J. OF THE NORTHEASTERN AGR. ECON. COUNCIL VOL. XII, NO. 2, FALL, 1983

RISK AND RETURN IN FIELD CROPS AS COMPARED TO PROCESSING VEGETABLES ON THE DELMARVA PENINSULA

Karen Zuckerkandel and G. Joachim Elterich

INTRODUCTION

The Delmarva Peninsula includes some rich farmland which is suitable for both vegetable and field crop production. Almost 80 percent of the acreage on the Delmarva Peninsula today is planted in field corn and soybeans. In the past fifteen years, the acreage of vegetables contracted to processing companies in the area has declined by about 50 percent (Smith, 1975 and 1981). This is due to four major factors: Delmarva's yield disadvantage relative to other regions; the disappearance of numerous, antiquated small canneries in the region; an unstable labor supply at existing wages; and growers' perceived higher yield risk for vegetables.

This study deals with the last two factors by analyzing production methods, income and risk and by assessing labor requirements in farm organizations for both processing vegetables and field crops. Intelligence from extension personnel cite both risk and income playing a major role in the decision to include processing vegetables as part of a total farm organization. Delmarva growers perceive vegetables--perhaps rightfully so--as more labor intensive, higher return, but also higher risk crop alternatives than field corn or soybeans.

Without delving into subjective risk assessments, risk can be defined as an uncertain situation in which a number of outcomes have given probabilities (Knight, 1921). Risk includes variation in crop prices and costs, labor supply (human element), crop yields, institutions (example, governmental actions) and technologies. This study treats yield risk and its interaction with activity returns as the crucial factor in total farm planning. Furthermore, resource requirements for the entire farm organization and the covariance among all crop activities, play equally important roles in the decision making process.

The objective of this study is to test two hypotheses:

(1) Do vegetables for processing present greater income risk when included in profit maximizing farm organizations?

(2) Do vegetables exhaust the supply of year-round and seasonal labor available to growers? If including vegetables for processing in a farm organization results in greater returns to resources with marginally higher income variability, then Delmarva growers who plant acreage exclusively in soybeans and field corn are sacrificing income and underutilizing their potentially available labor. By including processing vegetables in their farm organizations (which are demanding in managerial skills), farmers may obtain much higher incomes while also facing larger income variations.

DATA AND METHODOLOGY

A traditional linear programming model is used to obtain a profit maximizing farm organization without risk. An expectations model to ascertain the risk level for individual crops is incorporated into a second parametric linear programming model to determine risk for different income levels. The following assumptions were made:

(1) Resource endowments were defined for a representative 600 acre farm on Sassafras Fallsington sandy loam which constitutes the average size processing vegetable farm on the Delmarva Peninsula. The farmer could borrow up to $200,000 at 16 percent interest in operating capital for the growing season. Labor would be supplied by the farm operator, one year-round hired worker with a salary of $17,000 per year, and family members helping out on a part-time basis. For peak periods, the farmer could hire seasonal workers at a wage of $3.50 per hour. Two-thirds of the 600 acre farm was under irrigation, a stipulation for effectuating contracts with processors.

(2) Options among farm organizations were based on two field crops--field corn and soybeans--and five processing vegetables--peas, lima beans, sweet corn, snap beans and cucumbers.[1] Reflecting widespread practices, the grower's choice of crop activities included double-cropped combinations with a choice of self or custom harvest. Harvesting differences were accounted for in the varying crop gross margins (crop yields per acre times price net of variable costs). Tax considerations, since individually varying, were disregarded. Investment costs for harvesting machinery were considered fixed costs for each farm organization.

(3) Enterprise budgets were developed for all activities representing a crop or double crop. The budgets included operating costs and machinery and labor requirements for all crops. Eight years of yield and price data used for the expectations model based on actual returns were obtained from the interviews with growers and the USDA Annual Summaries for Processing Vegetables and Field Crops (USDA, 1973-80). Since it was determined beforehand that only yield and price

---

The authors are former Graduate Assistant and Professor in the Department of Agricultural and Food Economics, University of Delaware, Newark, Delaware 19711.

