at profit maximizing levels, not all of the class II land is used. This implies that there are no suitable cropping alternatives other than corn grain for class II soils. This conclusion is supported by the fact that in the sensitivity analysis all shadow prices for activities out of the basis are negative. Constraining the model to utilize all 750 acres of land resulted in an objective function value of $21,188 and deviations of $238,277. The resulting decline in net income and increase in risk compared to solution II (Table 12) was caused by no profitable alternatives for the class II soils. This demonstrated that idling land was a profitable decision at all levels of risk aversion given the expected prices as of February 1987 and an equal mixture of class I and class II soils.

Table 12. E-A Efficient Farm Plans with No Government Program Participation (HLNOG)

Activities	Farm Plans 1	2	3	4	5	6	7	8	9	10	11[1]
Net income ($)	2532	7849	13165	18045	20900	21234	21535	21827	22103	22165	22165
Deviations ($)	10000	31000	52000	73000	94000	115000	136000	157000	178000	199000	201162
Production activities[2] (acres)											
CLC	0	0	0	0	8	60	107	149	190	200	200
CHS	0	0	0	33	21	26	38	88	125	125	125
CHWS	38	119	199	250	250	250	250	250	250	250	250
CHBS	0	0	0	9	104	99	87	37	0	0	0
Total acres farmed	38	119	199	292	383	435	482	524	565	575	575
Marketing Activities (acres)											
CLFPC6	0	0	0	0	0	0	0	0	0	167	0
CLFPC2	0	0	0	0	0	0	0	0	0	0	200
CHFAS1	0	0	0	0	0	26	38	88	125	125	125
CHFAWS1	10	31	51	146	120	143	70	13	0	64	250
CHFABS1	0	0	0	9	0	99	87	37	0	0	0
CLCPC2	0	0	0	0	8	60	107	149	190	33	0
CHCPS2	0	0	0	33	0	0	0	0	0	0	0
CHCAS1	0	0	0	0	21	0	0	0	0	0	0
CHCPWS2	20	63	106	36	36	0	0	0	0	0	0
CHCAWS1	8	25	41	68	94	107	180	237	250	186	0
CHCABS1	0	0	0	0	104	0	0	0	0	0	0

[1]Profit maximizing solution.
[2]See Table 6 for activity definitions.

Corn grain (CLC) did not enter the farm plans until the fifth solution. In plans 5 to 9, all the corn grain was marketed in the cash market at harvest time (CLCPC2). This was based on the the expected harvest price as of the first week of February. In farm plan 10, 167 acres of the 200 acres of corn are hedged the first week of June and sold in the cash market at harvest (CLFPC6). This was based on the expected December futures price the first week of February. The remaining 33 acres of corn in plan 10 are sold in the cash market at harvest (CLCPC2). In the profit-maximizing solution, 200 acres of corn are hedged the first week of February and sold in the cash market at harvest (CLFPC2). This is based on the expected December futures price the first week of February. In plan 11 the shadow price for CLFPC6 is zero indicating this alternative could replace some or all of the corn acreage marketed under activity CLFPC2. Therefore, any combination of these two activities equaling 200 total acres would yield the same objective function value.

The presence of a substantial acreage of full-season soybeans is the major cropping difference between this scenario and the others discussed previously. Soybeans did not enter the solution until plan number 4 and increased to 125 acres and remained constant thereafter. In farm plan 4, the entire 33 acres of soybean are sold at harvest (CHCPS2). This harvest price is based on the expected November futures price during the first week of February adjusted by the harvest basis. In farm plan 5, the entire 21 acres of soybeans are stored from harvest to the first week of January and sold in the cash market (CHCAS1). The price received in January is based on the January futures price adjusted for the local basis. In farm plans 6 to 11, all soybean production is hedged and stored from harvest to the first week of January (CHFAS1). In plan 11 the shadow price for CHCAS1 is zero, hence this alternative could replace some or all of the soybean acreage marketed under activity CHFAS1. Therefore, any combination of these two activities, equaling 125 total acres, would yield the same objective function value.

