RISK TRANSFER AND COMMODITY PROGRAMS

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The transfer of farm price risk from farmers to the public sector has historically been a major justification of U.S. agricultural commodity policy. Under earlier program forms of price supports above market levels, price stability goals were achieved jointly with the other goal of farm income support (Hathaway). With the advent of program forms that separated income support from price supports, reemergence of the income stability problem became a possibility. With the increasing importance of agricultural exports and especially their fluctuations, such a stability problem became a reality in the 1970s (Robinson). During this same period, a new public commodity program form had also evolved for wheat, feed grains, and cotton. These voluntary programs are characterized by a double-pricing system which includes a guaranteed target price and a loan rate (Spitze; Gardner). The effectiveness of the current farm program, authorized under the Food and Agriculture Act of 1977, in reducing income stability of farmers has been given limited empirical consideration. One exception is Kramer and Pope, who concluded that participation will reduce risk for California producers. The limited empirical analysis is particularly serious since policy analysts disagree on the program's risk transfer potential. In the recent USDA report on structural issues, Penn, Harrington, and Johnson et al. all asserted (or assumed) that commodity programs reduce risks to farmers. In an earlier policy analysis of the 1977 Act, Spitze concluded that the 1977 Act would contribute to stability of farm incomes. However, Gardner concluded that the effectiveness of the program in reducing income variability is questionable because of its market orientation.

The purpose of this paper is to present a methodology to evaluate the impact of participation in the 1977 Act on risk transfer for a representative farm firm in South Central Georgia. Important policy provisions of the Act, including loan rate, deficiency payments, set aside, voluntary diversion, and disaster payments are incorporated into a quadratic risk programming model which is used in an E-V analysis of risk transfer. Since a major methodological problem of the analysis was the estimation of a variance-covariance matrix for commodities covered under the Act, this paper focuses on this aspect of the analysis.

Methodological Background

The standard presumption that an important goal of agricultural commodity programs is increased stability of farm income implies the assumption that farmers are risk averse. The theoretical foundation of this proposition is that farmers maximize expected utility. Recently, a number of studies has supported the use of the expected utility

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objective rather than the profit maximization objective in analysis of farm behavior. This support includes firm studies (Officer & Halter; Lin, Dean, & Moore), aggregate econometric models (Just; Ryan; Lin), and aggregate mathematical programming models (Niewoudt, Bullock & Mathia; Adams, King & Johnston). It must be noted, however, that Brink and McCarl found that the profit maximization hypothesis was adequate for a large number of Indiana farmers.

The method used in this paper to implement the expected utility hypothesis is quadratic programming. Following Markowitz and Freund, this methodology analyzes firm resource allocation problems in relation to trade-offs between expected net income and variance of net income. Quadratic programming does have theoretical and methodological limitations. On a theoretical level, the consistency of a mean-variance approach with the expected utility hypothesis requires an assumption of either a normal distribution of incomes or that the decision maker has a quadratic utility function, either of which has been considered restrictive (Pratt; Arrow; Robison & Barry). However, Levy and Markowitz recently demonstrated that the mean-variance approach closely approximates a wide range of situations in which these assumptions do not hold and thereby provides a renewed justification for the use of the mean-variance approach. Kramer and Pope in their recent study utilized a stochastic dominance model which involves less limiting assumptions. On the other hand, their method requires an *a priori* specification of activity levels and therefore precludes analysis of changes in diversification possibilities resulting from public programs. With all of these considerations, quadratic programming methodology appeared superior for the problem being considered in this study.

Another problem in utilizing the quadratic programming approach involves the estimation of appropriate levels of the risk aversion coefficient for micro applications. As Young *et al.* and Musser have recently noted, the methodology to estimate these coefficients has questionable validity. To avoid these difficulties, this study estimated expected income-variance (E-V) frontiers rather than unique expected utility maximizing solutions. Since these frontiers are derived from optimal parametric solutions (Sharpe), the frontiers are consistent with a wide range of risk aversion coefficients and thereby allow representation of a large number of situations (Markowitz; Scott & Baker; Hazell). Given the range of risk aversion coefficients found in recent studies in the U.S. farmers (Brink & McCarl; Halter & Mason), this approach allows more general analysis of the impact of farm programs on resource allocations at the firm level.