The authors appreciate the critical reviews of Drs. R. C. Smith and H. E. Brautigam, Department of Agricultural and Food Economics, University of Delaware, and anonymous referees to earlier versions of the manuscript.

[1] Tomatoes and green peppers were also initially considered, but due to very high cost of specialized equipment and very high risk respectively, did not enter with appreciable acreages into any of the plans.

variations (income risk) were crucial they were studied.[2] Somewhat surprising, but due to widespread forward contracting, product prices remained relatively stable and costs stayed within reasonable limits over the study's time period.

Before addressing the methods employed, aspects of individual crop variations and covariance between crop combinations will be discussed. An expectations model was developed to explore the relationship between the expected (8 year mean) gross margin (profitability) and the standard deviation (risk) from this expected value for each crop. This pure value--the coefficient of variation--is defined as the standard deviation of the mean gross margin, divided by the mean gross margin, and indicates a comparable measure (independent of scale of measurement) of dispersion of profitability for crops combined. A correlation analysis was also performed to determine the potential for diversification of pairs of crops or crop sequences.

The model 600 acre farm provided the framework for the two linear programming models used in farm planning. The first linear programming model determined an optimum farm organization for the representative farm disregarding risk. Hazell's Minimum of Total Absolute Deviations MOTAD (Hazell, 1971; Brink and McCarl, 1978; Schurle and Erven, 1979; Persaud and Mapp, 1979), approach was used in the second model.[3]

This latter model considers (in addition to resource constraints and activity coefficients employed in the first LP model) the following important information relative to income risk:

(1) The expected negative gross margin deviations for each year and activity (as opposed to the average gross margin in the first model).

(2) The objective function is changed from the first model so as to minimize the negative deviations for the entire farm organization (farm business risk) for different income levels. Thus, the "risk" in this study considers the income variability based on yield and price variability of individual crops as well as combinations of crops. This estimated mean absolute deviation is an efficient approximation of the standard deviation used as a measure of risk in quadratic programming Expected Income Variance (E-V) analysis (Thompson and Hazell, p. 58).[3]

A farm plan derived from the MOTAD programming is represented by its gross margin and standard deviation as a point on an efficient minimum mean absolute deviation frontier (E-A). This efficiency frontier delineates all feasible combinations of expected return and risk for a specific set of resource endowments and price-cost relationships.

Data for the various resource requirements were drawn from several sources. Questionnaires were administered to twelve area vegetable growers in 1980. Information was obtained on production practices, yields and prices received for crops grown during the past eight years.[4] Additional information from local farm suppliers and area extension personnel was also obtained.

RESULTS

The results will be reported in three separate sections. The first will briefly discuss the variation in the gross margin of individual crops over time, as represented by standard deviations and coefficients of variations (a composite measure of income and risk of individual crops), and the covariance between crops as represented by the correlation coefficients (income risk of pairs of crops). Then, a series of risk minimizing optimal organizations for given income levels (reflecting average expected yields) will be analyzed. Finally, the farm organizations on one additional frontier, based on higher yields achieved by superior vegetable growers, will be compared with respect to the business risk and income of managers with average skills.

Standard deviations of gross margins of individual crops are relatively large for cucumbers, peas and corn, while relatively small for soybeans and snap beans (Table 1). A comparable measure of profitability and risk for individual crops over time is represented by the coefficients of variation (Table 2). While vegetables show coefficients ranging from 43 percent (for a pea-lima bean double crop) to 106 percent (for sweet corn),[5] most have lower coefficients than field corn. This is due to unstable corn yields in this area caused by recurring drought conditions, especially on unirrigated land. Only soybeans (24 percent)--for which irrigation is not justifiable--show less variability than vegetables. Sweet corn and snap beans have high coefficients of variation and were not expected to enter any of the optimum plans as single crop activities.

Correlation coefficients[6] of gross margin among crops in particular years are also reported based on 1972 to 1980 gross margins. Large positive numbers indicate gross margin movements in the same direction, while small numbers indicate lack of association in yields, costs and/or prices. Large negative coefficients point to crop combinations that will offset low with high gross margins in a particular year, hence they are well suited combinations for stabilizing income. Diversification can best be achieved with the following pairs of crops: corn with a pea-snap bean combination; cucumbers with a pea-soybean combination or pea-snap bean combination (Table 2).

