ANALYSIS OF RISK MANAGEMENT STRATEGIES
FOR AGRICULTURAL PRODUCERS

by

Harry P. Mapp, Jr., Michael L. Hardin,
Odell L. Walker and Tillak Persaud*

Invited Paper Presented at the Annual Meetings of
the American Agricultural Economics Association,
Pullman, Washington, July 29-August 1, 1979

*Harry P. Mapp Jr. is Professor, Michael L. Hardin is Assistant
Professor and Extension Economist, Odell L. Walker is Professor
and Tillak Persaud is Graduate Research Assistant,
Department of Agricultural Economics, Oklahoma
State University

ANALYSIS OF RISK MANAGEMENT STRATEGIES FOR AGRICULTURAL PRODUCERS

Risk and uncertainty are pervasive phenomena in production agriculture. Many factors, including weather events, diseases, insect infestations, general economic conditions, the development and adoption of technological innovations, and public and private institutional policies, interact to create a unique decision making environment for the agricultural producer. General economic conditions in the economy, particularly the inflation rate, have increased prices paid by farm operators for operating inputs and capital equipment, but have had relatively little impact on prices received for products produced in the atomistic, decreasing cost agricultural industry. Rapid increases in input costs have squeezed net returns, created cash flow problems and increased the vulnerability of the firm to financial disaster.

Institutions and the uncertainty surrounding the development and implementation of their policies have become increasingly important to farm operators. A few years ago, farmers were primarily concerned with the policies of the U.S. Department of Agriculture - the nature of the new farm program, set aside acreage and support price levels. They are still concerned with USDA policy. However, today, perhaps to a greater extent than they would like, producers must respond to energy policy which affects the availability and cost of fuels, and trade policy which influences exports and imports of agricultural supplies and products. Farmers' decisions are influenced by environmental policy which specifies the types and quantities of pesticides and herbicides available and legislates safe levels of usage. Financial institutions have increased farm borrowers' risk of interest rate increases by adopting floating and variable interest rates.

Each of these factors contributes to the price, yield or net return variability of agricultural producers. Other institutional innovations, such as disaster payments, emergency loans, and federal crop insurance are designed to shift a portion of the adverse effects of price and yield varibility from the private to the public sector. The proposed Farm Production Protection Act of 1979 would provide varying amounts of protection and guarantee compensation for crop losses due to crop failure or natural disasters through an insurance program with the producer's premium subsidized by the government (Miller and Trock). Participation in these programs depends upon the decision makers' perceptions of the potential benefits and costs, and his attitude toward risk and uncertainty.

The conceptual and analytical base for education and research on problems of decision making under uncertainty is rich due to devotees to the subject in and out of agricultural economics. The topic has been an intermittent interest of many and a career focus of a few. Currently, the interest cycle is at a relative high, spurred by wide product price swings, institutional changes and inflation. A national extension project was recently completed (Nelson and Nelson) and a regional (national in participation) research project is in its third year. This paper briefly reviews the current research focus and presents an approach for evaluating risk management strategies under uncertain technical, economic and institutional futures.

The specific purposes of this paper are (1) to review research recently completed and currently in progress on approaches being used to assess and respond to production, market and financial risks in agriculture; and (2) to present an evaluation of production and marketing strategies designed to minimize variability of net farm income subject to receiving a specified level of income for a southwestern Oklahoma farm operation; and, (3) to relate the effects of alternative assumptions regarding beginning equity level, rate of increase in land value and rate of increase in the cost of agricultural inputs to the probability of "success" of risk efficient farm plans for the southwestern Oklahoma operation.

REVIEW OF RECENT RESEARCH APPROACHES

Several review articles addressing various portions of the literature on decision making under conditions of risk and uncertainty are available (Walker and Nelson: Anderson, 1976; Dillon; Anderson, 1974). Rather than duplicating previous efforts, we will concentrate on a brief review of recently published studies and research currently in progress.[1]

Research is being conducted at both the firm and aggregate levels. The aggregate work has been stimulated in part by the desire to incorporate risk into efforts to explain or predict supply response. Much of this work involves the use of econometric techniques to estimate supply response under conditions of risk and uncertainty (Behrman; Pope; Just; Ryan; Lin). Robison and Carman are building on these efforts by focusing on the derivation of supply and demand functions from individual utility functions, to be aggregated into a model amenable to econometric estimation.