Empirical Model[1]

The basic methodological approach of this study was to derive E-V frontiers for a representative farm firm under two situations: (1) participation in the 1977 Act for all commodities and (2) nonparticipation in the 1977 Act for all commodities. The cross-compliance provisions

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[1]For more information on the assumptions and source of data for the model, see Stamoulis.

in the Act, limit the farmer to these two situations. In order to avoid solutions which include both participating and nonparticipating activities, separate models were run for the two situations. It must be stressed that the nonparticipating situation was designed to reflect an open market situation given the existence of voluntary programs under the 1977 Act and participation in the program by some farm producers. In other words, comparison of the results of the two situations will provide information on incentives for the farm to participate in programs under the 1977 Act.

The basic farm situation reflected a representative farm firm in South Central Georgia. The firm owned 500 acres of land; however, the sole concern in this analysis was the 182.6 acres of cropland. The farm also had a 60.9 acre peanut allotment and a 21.0 acre tobacco allotment. Crop activities included corn, cotton, peanuts, tobacco, soybeans, second crop soybeans, wheat, oats, and grain sorghum. Cotton and peanuts were both subject to agronomic restrictions. The farm firm was endowed with 2500 hours of operator labor and activities were included to allow hiring seasonal labor subject to a managerial restraint. The budgets for the crops reflected above average management and 1978 prices. The constraints, constraint matrix and linear objective function for the nonparticipating farm reflected standard methodology in farm organization studies. The variance-covariance matrix was estimated with historical data on gross revenues for crop enterprises for 1958-1977. These data were detrended with the variance difference method under the assumption that only the random component of the data reflected risk (Tintner; Carter & Dean).

In the participating situation, the basic model was altered to reflect the 1978 commodity programs. The objective function was adjusted to reflect charges in net income for program participants; the only payments in 1978 were deficiency payments for grain sorghum and wheat equal to $20.35 and $12.25 per acre, respectively. Voluntary diversion activities were included for cotton, corn, and grain sorghum which were constrained to be 10 percent of the plant acreage of the respective crop. A normal crop acreage restriction of 124.96 acres was included, which represented the average land area devoted to the crops covered by the provision in this area. Crops covered by this provision included all crops except tobacco and peanuts; all of these crops and the diversion activities had an entry in this restriction. The set aside provision was incorporated in the model by altering the entries for appropriate activities in the cropland and normal crop acreage restrictions to 1.1 for corn and grain sorghum and 1.2 for wheat; cotton did not have a set aside in 1978. Details of the constraint matrix for this situation are presented in Table 1. Estimation of the variance-covariance matrix for this situation was a major innovation of this study since no consistent data for target prices, loan rates, deficiency payments, disaster payments or normal yields existed for years prior to 1977. The methods used to synthesize such a time series are discussed in the next section.

Time Series of Program Benefits

Before methods of estimating program benefits are considered, the definition of participating gross revenues used in this study needs to be considered. This definition is:

$$(1) \qquad R_{it} = P_{it} Y_{it} + A_t DP_{it} Y'_{it} + D_{it} Y''_{it}$$

where R_{it} = gross revenue from crop i in year t, P_{it} = higher of market price or loan rate for crop i in year t, Y_{it} = actual yield of crop i in year t, A_t is the allocation factor for year t, DP_{it} is the deficiency payment for crop i in year t, Y'_{it} is the normal crop yield for crop i in year t, D_{it} is the per unit disaster payment rate for crop i in year t, and Y''_{it} is the yield eligible for disaster payment in year t. All definitions are on a per acre basis. DP_{it} is defined as:

$$(2) \qquad DP_{it} = P'_{it} - P_{it} \quad \text{if } P'_{it} - P_{it} > 0$$

$$= 0 \quad \text{if } P'_{it} - P_{it} \leq 0$$

where P'_{it} = the target price for crop i in year t.

Y''_{it} is defined as:

$$(3) \qquad Y''_{it} = d_{it}Y'_{it} - Y_{it} \quad \text{if } d_{it}Y'_{it} - Y_{it} > 0$$

$$= 0 \quad \text{if } d_{it}Y'_{it} - Y_{it} \leq 0$$

where d_{it} = portion of Y'_{it} covered by disaster payments.