---

[2] A producer price index was used.

[3] Space limitations do not permit reproduction of the two mathematical models, which are presented in the references listed.

[4] Obviously a longer time series would increase the confidence of the study's results; however, they would not change materially.

[5] These percentages may be greater than 100 percent as defined above.

[6] Deviations from their respective mean gross margins, which are normalized by their respective means and sample size. Thus, correlation coefficients constitute "refined" covariances.

Table 1. Gross Margins Per Acre Reflecting Average and Improved Yields for Field and Vegetable Crops on the Delmarva Peninsula, 1980.

Crop	Gross Margins Reflecting Average Management Model A	Standard Deviation	Gross Margins Reflecting Superior Management Model B
		-- in dollars --	
Peas (Grower Harvested)	248.56	115.30	285.61
Lima Beans (Grower Harvested)	103.14	67.30	166.14
Cucumbers (Machine Harvested)	489.47	290.31	659.97
Sweet Corn (Processing Harvested)	43.85	45.80	86.25
Snapbeans (Processing Harvested)	43.51	41.89	91.91
Soybeans	134.51	32.43	134.51
Field Corn	70.86	58.93	70.86
Double Crop Combinations:			
Peas and Limas	391.34	169.46	
Peas and Soybeans	317.61	85.50	
Peas and Snapbeans	238.83	113.59	

Source: Computations based on Vegetables, 1973-80 Annual Summaries and returns from grower interviews.

Efficiency Frontier A

The results on the efficiency frontiers report each farm gross margin, its corresponding standard deviation and coefficient of variation, fixed costs,[7] returns to operator labor and management and other overhead, operating costs and crop mix for each plan. Seasonal labor requirements for plans on the efficiency frontier are described in the text.

Efficiency frontier A is based on average yields for the crops considered in the study area (Tables 1 and 3). The first farm organization represents the highest gross margin. Other farm plans along this frontier represent both declining farm gross margin and risk level (Table 4). A declining coefficient of variation indicates that the risk per dollar of expected return diminishes as expected. The farm gross margin levels were parameterized downward from the first LP solution in $20,000 intervals.

The optimum plan, A1, consists of: 50 percent double cropped pea-lima beans harvested by the grower; 20 percent machine harvested cucumbers; and 30 percent short season soybeans. The gross margin for this farm amounts to $202,000. The crops selected for this plan use almost all of the full-time labor on the farm and require the hiring of only seven additional laborers of the last two weeks of June.

The income lost, when forcing an additional acre of sweet corn or snap beans into Plan A1, amounts to about $300. On the resource side, the cost of taking one acre of land from the plan equals $137 (shadow price or MVP), which is above the range for land rentals. A 15 percent change in the activity gross margins of the basis activities did not affect either the activity levels or resource use.

Plan A1 disregards risk considerations and normally shows the highest farm business risk ($59,000) and coefficient of variation (29 percent) among solutions on this efficiency frontier (Figure 1). Risk-averse farm operators would be more interested in enterprise combinations which compensate lower returns with lower risk. Such plans include fewer acres of double cropped pea-lima beans but more of peas and soybeans double-cropped. As the gross margin decreases to $140,000, at least 250 acres are in vegetable production (peas partially double cropped with soybeans are predominant). Irrigated field corn enters the plans (up to 21 percent) and soybean acreage more than doubles. Farm risk (and the coefficient of variation of the farm gross margin) declines to less than half the original level due to diversification. Seasonal labor requirements decline from five workers for the last two weeks of June for A2, to no seasonal labor for A5.