All micro models for decision making under uncertainty require extensive data which reflect the nature of price and production variability. Several research projects are concerned with measurement of variability, risk, and farmers' subjective probability distributions for key variables. These are important independent topics, but they also support applications of micro models, such as quadratic programming and simulation. Other studies are evaluating the impact of farm income variability on lending institutions' credit policies, loan administration procedures and subsequent credit to farmers.

A number of recent firm-level studies have focused on whole farm planning under conditions of risk and uncertainty. An approach frequently used is quadratic risk programming (Fruend; Kliebenstein and Scott). Researchers using this approach usually assume the decision maker maximizes expected utility, with the utility function quadratic with respect to expected income and variance of income or net returns of the production activities are assumed to follow a multivariate normal distribution. Historical price, yield, and cost data provide the basis for calculating net returns associated with each production activity. The model is solved to determine the set of production activities that minimizes variance of net returns subject to receiving a specified level of income. By varying the level from zero to its maximum value, the efficiency frontier showing tradeoffs between expected income and variance of income may be determined.

Hazell developed an approach which minimizes total absolute deviation rather than variance, may be solved using a linear programming algorithm and gives results remarkably similar to those of quadratic programming. This approach, referred to as MOTAD, had been applied successfully to several different types of problems (Brink and McCarl; Nieuwoudt, Bullock and Mathia; Simmons and Pomareda; Schurle and Erven).

An alternative approach to studying the effects of risk and uncertainty at the firm level has involved development of firm level simulation models. Patrick studied the effects of debt levels and loan arrangements on farm firm survival and growth. Held and Helmers developed a financial simulation model to investigate firm growth, income, and survivorship relationships in wheat farming. Hardin also developed a simulation model to evaluate risk and financial management implications of major capital investments in an uncertain environment.

Both the MOTAD and simulation approaches have advantages and disadvantages. There is no assurance that the risk efficient farm plans developed in a MOTAD model based on historical price, yield, and net return relationships will be optimal in the future. On the other hand, organizations of production used to evaluate risk management strategies in simulation models are seldom risk-efficient farm plans. Rae has suggested that an improved methodology for evaluating risk management policies would involve determining an optimum farm plan in a risk programming model and evaluating the feasibility of the plan over a wider range of possible states of nature in a simulation model. Young, et al, suggest that individual risk aversion parameters required for research and extension applications should be of the safety first type rather than expected utility theory based, risk aversion coefficients.

The analysis on which the remainder of this paper is based uses both MOTAD and simulation models to evaluate risk efficient farm plans under alternative economic futures. The analysis simulates the potential effects of reduced rates of increase in land value, increased costs of production and alternative beginning equity levels on the viability of risk efficient farm plans developed on the basis of historical data in a MOTAD framework.

FARM SITUATION AND DATA REQUIREMENTS

A typical farm situation for southwestern Oklahoma was defined for the MOTAD-simulation analysis. The farm contains 1,200 acres of cropland and 300 acres of native pasture. Crop activities in the model include alfalfa, cotton, grain sorghum, wheat, barley and oats. Both models require data on variability for each activity. Experimental plot data from field stations in southwestern Oklahoma were analyzed and a series of trend adjusted annual yields for each activity was estimated for the period 1965-1977.

Activities for steers and heifers on wheat pasture and summer stockers were included in the model. Experimental data did not exist to establish yield variability for the livestock activities. Oklahoma crop and livestock price series for 1965-1977 were obtained for each activity in the model. Product prices were adjusted for trend where appropriate and expressed in constant 1977 dollars. Oklahoma crop and livestock budgets were used to establish the 1977 cost of production for each activity. The Index of Prices Paid by Farmers was used to generate the cost of production series from 1977 back to 1965 for each activity. The result was then expressed in constant 1977 dollars.

Gross margins for each activity were calculated by subtracting the variable cost of production during each year from the appropriate gross revenue in that year. Estimated gross margins for selected crop and livestock activities used in the MOTAD analysis are presented in Table 1. Triangular distributions reflecting these relationships along with correlations among activity yields and prices were used in the simulation analysis. The triangular distributions were defined by specifying the maximum, minimum and modal values for each activity.

