INFLUENCE OF MARKET DIVERSIFICATION ON FARM INCOME VARIABILITY OF SOYBEAN PRODUCERS

B. R. Eddleman and J. E. Moya-Rodriguez

Many decisions made by farm producers are based on expectations. The process of formulating and incorporating these expectations into decision making is difficult when high variability occurs in product prices, crop yields, production costs, or other factors affecting net income. Farm producers may be influenced by a number of goals in selecting combinations of crops to produce and marketing outlets for the crops. Two goals generally held to be important to farm decision makers are maximization of net income and net income stability. Given the price, yield, and cost of production variability characteristics of a farm enterprise and these two goals of farm decision makers, a fundamental problem is to determine what combination of alternative marketing actions can best satisfy the two objectives. A systematic examination of the relationship between the level of net income and net income variability for combinations of marketing alternatives would aid farmers in deciding on marketing actions to attain these goals.

The purposes of this study are to estimate the average net income and net income variability parameters for five soybean marketing alternatives and to use these estimates to evaluate combinations of farm marketing alternatives which would enable soybean producers in the Delta of Mississippi to attain the two broad goals.

Three decision periods are considered applicable to soybean marketing actions: (1) the planting season (April and May), (2) after planting but before harvest (July and August), and (3) Harvest (October and November). Forward price contracting is the marketing alternative considered for the April-May and July-August decision periods. Three marketing alternatives considered applicable to the harvest period are (1) open market sales to elevators, (2) on-farm storage for six months and open market sales to elevators during the following May and June, and (3) on-farm storage with forward price contracting during October and November for delivery the following May. On the basis of these considerations, five marketing alternatives are evaluated.

1. Forward price contract sale during April-May for harvest delivery, year t.
2. Forward price contract sale during July-August for harvest delivery, year t.
3. Open market sale at harvest during October-November, year t.
4. On-farm storage and open market sale during May-June, year t+1.
5. On-farm storage and forward price contract sale during October-November for May delivery, year t+1.

PROCEDURE

Under the assumption of perfect knowledge, the problem of allocating the firm's resources is one of equating the marginal value products of the enterprise alternatives. However, the conventional certainty assumption, made for purposes of simplification or abstraction, is not very realistic, especially if variability is known to be high. The perfect knowledge assumption can be relaxed to facilitate more realistic decision models. One approach to incorporating uncertainties into economic models of allocation is to use a mean outcome as a measure for the anticipated returns from marketing alternatives. Once the mean values for returns from the marketing alternatives are determined, the optimal combination of activities for any set of resources is subject to solution. A second general approach to farm net income determination is to consider not only mean net incomes but also some measure of the variability of farm net incomes. This method provides a basis for a systematic examination of the changes in net income variability that result from diversification among crop marketing alternatives.

The method used in this analysis includes both the mean net income and the variability of net income. The measure of the mean net income is average net income per acre during the 1973-78 period for each marketing alternative, and the measure of variability is the variance of net income per acre during that period.

B. R. Eddleman is Professor and J. E. Moya-Rodriguez is Research Assistant, Department of Agricultural Economics, Mississippi State University.

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Net income per acre is defined as the return to operator's labor, management, fixed capital assets, and general farm overhead and is calculated as gross income minus variable costs and interest on the capital outlay for variable costs. Net income per acre was chosen as the expression of economic returns in this analysis because the analytical technique used requires an assumption of no economies or diseconomies of scale. Use of net income per acre as the measure of returns allows that assumption to be reduced to constant returns to scale on the variable costs of production and storage of soybeans. The scale assumption and the use of net income per acre as the measure of economic returns for each marketing alternative allow the analysis to be carried out on a per-acre basis and thus to be generalizable to any size farm. Variability of soybean prices for each marketing alternative is one source of variation. Yields, purchased input prices, and storage costs are other sources of net income variability considered in the analysis.