The wheat/soybean activity are only produced on high yielding soils and reach the rotational constraint (250 acres) before corn grain is planted. In all of the wheat/soybean and barley/soybean activities, the wheat and barley are sold at harvest, therefore, the following discussion will center on soybeans alone. In plan 1, 20 of the 38 acres of soybeans are sold at harvest based on the expected harvest price in February (CHCPWS2). The remaining 18 acres are stored until the first week of January and sold in the cash market (CHCAWS1). Of the 18 acres stored, 10 are hedged from harvest until January (CHFAWS1). This same relationship is observed in farm plans 1 to 5, with changes in the number of acres in each of the three alternatives. In farm plan 6, the harvest sales are stopped, and all production is stored until January, 143 acres are hedged (CHFAWS1) and 107 acres are not (CHCAWS1). In farm plans 7 and 8, the trend continues; however the acres hedged decrease until plan 9 where all hedging is stopped. In plan 9, all soybeans are stored un-hedged until January (CLCAWS1). In plan 10, all soybeans are stored until January with 186 acres sold in the cash market (CHCAWS1) and 64 acres hedged (CHFAWS1). In plan 11, all soybeans are hedged (CHFAWS1). Since the shadow prices for CHCAWS1 and CHFAWS1 are zero, both of these alternatives are equally likely to enter the solution.

The barley/soybean enterprise does not enter the solution until farm plan 4. The 9 acres are stored and hedged until January (CHFABS1). In plan 5, the entire acreage is stored until January but is not hedged (CHCABS1). This trend reverses in plans 6 to 8, and all soybeans are stored and hedged until January (CHFABS1). There is no production of barley/soybean in the remaining farm plans. However, the barley/soybean activity is in the basis, but at a zero level that implies a tie with another activity. The entry of this activity into the basis would be offset only by a reduction in another crop on class I soils. All shadow prices of crops on class II soils are negative.

In summary, the removal of the government programs brought about a significant reduction in net returns and an increase in risk at all levels of risk aversion. An important finding is that 175 acres of class II land was idled at or near the profit-maximizing level given expected prices for 1987. This implies that there are few alternatives available for below average soils given this farm's yield history. Government program participation insured payment for unprofitable land. The marketing strategies for corn, wheat, and barley all involve selling at harvest. Corn is hedged in plans 10 and 11, but it does not increase net income. At all levels of risk aversion, soybeans are stored until January. In plans 1, 2, and 3, 26 percent of expected soybean production is hedged at harvest and sold in January, indicating that hedging soybeans at harvest is profitable. As risk aversions declines and more soybeans are produced, hedging increases until all soybeans are hedged at harvest for sale in January. Every farm plan involves some hedging of soybeans at harvest for sale in January.

The E-A Frontiers

Figure 1 contains E-A frontiers depicting the trade-offs between increasing risk and increasing net income for the four scenarios. Each point on the E-A frontiers corresponds to a specific farm plan found in Tables 9 to 12. Thus, the *x* and *y* axes correspond to the first two lines of each of those tables "Net Income" and "Deviation".

The resulting relationships between the deviations and net income can be separated into 2 groups. The first group contains the frontiers HIGH, LOW, and HILOW and the second by HLNOG. In group one, the HILOW frontier provides returns that are approximately equal per unit of risk as the HIGH frontier. As expected, the LOW frontier provides riskier farm plans for each unit of returns as compared to HIGH and HILOW. Specifically, between deviations of $20,000 and approximately $76,000, the mixture of soil types (375 acres each of class I and class II soils) yields slightly higher net returns but virtually the same combination of risk and mean returns as does the HIGH frontier. This implies that a risk-averse producer desiring deviations less than approximately $76,000 would be indifferent between a equal mixture of soil types and all class I soils.

The finding that a farm with equal mix of class I and II soils performs as well as a farm with all class I soil over a wide range of deviations was unexpected, since the mix of soils would imply lower average fertility levels. This result arises from the negative covariance relationship between soybeans on class I soils with post-harvest cash sales in January (CLCAS1), and the two government program activities: 1) soybeans and wheat double-cropped on class I soils with no additional paid diversion (CHGPWSND) and 2) soybeans and barley double-cropped on class I soils with additional paid diversion (CHGPBSPD). The acreage of CLCAS1 in the HILOW