The farm plans with gross margins of $180,000 to $202,000 (Plans A1 and A2) include crop activities which the grower himself harvests. Annual machinery investment for pea-lima stripper-viner combine is $18,600 over a ten year life span at 1980 price levels net of taxes. The investment for a cucumber harvester amounts to $6,440. If a grower produces over 300 acres of field corn and soybeans, he might invest profitably in a combine which results in an annual investment of $10,600. In addition to the typical fixed machinery costs of $25,000 per year, the vegetable grower is faced with specialized vegetable planting machinery of $14,000 per year and annual costs for an irrigation system of approximately $26,000. When fixed labor costs of $17,000 (one year's wages and fringe benefits for a hired hand) are added to the other annual costs, the total fixed machinery and labor costs equal $117,800. Thus, a grower experiences a re-

7 Other fixed costs include: taxes, insurance, building depreciation (excluding shelter for machines), power and management services.

Table 2. Coefficients of Risk/Income Variation for Individual Crops (on Diagonal) and Correlation Coefficients Between Crops Based on Eight Years of Gross Margins Derived From Actual Yields for Farms on Sassafras Fallsington Soils, Delmarva Peninsula, 1972-80.

	Peas	Lima Beans	Peas & Limas	Sweet Corn	Peas & Snap Beans	Cucum-bers	Snap Beans	Custom Harvest Soybeans	Peas & Soybeans	Grower Harvested Unirrigated Field Corn	Irrigated Field Corn
Peas	0.48	0.57	0.94	0.49	0.95	-0.67	0.55	-0.13	0.92	0.76	0.81
Lima Beans		0.66	0.81	0.72	0.59	-0.01	0.44	-0.12	0.51	0.86	0.84
Peas & Limas			0.43	0.64	0.92	-0.48	0.57	-0.15	0.87	0.89	0.92
Sweet Corn				1.06	0.57	-0.28	0.52	0.14	0.53	0.57	0.53
Peas & Snap Beans					0.44	-0.70	0.79	0.10	0.96	-0.84	0.86
Cucumbers						0.59	-0.53	-0.14	-0.71	-0.28	-0.28
Snap Beans							0.96	0.51	0.74	0.74	0.70
Soybeans								0.24	0.25	0.03	-0.35
Peas & Soybeans									0.25	0.75	0.78
Unirrigated Field Corn										0.83	0.99
Irrigated Field Corn											0.68

Table 3. Average and Improved Yields Per Acre and Prices for Selected Processing Vegetables and Field Crops, Delmarva Peninsula, 1980.