The analysis is structured as a parametric quadratic program that minimizes the variance of net income per acre for a given mean net income per acre value. Parametric variation of the mean net income per acre value allows systematic examination of the changes in variance of net income per acre that result from marketing diversification. The parametric quadratic programming problem is formulated as follows.[1]

Find the $Q = (q_1, q_2, \ldots, q_n)$ vector that

$$\min Z = Q'SQ - \theta R'Q$$

subject to

$$\sum_{j=1}^{n} q_j = 1$$

$$q_j \geqslant 0, j = 1, 2, \ldots, n$$

where Z = the value of the objective function, S = the variance-covariance matrix (with entries on the contract sale and open market sale alternatives over the designated time periods), Q = a column vector of activity levels reflecting the proportion of an acre claimed by each marketing alternative, θ = a scalar to be varied parametrically from zero to unbounded, R = a column vector of net income per acre from each marketing alternative, and 1 = the proportionality constraint.

The variabilities for yields and prices of soybeans, costs of production, and storage costs are assumed to be reflected solely in objective function values for variances and covariances of net returns per acre for the soybean marketing activities [2]. The program solution provides the decision maker with knowledge about the changes in variance of net income per acre for various levels of net income per acre that result from the combinations of marketing alternatives. The decision maker must choose the combination of marketing plans that satisfies his preferences toward average net income and variance of net income per acre.

MEASUREMENT OF VARIABILITY COEFFICIENTS

Production, storage, and sale of the soybean crop provide the major sources of net returns (and risk) to soybean producers in the Delta of Mississippi. Estimates of the variances and covariances for net income per acre were derived from time-series observations of farm-level prices and county-level yields in the Mississippi Delta over a five-year period. Weekly prices during the October and November harvest period and the following May and June marketing period, adjusted for annual trend, are used for the open market selling alternatives. These prices were collected from market news reports during the 1973-78 period. The forward contract prices for April-May and July-August are closing November futures quotations at the Chicago Board of Trade for each Thursday during the contracting periods for each year. The forward contract prices for the October-November contracting period are the closing May futures quotations for the following year. These prices are adjusted for annual trend and reduced by 35 cents per bushel to reflect costs of contracting and any price margin required by elevator operators for the acceptance of contracting risk.[2] Annual yields were collected from county-level data in secondary sources [4, 6].[3] Estimates of historical variable production costs per acre were obtained from published reports [3, 4, 7] and deducted from the product of weekly prices and annual yields to provide weekly time series of estimated net income per acre.

[1]Parametric quadratic programming can be formulated in several ways. This formulation follows that of Simmons [8, p. 224] with an algorithm programmed for computation by Wolfe [5, p. 106].

[2]A survey of elevator operators in the study area did not provide enough information to use weekly contracting margins. The survey revealed that annual contracting margins generally ranged from 30 cents to 43 cents per bushel during the 1973-78 period, the most frequently occurring quote being 35 cents per bushel. The major components of contracting costs are handling, storage, and transportation charges. The most important factor influencing the margin spread appeared to be elevator location in proximity to the Mississippi River where river barge transport is less costly than shipment by rail or truck. One reviewer pointed out that use of the 35-cent reduction on all contracts may have unduly penalized the October-November contracting alternative because elevator operators would be expected to offer a forward price for May delivery at near par. A following discussion gives other reasons for not considering this alternative as a feasible marketing strategy.

[3]Farm-level yields show greater variability than county-level yields. However, no consistent series of farm-level yield observations were available for the 1973-77 period.

On-farm storage costs include both investment and monthly storage operating expenses as variable costs. A 1976 study [1] provided estimates of ownership and monthly operating cost for a 15,000-bushel capacity facility. In the absence of historical annual storage cost information, these costs were adjusted by the index of prices paid by farmers to derive annual estimates of on-farm storage costs during the period. The resulting storage cost series probably diverges considerably from historical storage cost variability. Monthly storage costs per acre for each year reflect variations in both resource prices and annual crop yields. Mean values for yields, variable production costs per acre, and six-month storage costs per acre for each of the years are given in Table 1.

TABLE 1. YIELD, VARIABLE PRODUCTION COSTS, AND STORAGE COSTS PER ACRE FOR SOYBEANS, DELTA OF MISSISSIPPI, 1973-77

Year	Yield per acre	Variable production costs per acre	Six month storage costs per acre
	(bushels)	(dollars)	(dollars)
1973	21.8	29.57	7.83
1974	18.8	33.62	7.63
1975	22.2	36.86	9.88
1976	21.3	39.09	10.07
1977	20.2	41.10	10.02

Estimates of net income variability derived from these time series reflect jointly the effects of annual yield and resource price variation, weekly soybean price variation, and other random factors. The estimated mean net income per acre from each marketing alternative and the variance-covariance matrix are given in Table 2.