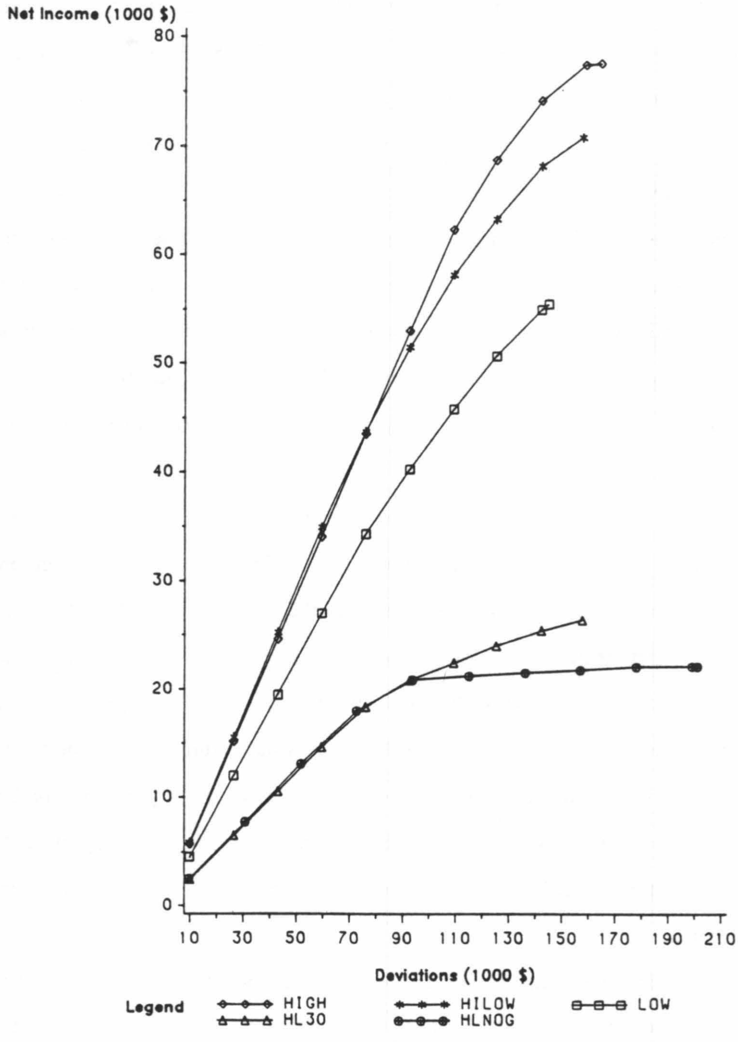

Figure 1. E-A Frontiers for 5 Alternative Scenarios

solution corresponds to the solutions in which the frontier HILOW slightly exceeds HIGH. The covariances between CLCAS1 and CHGPWSND and CHGPBSPD are -$3263 and -$849 respectively. The negative covariance indicates that risk can be reduced by the inclusion of CLCAS1 in the farm plan. This result may be due to the method used by the government to calculate the program yields used in determining government payments.

Program yields are calculated by averaging the last 5 years of yields after dropping the highest and lowest years. This method of calculating program yields (and ultimately government payments) coupled with risk aversion allows producers on lower quality or marginal soils to achieve net returns similar to producers on higher quality soils because the government payment in low-yielding years acts as a disaster payment. The government payment thus reduces the total farm risk normally experienced on lower-yielding soils.

The loss of the government support payments is dramatically illustrated by figure 1. At all levels of deviations, the HLNOG frontier is dominated by all unrestrained government program options. The profit-maximizing solution as compared to the solution for all class II soils (LOW) has less than half the net income at higher levels of risk. The relationship is even more dramatic as the soil type improves. In the case of all class I soils, the profit-maximizing solution has more than three times the level of net income. Given the expected net returns used in the analysis for 1987, participation in the commodity programs clearly provides the most profitable combination of activities at all levels of risk aversion. These results could change substantially in subsequent years if expected net returns based on market prices exceed expected net returns from government program participation.

The relationship between net income and deviations for the HLNOG frontier demonstrates that a risk-averse farmer could halve the level of income deviations and have little impact on net income. This can be accomplished by reducing production to substantially lower levels corresponding to farm plan 5. By idling 192 acres of cropland, the income deviations could be reduced from $199,000 to $94,000 while reducing net income only from $22,165 to $20,900. Thus, this example illustrates the problems with choosing farm plans from standard profit maximizing linear-programming models relying solely on expected outcomes.

Chapter 4. Conclusions and Limitations

The overall conclusions of this study can be related to the problem statement and objectives in Chapter 1. The underlying problem was defined as price and yield variability, which appears to have been increasing over time. The objective of evaluating different production, marketing, and government program alternatives in a E-V framework was directly related to the problem statement. The majority of research and extension studies addressing farm risks have concentrated only on production, marketing, or government programs and have not attempted to integrate these activities into a single decision-making model. This study provides a method of assisting farmers in making management decisions in an integrated framework.