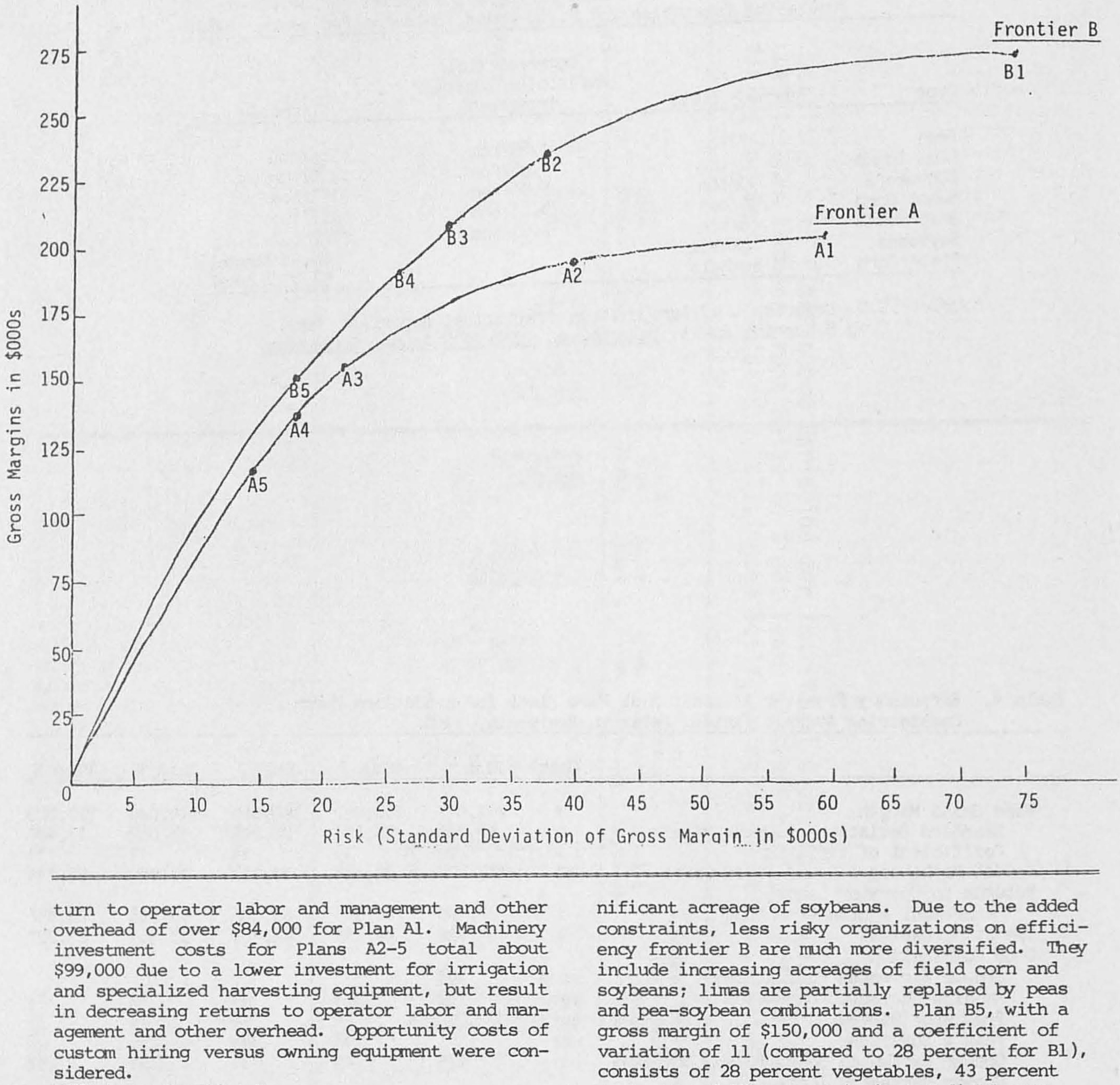
Crop	Average Yield	Improved Yield Reflecting Superior Management	Price
Peas	1.47/ton	1.80/ton	$185/ton
Lima Beans	0.88/ton	1.06/ton	$225/ton
Cucumbers	4.90/ton	6.00/ton	$155/ton
Sweet Corn	4.00/ton	4.80/ton	$53/ton
Snap Beans	2.16/ton	2.50/ton	$110/ton
Soybeans	28 bushels	--	$8.08/bushel
Field Corn	85 bushels	--	$2.65/bushel

Source: U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, Vegetables, 1973-1980 Annual Summaries.

Table 4. Efficiency Frontier A: Least Risk Farm Plans for a 600 Acre Farm Considering Average Yields, Delmarva Peninsula, 1980.

	Unit	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5
Farm Gross Margin	$	202,077	180,000	160,000	140,000	120,000
Standard Deviation of Gross Margin	$	58,758	28,678	22,746	18,052	13,405
Coefficient of Variation	%	29	16	14	13	11
Annual Machinery & Labor Fixed Costs	$	117,777	99,144	99,144	99,144	99,144
Returns to Operator Labor, Management & Other Overhead	$	84,300	80,856	60,856	40,856	20,856
Operating Capital	$	124,436	98,315	93,962	88,369	83,022
Crop Combination:						
Grower Harvested Peas & Limas	acre	298				
Machine Harvested Cucumbers	acre	127	103	91	81	71
Processor Harvested Peas	acre		44	74	18	35
Peas & Soybeans	acre		298	249	155	62
Grower Harvested Short Season Soybeans	acre	175	145	186	219	253
Grower Harvested Irrigated Field Corn	acre		10		127	179

FIGURE 1. Efficiency Frontiers A and B for a 600 Acre Farm on Sassafras Fallsington Soils, Delmarva Peninsula, 1980



turn to operator labor and management and other overhead of over $84,000 for Plan A1. Machinery investment costs for Plans A2-5 total about $99,000 due to a lower investment for irrigation and specialized harvesting equipment, but result in decreasing returns to operator labor and management and other overhead. Opportunity costs of custom hiring versus owning equipment were considered.