Production assets for the hypothetical 1,500 acre dryland farm include land and buildings valued at \$855,000 and machinery valued at \$70,000. Production liabilities were confined to real estate debt of \$270,628. Beginning equity is \$654,372 (70 percent). In part of the study described later, real estate and machinery debt are increased to create a beginning equity of 45 percent.

DEVELOPMENT OF MOTAD AND SIMULATION MODELS

The MOTAD model used to develop risk efficient farm plans is a variation of linear programming. The MOTAD model formulation used in this study was:

(1) Minimize Ld^-

Subject to:

(2) $A\ X \leq B$

(3) $DX + Id^- \geq 0$

(4) $C'X = \lambda$

(5) $X,\ d^-,\ \lambda \geq 0$

where X, A, B, and C represent activity levels, resource requirements, resource availabilities and gross margin expectations, respectively. Gross margin is defined as gross return minus total variable cost. The

Table 1. Estimated Gross Margins in Constant 1977 Dollars for Selected Crops, Southwestern Oklahoma

Year	Wheat Sale at Harvest	Cotton	Grain Sorghum	Winter Steers	Summer Steers
	($/AC)	($/AC)	($/AC)		
1965	23.03	64.51	36.21	31.50	53.77
1966	76.62	-55.84	17.74	69.28	8.08
1967	35.55	72.55	38.03	20.14	27.03
1968	-29.57	-6.35	38.71	35.25	24.14
1969	43.95	87.56	43.04	56.86	11.61
1970	17.10	39.86	34.21	73.06	26.30
1961	-29.89	85.54	19.65	34.95	60.49
1962	-32.30	-16.66	38.41	64.66	90.63
1973	35.86	-61.90	130.91	134.35	35.20
1974	135.24	22.53	106.71	-21.14	-45.85
1975	57.77	24.77	98.72	6.86	69.52
1976	86.37	89.12	35.70	61.75	-22.38
1977	48.56	113.37	29.08	44.38	15.96
Mean	36.02	35.31	52.86	47.07	27.27
Standard Deviation	48.79	56.99	34.92	37.57	36.78
Coefficient of Variation	135.44	161.38	66.05	79.82	134.87

gross margin expectation is the mean of the series. The difference between the observed gross margin and the gross margin expectation in a given year is an element of D, the matrix of deviations. The vector d^- represents yearly total negative deviations summed over all risky activities. Ld^- represents the summed total negative deviations over all years. λ is a scalar used to represent the income constraint. The efficiency frontier may be traced out by parameterizing λ from zero to its maximum value.

The simulation model, described in detail by Hardin, traces the operation of the firm thru a specified planning horizon under stochastic prices and yields. Two types of results are generated by the simulation model: (1) cash flow data used in present value and feasibility analysis for the farm and (2) balance sheet information needed to determine if equity is sufficient to maintain the financial viability of the farm thru the planning horizon. For the alternative plans developed by MOTAD, the simulation model can answer questions such as "Is the plan financially feasible given the farmer's consumption needs, initial financial position and potential income distribution over the planning horizon." The simulation model evaluates the effects of interactions between years which is not possible with the MOTAD model. The simulation model can incorporate firm growth through the addition of land and other investments, but for simplicity additional investments were not considered in this study. The risk management strategy to be simulated is specified as input data for the model. Alternative assumptions regarding future economic trends may be specified. In this analysis, changes in the rate of increase in land values and input prices were evaluated for alternative beginning equity levels.

ANALYSIS AND RESULTS

The MOTAD model was used to analyze a base plan and two risk management scenarios. The base plan (the linear programming solution) assumes the farm operator chooses from a set of production activities which involve sale of the product at harvest and that his objective is to maximize gross margins. In the first risk management scenario, the producer is assumed to minimize total negative deviations from the gross margin expectations, subject to receiving a specified level of income. The second risk management scenario assumes that storable commodities, such as wheat, may be marketed at harvest or sequentially during the crop year. Storage costs are accounted for and the producer may sell any portion of the stored wheat during any month of the crop year. In addition, this scenario permits consideration of forward contracting for a portion of the wheat crop. The forward contracting activity assumes the producer contracts in March for June delivery.