The mean forecast deviation (MFD) method described in Chapter 2 is a variation of the Mean Squared Error Forecast method developed by McSweeny, Kenyon, and Kramer. This method provided an alternative to the traditional way of using historical data to calculate income deviation matrices. In the MFD approach, the mean error between the expected and the observed outcomes within production and marketing season are minimized instead of deviations from the arithmetic mean across a number of years. The decision to use this technique was based on how farmers are believed to form expectations about prices and yields and expected income per acre. The authors' opinion is that the MFD method provides a reasonable means of measuring income deviations.

The usefulness of this study is in the method of combining production, marketing, and government program decisions into a single model since the results only apply to one year 1987. Farmers make major decisions early in the year and then spend the rest of the season attempting to assure a favorable outcome to those decisions. A considerable amount of farm level research and extension is tailored to helping assure favorable outcomes to these decisions, but little assistance is given to producers early in the decision-making process. The method of modeling farm level decisions applied in this study uses available information to make informed decisions before planting time.[18] Hopefully, this would reduce the number of unfavorable outcomes which a producer must overcome during the cropping cycle.

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[18] This model could be applied at the farm level with little difficulty except for the representation of an individual farmers historical yields. The work by Pease (1987) looks promising as a possible method to elicit subjective yield distributions in place of historical data. This would strengthen the application of risk programming techniques at the farm level.

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Appendix A. Model Structure Details

Introduction

This Appendix provides the details of the model structure used to generate the four E-A frontiers. The first section contains a diagram of the model tableau. The second section explains the names and nature of each row and column used in the model. The last section provides the detailed listing of each coefficient used in the model.

The Model

The next three pages contain the detailed tableau of the model. This was obtained by using the "Picture" option in the MPS (Math Programming System) program which resides on the Virginia Tech main-frame computer. The symbols in Table 15 represent the magnitude of the coefficients used in the model.

Table 13. MPS Symbols Used In Model Tableau

Symbol	Lower Range	Upper Range
T	0.100000	0.999999
1	1.000000	1.000000
A	1.000001	10.000000
B	10.000001	100.000000
C	100.000001	1,000.000000
D	1,000.000001	10,000.000000
E	10,000.000001	100,000.000000
F	100,000.000001	1,000,000.000000

A detailed model Tableau is listed in Table 14.

Table 14. Model Tableau

Row	Type	CTOTALAC	CTOTALSA	CHCC	CLCC	CHSS	CLSS	CHWSS	CLWSS	CHBSS	CLBSS
OBJ	N			-C	-C	-C	-C	-C	-C	-C	-C
CHGCOL	N										
RHLAND	L			1		1		1		1	
RLLAND	L				1		1		1		1
RMAXDC	L							1	1	1	1
RMAXCORN	L			1	1						
RMAXWS	L							1	1		
RMAXBS	L									1	1
RTOTALAC	E	1		-1	-1	-1	-1	-1	-1	-1	-1
RTOTALSA	E		1								
RHCC	L			-1							
RLCC	L				-1						
RHSC	L					-1					
RLSC	L						-1				
RHWSC	L							-1			
RLWSC	L								-1		
RHBSC	L									-1	
RLBSC	L										-1
RCSTORE	L										
RCINCAR	L										
RBSTORE	L										
RBINCAR	L										
RLOAN1	E										
RDEFPAY1	E										
RMAXDPAY	L										
RDEFPAY2	E										
RCOFSA	L										
ROPCAP	L			C	B	B	B	C	C	C	C
RYR75	G										
RYR76	G										
RYR77	G										
RYR78	G										
RYR79	G										
RYR80	G										
RYR81	G										
RYR82	G										
RYR83	G										
RYR84	G										
RYR85	G										
RYR86	G										
RMAD	L										