The statistical properties that are necessary for any analysis depend on how the estimates are to be used. The mean and variance-covariance parameters estimated from the weekly and annual time series data are not used in this analysis to establish confidence limits or to test hypotheses. Therefore, the normality of the distributions from which they are derived is not of particular importance if the distributions are not skewed. The distributions must not be skewed because these estimates are to be used as descriptive parameters. Skewedness was tested as the third moment about the mean for the series of the net returns per acre for each marketing alternative.[4] Tests showed that the samples were not significantly skewed at the 99 percent level of significance for four of the five marketing alternatives considered. The data for the alternative of on-farm storage and forward price contract sale during October-November for delivery the following May was found to be skewed at the 95 percent level of significance. However, this alternative enters the optimal solution of the quadratic program only at the two lowest levels of net income per acre and variance of net income per acre. Over the major range of the programming solutions the other four marketing alternatives are dominant. Thus, the statistical properties of the sample distributions are considered sufficient to permit the parameter estimates to be used for a descriptive analysis.

RESULTS

The optimal marketing plans are derived for all combinations of the forward contracting, open market, and storage alternatives. The percentages of the crop acreage marketed with each alternative and the values of the objective function components of selected optimal solutions for the model are shown in Table 3. The final solution represents the net income-maximizing marketing alternative.

The optimal plans at the lower levels of net income per acre show the largest amount of market diversification; the forward price contracting alternatives at planting time (April-May) and before harvest (July-August)

TABLE 2. MEAN NET INCOME PER ACRE AND VARIANCE-COVARIANCE MATRIX FOR SOYBEAN MARKETING ALTERNATIVES, DELTA OF MISSISSIPPI

	Contract sale Apr.-May (CS, A-M)	Contract sale July-Aug. (CS, J-A)	Open market Oct.-Nov. (OM, O-N)	Storage and open market May-June (SOM, M-J)	Storage and contract sale Oct.-Nov. (SCS, O-N)
	dollars				
Mean	73.59	93.87	85.74	86.65	80.70
Variance-covariance					
CS, A-M	250.30	-197.93	-161.42	21.96	-185.73
CS, J-A	-197.93	504.13	134.13	6.58	159.41
OM, O-N	-161.42	134.13	369.23	-110.67	387.63
SOM, M-J	21.96	6.58	-110.67	813.23	-173.43
SCS, O-N	-185.73	159.41	387.63	-173.43	428.47

[4]Skewedness was tested by the following formula.

$$g = \frac{\sum_{i=1}^{n} [(X_i - \bar{X})/s]^3}{n}$$

TABLE 3. RESULTS OF QUADRATIC PROGRAMMING OF ALTERNATIVE SOYBEAN MARKETING ACTIONS

	Proportion of crop acreage marketed through						
Solution	Contract sale Apr.-May	Contract sale July-Aug.	Open market Oct.-Nov.	Store and open market May-June	Store and contract sale Oct.-Nov.	Mean net income per acre	Variance of net income per acre
	(Percent)					(dollars)	(dollars)
1	46.49	18.96	4.92	8.70	20.93	80.66	37.46
2	45.29	20.70	22.23	7.88	3.90	81.79	39.19
3	43.17	22.56	26.01	8.26		82.40	40.83
4	41.08	24.22	25.81	8.89		82.80	42.80
5	39.00	25.88	25.60	9.52		83.19	45.55
6	36.91	27.54	25.39	10.16		83.59	49.10
7	26.49	35.84	24.35	13.32		85.55	78.64
8	16.07	44.13	23.31	16.49		87.52	127.86
9	5.65	52.43	22.27	19.65		89.49	196.79
10		60.42	18.94	20.64		90.84	255.62
11		68.05	12.91	19.04		91.44	288.90
12		75.71	6.84	17.45		92.05	328.45
13		83.36	0.79	15.85		92.66	374.00
14		100.00				93.87	504.13

dominate the efficient solution. However, for higher levels of net income per acre (beyond solution 1), open market sales at harvest and storage with open market sales in the following May and June become more important (up to 42 percent of the crop is marketed through these two alternatives) until solution 9 is reached. The proportion of acreage contracted during the crop production year (April-May and July-August) remains relatively high in all optimal solutions, but declines somewhat for the intermediate plans (solutions 7 through 10). As the net income-maximizing solution is approached, forward price contracting during July and August dominates until all of the crop is contracted during this period.[5]