The solutions determined under the base plan and the two risk scenarios are presented in Table 2. When production and sale at harvest are the only alternatives, the profit maximizing organization of production is very specialized. Only two crop activities enter the solution--1,172 acres of grain sorghum and 28 acres of alfalfa. In addition, 171 steers are included in the solution. Gross margins total $66,340 and standard deviation is $41,360. Risk is assumed to be of no importance to the producer in the base plan. This solution represents the maximum profit point on the efficiency frontier.

The first risk management scenario assumes the producer wishes to minimize total negative deviations from the gross margin expectations subject to receiving $65,000 in revenue above variable costs of production. Lowering gross margins slightly results in a considerably

Table 2. Programming Solutions Under Three Production and Marketing Scenarios

Activities in the Optimum Solution	Units	Profit Maximizing Solution-Sale at Harvest	MOTAD Solution-Sale at Harvest	MOTAD Solution Sequential Marketing and Forward Contracting
Steers	Head	171	233	222
Grain Sorghum	Acres	1172	918	866
Alfalfa	Acres	28	28	28
Cotton	Acres		65	150
Wheat-sell in June	Acres		189	
Wheat-sell in December	Acres			60
Wheat-Forward contract in March for June sale	Acres			96
Gross Margins	Dollars	66,340	65,000	65,000
Standard Deviation[a]	Dollars	41,360	36,100	33,605

[a]Standard deviation is estimated by multiplying the objective function value from MOTAD (Ld^-) by a constant K. K is calculated as $K = 2/t\sqrt{\frac{t \cdot \pi}{2(t-1)}}$ Where t = 13, the number of years in the series, and π=3.14286 (Hazell).

more diversified farm plan and substantially less risk (Table 2). The MOTAD solution still contains grain sorghum (918 acres) and alfalfa (28 acres), but also contains 65 acres of cotton and 189 acres of wheat. Steers remain in the solution, but at a considerably higher level. The efficiency frontier appears to be relatively steep in the vicinity of the profit maximizing point. Diversification of the farm plan permits the producer to receive gross margins of $65,000 while reducing the standard deviation to $36,100. The coefficient of variation (standard deviation divided by the mean) is reduced from 62.35 percent under the base plan to 55.54 percent under the first risk management scenario.

The second risk management scenario introduces the possibility of sequential marketing and forward contracting of wheat. It is on an efficiency frontier different than the first MOTAD solution for gross margins of $65,000 (Table 2). The resulting farm plan contains 866 acres of grain sorghum, 156 acres of wheat, 150 acres of cotton, and 222 steers. The production from 96 acres of wheat is forward contracted in March for sale in June. Production from 60 acres of wheat is harvested in June and stored until December when it is sold. Introduction of sequential marketing and forward contracting as marketing alternatives permits the producer to reach a higher efficiency frontier. He is able to generate $65,000 in gross margins while reducing the standard deviation to $33,605. The coefficient of variation for this scenario is 51.70 percent.

A number of additional risk management strategies are possible. Several of the more interesting include purchase of crop insurance, cash versus crop share rental arrangements, use of the futures market for wheat and cattle, and the utilization of federal disaster payment programs. These alternatives are being explored, but time did not permit their inclusion in this paper. Instead, we have focused on the feasibility of the risk efficient farm plans under alternative assumptions regarding future economic conditions--questions not easily addressed in a MOTAD framework.

Simulation Analysis:

The base solution and two MOTAD risk management solutions discussed above were evaluated under alternative assumptions regarding future economic conditions. Each of these farm plans was simulated over a 20 year period under the assumptions that the producer had a 70 percent beginning equity, the prices of agricultural products would increase 3.75 percent annually, the prices of agricultural inputs would increase 5 percent annually, land price would increase at an annual rate of 7 percent, and family living requirements and machinery and building costs would increase by 5 percent per year. Each of the farm plans was also simulated over a 20-year period under the assumption that the land values increase at an annual rate of only 4 percent, and then under the assumption that the prices of agricultural inputs increase at an annual rate of 6 percent, all other rates of increase as originally specified. These simulation runs are summarized in Table 3.