Row	CHFPC2	CHFPC4	CHFPC6	CHFAC1	CHFAC3	CHFAC6	CLFPC2	CLFPC4	CLFPC6	CLFAC1	CLFAC3	CLFAC6	CHFPS2	CHFPS4	CHFPS6	CHFAS1	CHFAS3	CHFAS6	CLFPS2	CLFPS4	CLFPS6	CLFAS1	CLFAS3	CLFAS6
OBJ	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B	B	B
CHGCOL																								
RHLAND																								
RLLAND																								
RMAXDC																								
RMAXCORN																								
RMAXWS																								
RMAXBS																								
RTOTALAC																								
RTOTALSA																								
RHCC	1	1	1	1	1	1																		
RLCC							1	1	1	1	1	1												
RHSC													1	1	1	1	1	1						
RLSC																			1	1	1	1	1	1
RHWSC																								
RLWSC																								
RHBSC																								
RLBSC																								
RCSTORE				C	C	C				C	C	C												
RCINCAR				C	C	C				B	B	B												
RBSTORE																B	C	C				B	B	C
RBINCAR																B	B	B				B	B	B
RLOAN1																								
RDEFPAY1																								
RMAXDPAY																								
RDEFPAY2																								
RCOFSA																								
ROPCAP																								
RYR75	-C	-C	-B	-C	-C	-C	-C	-C	-B	-C	-C	-C	-A	A	B	B	B	B	-B	-B	-B	-B	-B	-B
RYR76	-C	-C	-C	-C	-B	-C	-C	-C	-C	-C	-B	-C	C	C	B	B	B	B	B	B	B	B	B	B
RYR77	C	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B	B	B	B	B	B	B	B	B
RYR78	-B	-B	-B	-B	-B	-B	A	-B	-B	A	B	B	B	A	-B	-B	-B	-C	B	B	B	B	B	B
RYR79	-C	-C	-C	-C	-B	-B	-B	-B	-C	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B
RYR80	C	B	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B	B	B
RYR81	B	C	C	-B	T	-B	C	C	C	B	B	B	-B	-B	-B	B	B	B	-B	-B	-A	B	B	B
RYR82	-C	-C	-B	B	-C	-C	-C	-C	-B	-B	-C	-C	-C	-C	-C	-C	-C	-C	-C	-C	-C	-C	-C	-C
RYR83	C	B	B	B	B	B	B	B	B	-B	B	B	C	C	C	B	B	B	B	B	B	-T	A	T
RYR84	-B	-B	-B	-B	-B	-B	-B	-C	-C	-B	-B	-B	-C	-C	-C	-B	-B	-B	-B	-B	-B	A	A	A
RYR85	-A	-A	A	B	B	B	A	A	A	B	B	B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B
RYR86	C	C	C	C	B	C	C	C	C	B	B	C	-A	-A	-A	-B	-B	-B	T	A	T	-A	-A	-A
RMAD																								

Row	CHFPWS2	CHFPWS4	CHFPWS6	CHFAWS1	CHFAWS3	CHFAWS6	CLFPWS2	CLFPWS4	CLFPWS6	CLFAWS1	CLFAWS3	CLFAWS6	CHFPBS2	CHFPBS4	CHFPBS6	CHFABS1	CHFABS3	CHFABS6	CLFPBS2	CLFPBS4	CLFPBS6
OBJ	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
CHGCOL																					
RHLAND																					
RLLAND																					
RMAXDC																					
RMAXCORN																					
RMAXWS																					
RMAXBS																					
RTOTALAC																					
RTOTALSA																					
RHCC																					
RLCC																					
RHSC																					
RLSC																					
RHWSC	1	1	1	1	1	1															
RLWSC							1	1	1	1	1	1									
RHBSC													1	1	1	1	1	1			
RLBSC																			1	1	1
RCSTORE																					
RCINCAR																					
RBSTORE				B	C	C				B	B	C				B	C	C			
RBINCAR				B	B	B				B	B	B				B	B	B			
RLOAN1																					
RDEFPAY1																					
RMAXDPAY																					
RDEFPAY2																					
RCOFSA																					
ROPCAP																					
RYR75	-C	-C	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	B	B	B	-C	-B	-B
RYR76	B	B	B	-B	-B	-B	B	B	B	B	B	B	B	B	A	-B	-B	-B	B	B	A
RYR77	C	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B	B	B	C	C	C
RYR78	B	A	-A	-B	-B	-B	B	B	A	-B	-B	-B	B	B	-A	-B	-B	-B	B	-A	-B
RYR79	-B	-B	-C	-B	-B	-B	-B	-C	-C	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B
RYR80	C	C	C	B	B	B	C	C	C	B	B	B	C	C	C	B	B	B	C	C	C
RYR81	-B	-B	-B	B	B	B	-B	-B	-B	A	A	B	-B	-B	-B	B	B	B	-B	-B	-B
RYR82	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-C	-C	-C	-C	-C	-C	-C	-C	-C
RYR83	C	B	C	B	B	B	B	B	B	B	B	B	C	C	C	B	B	B	C	B	C
RYR84	-B	-B	-B	T	A	A	-B	-B	-B	-B	-B	-B	-B	-B	-B	-A	A	-A	-B	-B	-B
RYR85	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B	-A	-T	B	B	B	B	B	B	B
RYR86	-B	-B	-B	-B	-B	-B	-A	-T	-T	-B	-B	-A	-B	-A	-A	-B	-B	-B	-B	-B	-B
RMAD																					