This definition does not include all potential program benefits available in 1978. Data on prevented plantings could not be synthesized so that disaster payments are not included for this situation. Consideration of the potential benefits for participation in storage and farmer reserve programs were also beyond the scope of this study. Thus, equation (1) is a conservative estimate of gross revenue under the 1977 Act.

The specification of A_t and d_{it} were fairly straightforward. In 1978, d_{it} equaled .6 for wheat and feed grains and .75 for cotton so these figures were used in this analysis. A_t can vary from .8 to 1.0 with the minimum level set annually by the Secretary of Agriculture. A farm can have the maximum amount if acreages are reduced (or not increased in some years) from that of the previous year. Due to the complexity and administrative discretion involved with A_t, the minimum statutory value of .8 was used in this analysis.

Methods of deriving Y'_{it} for individual farms are specified in the Act. In this study, historical data were used in these statutory formulas. For wheat and feed grains, normal yields in year t are established as the higher of three moving averages: (1) an adjusted t-4 to t-2 (three-year) average, (2) t-6 to t-2 (five-year) average, and (3) a t-11 to t-2 (ten-year) average. The adjusting three-year average is calculated as follows:

(1) Drop the lowest yield during crop years t-6 to t-2, and average the remaining four.
(2) If actual yield in t-4 to t-2 is less than 95 percent of the average from (1), substitute the average for the actual.
(3) Compute the average of the series created in (2).

In almost all calculations, the adjusted three-year moving average served as the basis for the normal yield. For cotton, Y'_{it} was established as the higher of an adjusted three-year average or 90 percent of Y'_{it-1}. The adjusted average was calculated as for feed grains and wheat except the base period was t-3 to t-1 (Stamoulis).

The time series for loan rate, target price, and disaster payment rate had to be calculated in a more arbitrary fashion than normal yields. For these series, the assumption was made that the provisions of the 1977 Act which mandated that target prices be escalated to reflect increases in variable and fixed costs (excluding land) reflected the current political judgment about relationships between payment levels and cost of production. A time series on cost of production is not available so that a proxy was necessary. Miller and Sharples recently noted three objective alternatives to cost of production--parity prices, index of prices paid adjusted for yield changes, and output price trends. The method used in this analysis was an adaptation of the second--the 1978 target price, loan rate, and disaster payment rate were multiplied by the ratio of the index of prices paid by farmers for production items in earlier years to the same ratio for 1978. Estimated target prices are included in Table 2 for illustration of the results.

The program time series for corn, wheat, grain sorghum, and cotton were estimated with equation (1). Oats and soybeans were only eligible for price support loans so only the first term of equation (1) was used for the time series for these crops. Peanuts and tobacco have mandatory programs so the program time series was the same as the nonparticipating series.

Results

As a preliminary to presenting the E-V analysis for the two situations, some consideration of the estimated program payments is interesting. The loan rate was almost always lower than the market price; the only exception was cotton in 1966, 1969, and 1970. However, the differences were small, always being less than three cents per pound (Stamoulis). Deficiency payments were made in more years and for more crops. As shown in Table 3, the target price was higher than the loan rate in five years for wheat, four years for cotton, and two years for grain sorghum. The existence of no effective loan rates or deficiency payments before 1966 reflects a bias in the analysis. Prior to this period, the market prices were influenced by higher price supports than under subsequent programs. This bias also contributes to the underestimation of program benefits.

The time periods in which disaster payments for low yields would have been paid are indicated in Table 4. Payments were estimated for wheat, corn, and cotton. The same situation of no payments before the second half of the 1960s are apparent; however, it is not clear what factors contributed to this result. The quantities on which disaster payments were paid are small, especially for wheat and corn. However, relative to actual yields, corn had the highest value in 1977.