Table 4 presents ending net worth and farm bankruptcies for each farm plan and economic future evaluated, based on a twenty year simulation under the indicated situation. At the end of the twenty years there would be substantial amounts of capital gains in land and capital gain taxes to be paid if the land were sold. The ending net

Table 3. Economic Situations and Strategies Evaluated in Simulation Runs for a Southwestern Oklahoma Farm

	Programming Solution									
	Base	MOTAD 1	MOTAD 2	Base	MOTAD 1	MOTAD 2	Base	Base	Base	Base
Simulation Run	1	2	3	4	5	6	7	8	9	10
Percent Equity	70	70	70	45	45	45	70	45	70	45
Annual Percent Increase in:[a]										
Land Values	7.0	7.0	7.0	7.0	7.0	7.0	4.0	4.0	7.0	7.0
Input Prices	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0	6.0

[a]The following were held constant at the indicated rates of increase: output prices, 3.75 percent; family living, 5.0 percent; and machinery and building prices, 5 percent.

Table 4. Ending Net Worth and Farm Bankruptcies Under Alternative Farm Plans and Economic Futures, Southwestern Oklahoma Farm

Situation	Simulation Run	Ending Net Worth[a] Mean	Minimum	Maximum	C.V.	Number of Bankruptcies
		--------($1000)--------				
70% Equity:						
Base	1	3135.7	2169.8	3856.4	9.6	0
MOTAD 1	2	3056.0	2320.9	3682.4	8.0	0
MOTAD 2	3	3099.1	2422.1	3668.6	7.3	0
Base (4% Land Price Increase)	7	1801.2	835.4	2522.9	16.7	0
Base (6% Input Price Increase)	9	2991.4	1899.0	3738.2	11.0	0
45 % Equity						
Base	4	2464.0	1185.6	3344.4	16.8	6
MOTAD 1	5	2330.7	1338.7	3137.0	15.4	2
MOTAD 2	6	2390.0	1448.8	3128.4	14.2	1
Base (4% Land Price Increase)	8	1129.5	-148.8	2009.9	36.7	20
Base (6% Input Cost Increase)	10	2265.2	880.1	3214.3	20.0	8

[a] Ending Net Worth is based on twenty years of simulated operation of the 1500 acre farm under the run situation indicated and is net of capital gains taxes on the ending value of land (payable if the land were sold).

worth has been adjusted to reflect the net that would remain after the capital gain taxes are paid, as though the land is sold in year twenty. The simulation model will generate cumulative probability distributions of selected variables such as net worth for use with stochastic dominance or other criteria. Only the parameters of net worth are considered here for brevity.

The expected ending net worth under each alternative is presented in the column labeled mean in Table 4. As expected, the highest expected net worth was obtained from the linear programming, profit maximizing solution (Base) (Run 1) where risk is assumed ignored. Simulation of MOTAD 1 (Run 2) results in lower expected net worth at the end of 20 years and a reduction in the coefficient of variation. Simulation of MOTAD 2, (Run 3), the solution on a higher efficiency frontier, results in slightly higher expected net worth and a lower coefficient of variation. The minimum ending net worth is higher and range of ending net worths lower for the MOTAD solutions than for the Base solution which ignores risk.

Run 7 simulated the effects on the Base solution of a reduction in the rate of increase in land values from 7 to 4 percent, other factors unchanged. The importance of land price increases on the level and stability of ending net worth is dramatically illustrated. Mean ending net worth drops from \$3.1 million to \$1.8 million and the coefficient of variation increases substantially.

The potential impact on the Base solution of a change in the annual rate of increase in the cost of inputs from 5 to 6 percent is shown in Run 9. The expected ending net worth is reduced slightly from \$3.1 million to about \$3.0 million and the coefficient of variation is increased to 11.0 percent. As expected, the modest increase in the price of inputs has substantially less effect than the substantial reduction in the rate of increase in land values. No bankruptcies occurred under any of the simulation runs when the producer had a beginning equity of 70 percent.

When the beginning equity was reduced to 45 percent, the possibility of bankruptcies occurs under all five simulation runs (Table 4). The relationships between and among the Base, MOTAD 1 and MOTAD 2 solutions under the assumption of 45 percent equity (Runs 4, 5 and 6) are again as expected. The Base solution has the highest expected ending net worth, the highest coefficient of variation, and the possibility of six bankruptcies. MOTAD 2 has the lowest coefficient of variation and the possibility of only one bankruptcy.