Table 14. Model Tableau (Continued)

Row	Type	CLFABS1	CLFABS3	CLFABS6	CHCPC2	CHCAC1	CHCAC3	CHCAC6	CLCPC2	CLCAC1	CLCAC3	CLCAC6	CHCPS2	CHCAS1	CHCAS3	CHCAS6	CLCPS2	CLCAS1	CLCAS3	CLCAS6	CHCPWS2	CHCAWS1	CHCAWS3	CHCAWS6	CLCPWS2	CLCAWS1	CLCAWS3	CLCAWS6
OBJ	N	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B	C	C	C	C	C	C	C	C
CHGCOL	N																											
RHLAND	L																											
RLLAND	L																											
RMAXDC	L																											
RMAXCORN	L																											
RMAXWS	L																											
RMAXBS	L																											
RTOTALAC	E																											
RTOTALSA	E																											
RHCC	L				1	1	1	1																				
RLCC	L								1	1	1	1																
RHSC	L												1	1	1	1												
RLSC	L																1	1	1	1								
RHWSC	L																				1	1	1	1				
RLWSC	L																								1	1	1	1
RHBSC	L																											
RLBSC	L	1	1	1																								
RCSTORE	L					C	C	C		C	C	C																
RCINCAR	L					C	C	C		B	B	B																
RBSTORE	L	B	C	C										B	C	C		B	B	C		B	C	C		B	B	C
RBINCAR	L	B	B	B										B	B	B		B	B	B		B	B	B		B	B	B
RLOAN1	E																											
RDEFPAY1	E																											
RMAXDPAY	L																											
RDEFPAY2	E																											
RCOFSA	L																											
ROPCAP	L																											
RYR75	G	-B	-B	-B	-C	-C	-C	-C	-C	-C	-C	-C	A	B	B	B	-B	-B	-B	-B	-B	B	-A	B	-B	-B	-A	A
RYR76	G	-B	-A	-A	-C	-B	-C	-C	-C	-B	-C	-C	B	B	B	B	B	B	B	B	-A	-A	-A	-B	B	B	B	-A
RYR77	G	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B	B	-B	B	B	C	B	C	B	C	C	C	C
RYR78	G	-B	-B	-B	-B	-B	-B	A	B	B	A	B	-B	-B	-C	-C	B	-B	B	A	-B	-B	-B	-C	-A	-B	-B	-B
RYR79	G	-B	-B	-B	-C	-B	-B	-B	-C	-B	-B	-B	-B	-B	-C	-B	-B	-C	-B	-B	-B	-C	-C	-C	-B	-B	-C	-C
RYR80	G	B	B	B	C	C	C	C	C	C	C	C	B	C	C	C	B	-B	B	B	B	B	B	C	B	B	B	B
RYR81	G	B	B	B	B	-B	B	-B	B	B	B	A	B	B	B	B	A	-B	B	B	B	-B	B	B	-A	B	B	B
RYR82	G	-C	-C	-C	A	-B	-B	-B	-B	-B	-B	-C	-B	-B	-B	-B	-B	-C	-B	-B	-A	-B	-A	A	B	A	B	B
RYR83	G	B	B	B	B	C	B	B	A	B	B	B	B	B	B	B	B	C	A	A	B	C	B	B	B	B	B	B
RYR84	G	A	B	A	-B	-C	-C	-C	-B	-C	-C	-C	-C	-B	-B	-C	-A	C	-T	-A	-B	B	-B	-B	-B	-B	-B	-B
RYR85	G	B	B	B	B	B	B	B	B	B	B	B	-B	-B	-B	-B	-B	A	-B	-B	-B	-B	-B	-B	-B	-B	-B	-B
RYR86	G	-B	-B	-B	C	B	B	C	C	B	B	C	-A	-B	-B	-A	-A	C	-B	-A	-B	B	-B	-B	-T	-B	-B	-A
RMAD	L																											