Since some program benefits were paid to all four crops fully covered by the 1977 Act, one would expect the variance of the program time series to be less. The variances of the detrended program series fulfilled this expectation. As shown in Table 5, the variances of the program crops are all less than their nonprogram counterparts. The reduction in variance for wheat and grain sorghum was slight; however, the reduction for corn and cotton was quite large. Another result of this analysis is that the covariances of program crops with crops not covered by the Act were significantly altered. Some of the reductions in covariance were quite dramatic. For example, the covariance between peanuts and cotton is -232 and between peanuts and program cotton is -653; the covariance between corn and soybeans is 300 and between program corn and soybeans is 56. The shift in covariances suggests that government programs can result in risk reduction even for crops not included in the Act if they are combined with covered crops.

The results of the E-V analysis are consistent with the variance-covariance matrix. As shown in Figure 1, the E-V frontier for the participating situation dominates the frontier for the nonparticipating situation at all levels of expected incomes. The results partly reflect the crops included in the optimum organizations: peanuts, tobacco, cotton, soybeans, oats, and voluntary cotton diversion. The only covered crop in these solutions is cotton, for which no set aside existed in 1978. To test the significance of no set aside, another solution was run in which a 10 percent set aside was required for cotton. These results were similar except a higher maximum profit could be achieved in the nonprogram situation (Stamoulis).

Besides the overall effects on variance of income, the government program did result in significant alterations in crop acreages. The most apparent result was the increase in cotton acreage in the lower part of the E-V frontier. For example, the cotton activity was in the solution at 25 acres at expected incomes of about $35,500 and at 61 acres at expected incomes of about $59,500 in the participation situation while the levels at these expected income levels were 3 acres and 17 acres, respectively, in the nonparticipating situations. Smaller levels of tobacco, soybeans, and oats provided the land for the cotton in the participating solution. Thus, participation in the 1977 Act can result in significant diversification effects.

Conclusions

This study has provided empirical support for the widely held view that government agricultural commodity programs transfer risks from the agricultural sector. For the representative farm situation in this analysis, participation in government programs would be optimal except for risk neutral producers. As in all micro studies, generalization of these results to other situations is hazardous. One aspect of this situation which is somewhat unique is the strength of cotton in this model. This study did support earlier observations that the cotton program is more favorable than for other commodities (Spitze; Gardner). In areas where wheat and feed grains are more important crops, the risk transfer would probably be less. However, risk transfer potential would still exist, especially when set asides are zero or small.

The conclusion is further supported by the overall conservative bias in the methodology to estimate the time series for gross income in the participating situation. Several aspects of the procedure would result in underestimation of the benefits of participation. First, payments for prevented plantings and benefits of the government storage program were not considered in the analysis. Assuming the minimum value of the allocation factor also reduced the level of deficiency payments. Finally, market prices in the early part of the time series reflected higher price supports than under the 1977 Act which contributed to no program benefits for this period. The methodology did include one aspect which could tend to overestimate the program benefits--the factors used to index the payment rates did not reflect changes in productivity. However, this latter factor appeared to be overshadowed by the underestimation particularly in the first part of the time series. The proposition that the methodology understates the program benefits suggests that even more risk reduction from participation is likely than was found in this analysis.

It must be stressed that this paper did not consider all the risk transfer which could be associated with agricultural commodity programs. This analysis only considered the issue of risk transfer available from participation given the existence of commodity programs. Another issue concerns the impact of the existence of voluntary commodity programs on the risk facing all farmers, including those who do not participate. This issue relates to the stabilizing (or destabilizing) effects of commodity programs. The methodology utilized in this paper would have to be extended to analyze this perhaps even more fundamental question. Synthesizing a time series of free market prices would require more sophisticated techniques than utilized in this paper. An econometric model(s) could perhaps be used to estimate predicted historical free market prices; however, some random process would have to be used in conjunction with these estimates to reflect shocks affecting the time series of prices. Such an analysis, if possible, would provide a definitive treatment of existing suppositions concerning risk transfer of commodity programs.