Efficiency Frontier B

The analysis of the influence of 20 percent higher attainable yields by superior vegetable farmers for the crops selected (ceteris paribus) shows a profit maximizing gross margin of $268,500 with a farm risk of $74,000 (Plan B1, Table 5).[8] Higher yields make lima beans more attractive as a crop alternative, and result in a rather specialized organization, consisting of 50 percent pea-lima beans double cropped, 25 percent lima beans, 25 percent cucumbers, and an insignificant acreage of soybeans. Due to the added constraints, less risky organizations on efficiency frontier B are much more diversified. They include increasing acreages of field corn and soybeans; limas are partially replaced by peas and pea-soybean combinations. Plan B5, with a gross margin of $150,000 and a coefficient of variation of 11 (compared to 28 percent for B1), consists of 28 percent vegetables, 43 percent soybeans and 29 percent irrigated field corn. Farm risk also declines to $17,000. Nine season-

[8] The cost range encompassed a 15 percent change, but the yields for the vegetables analyzed varied by up to 30 percent. Increased sweet corn yields did not enable the crop to enter the organization, while snap bean yield increases were eclipsed by the pea-soybean double crop combination.

Table 5. Efficiency Frontier B: Least Risk Farm Plans for a 600 Acre Farm Considering Yields Improved by 20 Percent for Peas, Lima Beans, and Cucumbers, Delmarva Peninsula, 1980.

	Unit	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5
Farm Gross Margin	$	268,466	240,000	210,000	180,000	150,000
Standard Deviation of Gross Margin	$	74,454	36,981	30,145	23,345	16,628
Coefficient of Variation	%	28	15	14	13	11
Annual Machinery & Labor Fixed Costs	$	122,088	117,777	117,777	117,777	117,777
Returns to Operator Labor, Management & Other Overhead	$	146,378	122,223	92,223	62,223	32,223
Operating Capital	$	142,939	113,626	104,384	95,141	89,733
Crop Combination:						
Grower Harvested Limas	acre	150				
Grower Harvested Peas & Limas	acre	298	175	110	86	63
Machine Harvested Cucumbers	acre	132	119	105	91	77
Grower Harvested Peas	acre		63	91	77	26
Peas & Soybeans	acre		76	59	10	
Grower Harvested Short Season Soybeans	acre		167			
Grower Harvested Irrigated Field Corn	acre			48	112	174
Custom Harvested Short Season Soybeans	acre	20		187	224	260

al laborers are required for the last two weeks of June and the month of September for B1. Plans B2-5 demand decreasing amounts of seasonal labor in these peak periods--from six laborers in B2 to no required seasonal labor in B5.

CONCLUSIONS

The estimated costs of growing soybeans and, to a greater extent, corn on the Delmarva Peninsula as compared to processing vegetables primarily involves questions of return, risk and labor availability. Therefore, ordinary linear programming and Hazell's MOTAD (Hazell, 1971) were employed to trace efficiency frontiers combining risk and income for a representative 600 acre farm.

It was hypothesized that vegetable crops would have much higher individual income risk coefficients than field crops. However, time series data reveal that field corn, aside from sweet corn and snap beans, is one of the riskiest activities considered.[9] Pairs of crop activities which are highly negatively correlated were identified on the basis of historical data.

Ignoring risk, the gross margin for the profit maximizing plan for the 600 acre farm with average yields amounts to $202,000 (Plan A1) from a rather specialized combination of vegetables (about 75 percent). Similar plans are followed only by vegetable growers with considerable management skills. By double cropping, a superior farm manager could realize an average gross return to personal labor, management and other overhead of $84,000. Farm plans at the lower end of the same efficiency frontier appear frequently in the area. These plans include about 75 percent field crops and 25 percent vegetable crops. These farm operators seem to value the limited effort of field crops compared to the labor intensive, somewhat riskier vegetable production. It is important to emphasize that both risk and profitability preclude any farm plans consisting solely of field corn and soybeans, the most popular organization in the region. Seasonal labor for all plans except B1 amounts to seven or fewer workers for two to six weeks. However, production of field corn and soybeans underutilizes available year-round labor on the farm, which has increasingly relied on off-farm employment as an addition to farm income.