Row	Type	CHCPBS2	CHCABS1	CHCABS3	CHCABS6	CLCPBS2	CLCABS1	CLCABS3	CLCABS6	CHGPCPD	CHGPCND	CLGPCPD	CLGPCND	CHGPSND	CLGPSND	CHGPWSND	CLGPWSND	CHGPBSPD	CHGPBSND	CLGPBSPD	CLGPBSND	CCSCOST	CCINCOST	CSSCOST	CSINCOST	CLOAN1	CDEFPAY1	CDEFPAY2	CCOFSA
OBJ	N	C	C	C	C	C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	-U	-U	-U	-U				-B
CHGCOL	N																												
RHLAND	L									T	T					T		T	T										
RLLAND	L											T	T				T			T	T								
RMAXDC	L																												
RMAXCORN	L																												
RMAXWS	L																												
RMAXBS	L																												
RTOTALAC	E																												
RTOTALSA	E									-T	-T	-T	-T			-T	-T	-T	-T	-T	-T								
RHCC	L									1	1																		
RLCC	L											1	1																
RHSC	L													1															
RLSC	L														1														
RHWSC	L															1													
RLWSC	L																1												
RHBSC	L	1	1	1	1													1	1										
RLBSC	L					1	1	1	1											1	1								
RCSTORE	L																					-1							
RCINCAR	L																						-1						
RBSTORE	L		B	C	C		B	C	C															-1					
RBINCAR	L		B	B	B		B	B	B																-1				
RLOAN1	E									-C	-C	-C	-C	-C	-B	-C	-C	-C	-C	-C	-C					1			
RDEFPAY1	E									-B	-B	-B	-B			-B	-B	-B	-B	-B	-B						1		
RMAXDPAY	L									B	B	B	B			B	B	B	B	B	B								
RDEFPAY2	E									-B	-B	B	-B			-B	-B	-A	-A	-A	-A							1	
RCOFSA	L									T	T	T	T			T	T	T	T	T	T								-1
ROPCAP	L																												
RYR75	G	-B	-B	B	B	-B	-B	A	B	-C	-C	-C	-C	B	-B	T	A	B	B	B	B								
RYR76	G	-B	-B	-B	-B	-A	-A	-A	-B	-C	-C	-C	-C	B	B	-T	B	-B	-B	-B	-B								
RYR77	G	C	B	B	B	C	C	C	B	C	C	C	C	B	B	B	B	B	B	B	B								
RYR78	G	-B	-B	-B	-C	-B	-B	-B	-C	-B	-B	B	B	-B	B	-B	-A	-B	-B	-B	-B								
RYR79	G	-B	-B	-C	-B	-B	-B	-C	-B	-C	-C	-B	-B	T	-B	B	-B	-A	-A	-B	-B								
RYR80	G	B	B	B	B	B	B	B	B	C	C	C	C	B	B	B	B	B	B	B	B								
RYR81	G	A	B	B	B	B	B	B	B	B	B	B	C	B	B	B	B	B	B	B	B								
RYR82	G	-B	-B	-B	-B	-B	-B	-B	-B	-B	-T	-B	-B	-B	-B	B	B	-B	-B	-B	-B								
RYR83	G	B	B	B	B	B	B	B	B	B	B	B	A	A	-A	-B	-B	B	B	A	A								
RYR84	G	-B	-B	-B	-B	-B	-A	-A	-B	-C	-B	-C	-B	-B	A	-A	-B	-A	-A	A	A								
RYR85	G	B	B	B	B	B	B	B	B	A	A	A	-A	-B	-B	-B	-B	A	A	B	B								
RYR86	G	-A	-B	-B	-B	-B	-B	-B	-B	C	C	C	C	-B	-B	-C	-B	-B	-B	-B	-B								
RMAD	L																												

Table 14. Model Tableau (Continued)

		COPECOST	CY75	CY76	CY77	CY78	CY79	CY80	CY81	CY82	CY83	CY84	CY85	CY86	RHS	CHGCOL
OBJ	N	-U														
CHGCOL	N															
RHLAND	L														C	
RLLAND	L														C	
RMAXDC	L														C	
RMAXCORN	L														C	
RMAXWS	L														C	
RMAXBS	L														C	
RTOTALAC	E															
RTOTALSA	E															
RHCC	L															
RLCC	L															
RHSC	L															
RLSC	L															
RHWSC	L															
RLWSC	L															
RHBSC	L															
RLBSC	L															
RCSTORE	L															
RCINCAR	L															
RBSTORE	L															
RBINCAR	L															
RLOAN1	E															
RDEFPAY1	E															
RMAXDPAY	L														E	
RDEFPAY2	E															
RCOFSA	L															
ROPCAP	L	-1														
RYR75	G		1													
RYR76	G			1												
RYR77	G				1											
RYR78	G					1										
RYR79	G						1									
RYR80	G							1								
RYR81	G								1							
RYR82	G									1						
RYR83	G										1					
RYR84	G											1				
RYR85	G												1			
RYR86	G													1		
RMAD	L		1	1	1	1	1	1	1	1	1	1	1	1	D	F

The individual solutions for each of the five E-A frontiers detailed in Chapter 4 were obtained by substituting the right hand side values listed in Table 16 into the proceeding model.