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Table 1. Input-Output Matrix and Constraint Vector for Participating Farm Situation

	Program Corn	Program Cotton	Peanuts	Tobacco	Program Wheat	Soybeans	Oats	2nd. Crop Soybeans	Program Grain Sorghum	Corn Diversion	Grain Sorghum Diversion	Hired Labor 1	2	3	4	5	Cotton Diversion	Right Hand Side
Crop land	1.1		1	1	1.2	1	1		1.1	.1	.1						.1	≤ 182.6 acres
Normal Crop Acreage	1.1				1.2	1	1		1.0	.1	.1						.1	≤ 124.6 acres
Labor January-February	.56	.56	.56					.56	.56			-.9						≤ 440 hrs.
March-April	1.67			25					1.67				-.9					≤ 435 hrs.
May-June	.24	2.00	2.18	25	1.58	1.67	1.58	2.23	.24					-.9				≤ 390 hrs.
July-August			.24	75		.24		.24							-.9			≤ 435 hrs.
September-October	1.72	1.00	4.22		2.22	1.58	2.22	1.58	1.58							-.9		≤ 385 hrs.
Double Crop Row					-1.00		-1.00	1.00										≤ 0
Tobacco Allotment				1.00														≤ 21.0 acres
Peanuts Agronomic Restriction			1.00															≤ 60.9 acres
Cotton Agronomic Restriction		1.00																≤ 91.3 acres
Peanut Cotton Restriction		1.00	1.00															≤ 121.80 acres
Grain Sorghum Diversion Row									-1		1							≤ 0
Corn Diversion Row		-1								+1								≤ 0
Cotton Diversion Row			-1														1	≤ 0

Table 2. Calculated Target Price Time Series, Adjusted with the Index of Prices Paid by Farmers for Production Items (1958-1978)

Year	Index	Wheat	Grain Sorghum	Corn	Cotton
		dollars			
1958	92	1.302	.958	.882	.218
1959	93	1.316	.968	.891	.221
1960	92	1.302	.958	.958	.218
1961	93	1.316	.968	.891	.221
1962	94	1.330	.978	.901	.223
1963	95	1.345	.989	.911	.226
1964	94	1.330	.978	.901	.223
1965	96	1.359	.999	.920	.228
1966	100	1.415	1.041	.958	.237
1967	100	1.415	1.041	.958	.237
1968	100	1.415	1.041	.958	.237
1969	104	1.472	1.083	.997	.247
1970	108	1.528	1.124	1.036	.256
1971	113	1.590	1.176	1.240	.268
1972	121	1.712	1.359	1.160	.287
1973	146	2.066	1.520	1.400	.347
1974	166	2.350	1.728	1.592	.394
1975	182	2.576	1.895	1.745	.432
1976	193	2.732	2.009	1.851	.458
1977	200	2.831	2.082	1.918	.475
1978	219	3.400	2.280	2.100	.520

Table 3. Estimated Deficiency Payment Rate for Years with Payments (1958-77)

Crop Year	Target Price	Market Price (or Loan Rate)	80% Deficiency Payment Rate
	($/bu.)		
Wheat			
1968	1.415	1.21	.164
1969	1.472	1.27	.162
1970	1.528	1.29	.190
1971	1.590	1.46	.104
1972	1.712	1.36	.282
	($/lb.)		
Cotton			
1966	.237	.210	.014
1970	.256	.240	.013
1971	.268	.242	.021
1972	.287	.249	.030
	($/bu.)		
Grain Sorghum			
1971	1.176	.84	.269
1972	1.36	1.20	.128

Table 4. Estimated Quantities Eligible for Disaster Payments (1958-77)

Year	Actual Yield	Normal Yield	Quantity for Which Payments Were Made
	------------------bu./acre------------------		
Wheat			
1972	18.12	32.52	1.39
1974	18.36	34.51	2.35
Corn			
1969	33.22	53.39	1.19
1977	23.90	55.45	9.37
	------------------lbs./acre------------------		
Cotton			
1968	273.84	386.13	15.75
1969	226.21	347.67	34.54
1970	222.42	317.30	15.55

Table 5. Variance Covariance Matrix for Gross Incomes Per Acre of Crop, 1958-1977

	Corn	Cotton	Peanuts	Tobacco	Wheat	Soybeans	Oats	Grain Sorghum	Program Corn	Program Cotton	Program Wheat	Prog. Grain Sorghum
Corn	217	17	207	746	363	300	39	108	207	11	40	107
Cotton		4436	-232	-3378	704	258	148	1308	22	4310	703	1284
Peanuts			863	5354	-106	-155	-111	29	219	-653	-100	25
Tobacco				37201	-736	973	-816	142	848	-3407	-646	110
Wheat					190	83	51	242	376	704	190	244
Soybeans						462	66	161	56	248	95	172
Oats							44	27	00	149	50	30
Grain Sorghum								596	104	1290	249	581
Program Corn									44	4	932	104
Program Cotton										1595	631	241
Program Wheat											190	250
Program Grain Sorghum												572