When yields for vegetable crops are increased by 20 percent in accordance with existing superior management practices, efficiency frontier B shows farm plans with higher gross margins accompanying lower risk and coefficients of variations than those on frontier A. However, Plans 2 and 3 of frontier B would attract growers more than any other plans on the two frontiers for their high income levels and lower risk coefficients (by one-third to one-half) compared to the plans disregarding risk. Generally, optimum farm plans require only small numbers of seasonal laborers for a short period of time. Thus, for optimal farm plans discussed, the additional seasonal labor involved should be less of a problem than it has been claimed to be. Aside from irrigation, the major factors in successful vegetable production in this area appear to be good labor, production and marketing management.

9 These findings differ from those of Schurle and Erven (1979) for Ohio, who established larger crop risks for vegetables as opposed to field corn. Ohio's heavier soils result in much higher (20-30 bushels) yields, and hence gross margins, for field corn than do the lighter soils of the Delmarva Peninsula.

REFERENCES

Brink, L. and B. McCarl. "The Trade-off Between Expected Return and Risk Among Cornbelt Farmers." American Journal of Agricultural Economics Vol. 60, No. 2, May 1978, pp. 259-63.

Dhillon, P.S. Cost of Producing Selected Fresh Market Vegetables in South Jersey. Bulletin B-853, Rutgers University, New Brunswick, New Jersey, 1979.

Hazell, P.B.R. "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty." American Journal of Agricultural Economics, Vol. 53, No. 1, February 1971, pp. 53-62.

Knight, Frank H. Risk, Uncertainty and Profit (New York, Houghton Mifflin Co., 1921), pp. 213-217.

Lubich, Antonette. "Organization of Fresh Vegetable Farms on the Delmarva Peninsula Under Risk." Unpublished M.S. Thesis, Department of Agricultural and Food Economics and Operational Research, University of Delaware, Newark, 1982.

Ohannesian, J. and G.J. Elterich. Economic Analysis of Alternative Tillage Systems for Delaware Grain Farms. Bulletin 429, Dept. of Agricultural Economics, University of Delaware, Newark, Delaware, 1979, pp. 51-58.

Persaud, T. and H.P. Mapp. "Effects of Alternative Measures of Dispersion on Risk Efficient Farm Plans in a MOTAD Framework." Professional Paper No. P-683. Oklahoma Agricultural Experiment Station, 1979.

Plant Science and Entomology Departments, University of Delaware; University of Maryland; Rutgers University; Virginia Truck and Ornamental Research Station and Virginia Polytechnic Institute and State University. Commercial Vegetable Production Recommendations. Extension Service, University of Delaware, Newark, Delaware, 1980.

Schurle, B.W. and B.L. Erven. "The Trade-off Between Return and Risk in Farm Enterprise Choice." North Central Journal of Agricultural Economics. Vol. 1, No. 1, January 1979, pp. 15-23.

Smith, Raymond C. Delaware Farm Income, Crop and Livestock Production, 1980. Agricultural Economics Pamphlet No. 71, University of Delaware, Newark, February 1981.

__________. Delaware Agricultural Statistics, Historical Series: 1866-1974, Agricultural Experiment Station Bulletin 419, University of Delaware, Newark, September 1976.

Thompson, K.J. and P.B.R. Hazell. "Reliability of Using the Mean Absolute Deviation to Derive Efficient E-V Farm Plans, American Journal of Agricultural Economics, Vol. 54, No. 3, August 1972, pp. 503-6.

U.S. Department of Agriculture, Economics and Statistics Service. Crop Reporting Board. Vegetables, 1980 Annual Summary. December 1980.

__________. Vegetables, 1979 Annual Summary. June 1980.

__________. Vegetables-Processing, 1974-76 Annual Summaries. December 1974, 1975 and 1976.

Zuckerkandel, K. "The Opportunity Costs of Growing Corn and Soybeans vis-a-vis Processing Vegetables on the Delmarva Peninsula." Unpublished M.S. thesis, Department of Agricultural and Food Economics, University of Delaware, Newark, Delaware, 1981.