Table 15. Right Hand Side Values For Each E-A Frontier

Row Names	HIGH	HILOW	LOW	HLNOG[a]	HL30
RHLAND	750	375	0	375	375
RLLAND	0	375	750	375	375
RMAXDC	400	400	400	400	400
RMAXCORN	200	200	200	200	200
RMAXWS	250	250	250	250	250
RMAXBS	250	250	250	250	250
RMAXDPAY	50000	50000	50000	0	50000
RMAD	10000	10000	10000	10000	10000
CHGCOL	165000	165000	165000	210000	165000

[a]The HLNOG solution required the removal of all government program activities.

Row and Column Names

See Table 7 for the procedure used to name the columns for each of the crop activities within the model. The following column and row names are an exception to the preceding naming convention and must be explained separately. However, the first letter of each name will be a C or R denoting a column or row. The explanation of the row and column activities are as follows:

CTOTALAC	= Total acres farmed including set-aside.
CTOTALSA	= Total acres of set-aside.
CCSCOST	= Corn storage cost ($/bu).
CCINCOST	= Cost of putting corn grain in storage ($/bu).
CSSCOST	= Soybean storage cost ($/bu).
CSINCOST	= Cost of putting soybeans in storage ($/bu).
CLOAN1	= Total loan payment from government program.
CDEFPAY1	= Total primary government program deficiency payment.
CDEFPAY2	= Total final government program deficiency payment.
CCOFSA	= Cost of maintaining set-aside acreage ($/ac).
COPECOST	= Interest charge on operating capital.
CY75...CY86	= Negative deviation counters for each year 1975 to 1986.
OBJ	= Objective function.
CHGCOL	= Change column used in MPS to parametrically change the RHS.
RHLAND	= Class I soils control.
RLLAND	= Class II soils control.
RMAXDC	= Maximum acres of double cropped crops.
RMAXCORN	= Maximum acres of corn grain.
RMAXWS	= Maximum acres of wheat soybeans double cropped.
RMAXBS	= Maximum acres of barley soybeans double cropped.
RTOTALAC	= Total acres of crop land control.
RTOTALSA	= Total acres of set-aside control.
RHCC	= Acres of corn grain on Class I soils control.
RLCC	= Acres of corn grain on Class II soils control.
RHSC	= Acres of soybeans on Class I soils control.
RLSC	= Acres of soybeans on Class II soils control.
RHWSC	= Acres of wheat/soybeans on Class I soils control.
RLWSC	= Acres of wheat/soybeans on Class II soils control.
RHBSC	= Acres of barley/soybeans on Class I soils control.
RLBSC	= Acres of barley/soybeans on Class II soils control.
RCSTORE	= Corn storage control bushels.
RCINCAR	= Corn in-charge (storage) control bushels.
RBSTORE	= Soybean storage control bushels.
RBINCAR	= Soybean in-charge (storage) control bushels.
RLOAN1	= Government loan control.
RDEFPAY1	= Primary deficiency payment control.
RMAXDPAY	= Maximum primary deficiency payment.
RDEFPAY2	= Final deficiency payment control.
RCOFSA	= Set-aside cost control.
ROPCAP	= Operating capital control.
RYR75...RYR86	= Negative deviation controls.
RMAD	= Mean absolute deviation control.

Virginia's Agricultural Experiment Stations

1—Blacksburg
Virginia Tech

2—Steeles Tavern
Shenandoah Valley Research Station

3—Orange
Piedmont Research Station

4—Winchester
Winchester Fruit Research Laboratory

5—Middleburg
Virginia Forage Research Station

6—Warsaw
Eastern Virginia Research Station

7—Suffolk
Tidewater Research and Continuing Education Center

8—Blackstone
Southern Piedmont Research and Continuing Education Center

9—Critz
Reynolds Homestead Research Center

10—Glade Spring
Southwest Virginia Research Station

11—Hampton
Seafood Processing Research and Extension Unit