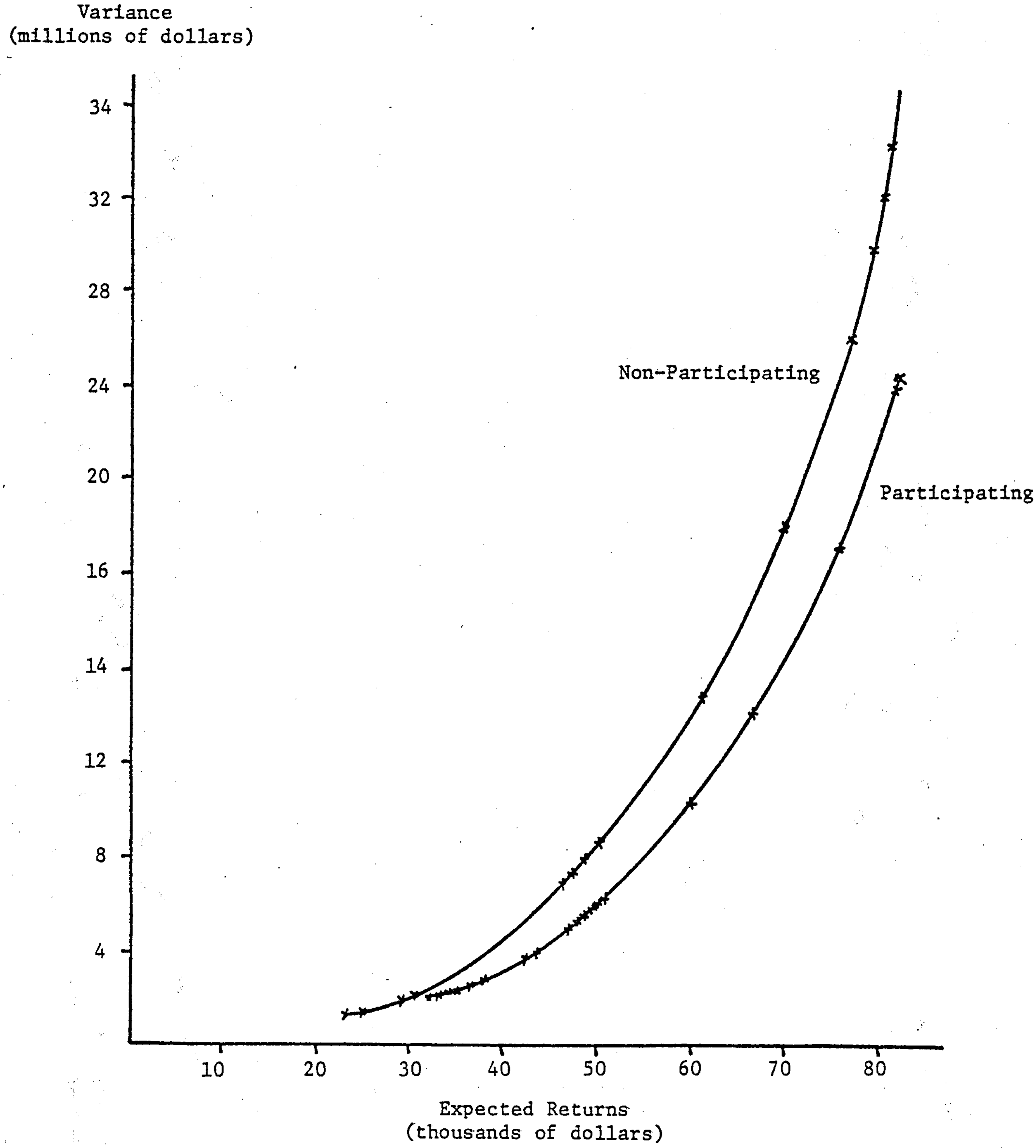

Figure 1. E-V Frontiers for a Participating and a Non-Participating Farm