The storage alternatives enter the optimal solutions at relatively low proportions of the crop acreage. Decision makers with high aversion to risk could consider storing about 30 percent of the crop (solution 1 of Table 3). These results are consistent with those of previous studies that show a relatively low proportion of the region's soybean crop is stored on farms [1].

IMPLICATIONS

The results indicate that the optimal marketing plans are dominated by forward price contracting. Even decision makers with little or no aversion to risk would forward price contract because net income possibilities appear less favorable with open market sales on the basis of past relationships. Whether or not the covariance relationships during the 1973-78 period are valid predictions of future relationships is not addressed in this study. The variance and covariance estimates are subject to wide variations through time. The optimal solutions are thus very sensitive to the covariance estimates. Researchers, extension workers, and other advising producers need to provide information on the circumstances under which it is profitable to use forward price contracting as a marketing option.

It is apparent from Table 3 that the sensitivity of the net income level and variability of net income for different proportions of the marketing alternatives is fairly low over the lower range of the net income and variance of net income values. For example, when the proportions of the marketing alternatives for solution 1 are compared with those of solution 6, net income variance increases about $12 per acre and mean net income per acre increases from $80.66 to $83.59. Thus, over the lower range of these values the relationship between net income per acre and net income variability might be considered operationally "supplementary." In effect, this means that the proportion of the total crop allocated to the various marketing alternatives can be varied considerably at a relatively small sacrifice in net income stability. At higher levels of net income (beyond solution 6), the relationship of net income maximization to net income stability becomes "competitive." That is, higher levels of net income per acre are attainable only by incurring considerably higher levels of net income variability.

The analysis is specific to the alternatives faced by soybean producers in the Delta of Mississippi. However, the results should be applicable to decisions on soybean marketing alternatives throughout the Mid-South region.

REFERENCES

[1] Adeyemo, Remi, et al. "On Farm Soybean Storage: Cost and Potential Returns", Mississippi Agricultural and Forestry Experiment Station Bulletin 863, December 1977.

[2] Barry, Peter J. and David R. Willmann, "A Risk-Programming Analysis of Forward Contracting with Credit Constraints", *American Journal of Agricultural Economics,* Volume 58, 1976, pp. 62-70.

[5]During this period pod set and pod filling occur. Thus, the decision maker acquires new information on expected crop yield in relation to the April-May contracting period. This reduces yield risk in relation to earlier contracting periods within the producing season. This reduction in yield risk was not incorporated into the programming model.

[3] Cooke, Fred T., Jr., et al. *Crop Budgets and Planning Data for Major Farm Enterprises in the Mississippi and Louisiana Delta, 1975,* Mississippi Agricultural and Forestry Experiment Station DAE Report No. 484, June 1975.

[4] Eddleman, B. R. and D. W. Parvin, Jr. "Crop Budgets, Cost of Production, Investment, Yield and Price Variability for Soybeans," AEC Staff Paper No. 25, Department of Agricultural Economics, Mississippi State University, May 1977.

[5] Kuester, J. L. and J. H. Mize. *Optimization Techniques With Fortran.* New York: McGraw-Hill Book Company, 1973.

[6] Mississippi Crop and Livestock Reporting Service. *Mississippi Agricultural Statistics, 1973-76,* Supplement No. 11, USDA Statistical Reporting Service, November 1977.

[7] Parvin, David W., Jr. et al. *Cost of Production Estimates for Major Crops, Mississippi Delta, 1976,* Mississippi Agricultural and Forestry Experiment Station Bulletin 843, February 1976.

[8] Simmons, Donald M. *Nonlinear Programming for Operations Research.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1975.