A drop in the rate of increase in land values to 4 percent had a drastic effect at the 45 percent equity level (Table 4, Run 8). Expected ending net worth is reduced to $1.1 million, the minimum ending net worth is negative and 20 bankruptcies occur in 100 replications. The impact of an increase in the annual cost of inputs to 6 percent is less severe. Mean ending net worth over 20 years is only reduced by $200,000 and the coefficient of variation and number of bankruptcies are increased slightly compared to the Base solution at 45 percent equity.

An approximate comparison of the results of operating the farm over twenty years under each of the plans with other off or on—farm opportunities is obtained by deflating the ending net worth to reflect present value. The mean ending net worth for the 3 plans with 70 percent equity and base assumptions reflected about a 6 percent compound rate of growth. The expected rate of growth with 40 percent equity is approximately 5 percent.

SUMMARY AND CONCLUSIONS

This analysis combines use of a MOTAD model to derive risk efficient farm plans and a simulation model to evaluate the feasibility of those plans under alternative economic and institutional futures. The MOTAD model demonstrates the possiblity of reducing relative variability through diversification and sequential marketing and forward contracting of wheat. The simulation model calculates annual net cash income, net worth, net present value and the chance of business failure when the risk efficient farm plans are subjected to alternative rates of increase in land values and input costs, assuming beginning equities of 70 and 45 percent. The chance of business failure was found to increase substantially when beginning equity is 45 percent and land value rise at only 4 percent annually.

A number of important limitations of this analysis deserve mention. First, we have assumed full ownership by the farm operator. Many large commerical farms combine land ownership and rental arrangements. An earlier Oklahoma study suggests that share rather than cash rent is an effective means of spreading risk among tenant and landlord (Walker and Hardin). Farm operators might also use pasture rental arrangements or livestock shares rather than ownership of cattle to reduce their risk. On the input side, machinery rental and/or custom hiring provide input cost flexibility. The impact of these deserves additional attention.

Second, given the ownership situation, only a few risk management strategies are evaluated. On the marketing side, we have considered only sequential marketing and forward contracting. Hedging opportunities are available for both wheat and cattle, but have been ignored in this analysis. All risk crop insurance is an alternative receiving current policy attention.

Preliminary analysis in another Oklahoma farming area indicated that, under the insurance arrangements assumed, federal crop insurance decreased the mean income without reducing income variability (Walker and Hardin). In fact, the number of bankrupcies increased, apparently due to the annual drain on cash flows to pay premiums and borrowings to meet cash needs. Other provisions of the proposed legislation discussed by Miller and Trock could also be evaluated.

The disaster payment provisions of the current commodity programs have also been subjected to preliminary analysis revealing that disaster payments improve the income and risk performance of farms (Walker and Hardin). The only cost to the farmer is participation in the commodity programs. The disaster payment sets a lower floor on returns from the commodities covered by the program. The deficiency payment also sets a lower floor on income variability associated with price fluctuations. Other institutional arrangements deserving attention include the impact of variable interest rates and alternative forms of business organization on the ability of the farm firm to survive economic fluctations.

REFERENCES

Anderson, Jock R. "Modeling Decision Making Under Risk." Paper presented at the Agricultural Development Council Conference on Risk, Uncertainty and Agricultural Development, CIMMYT, Mexico, March, 1976.

Anderson, Jock R. "Simulation: Methodology and Application in Agricultural Economics." Rev. Marketing Agr. Econ. 42(1974):3-55.

Behrman, Jere. Supply Response in Underdeveloped Agriculture, North Holland Publishing Company, 1968.

Brink, Lans and Bruce McCarl. "The Tradeoff Between Expected Return and Risk Among Cornbelt Farmers." Amer. J. Agr. Econ., 60 (1978):259-263.

Dillon, John L., "An Expository Review of Bernoullian Decision Theory in Agriculture: Is Utility Futility?" Rev. Marketing and Agr. Econ., 42(1974):3-55.

Fruend, Rudolf J., "The Introduction of Risk into a Programming Model." Econometrica, 24(1956):253-263.

Hardin, Michael L. "A Simulation Model for Analyzing Farm Capital Investment Alternatives," Ph.D. Thesis, Oklahoma State University, 1978.

Hazell, P.B.R. "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty." Amer. J. Agr. Econ., 53(1971):53-62.

Held, Larry J. and Glenn A. Helmers. "Growth, Income, and Survivorship Relationships in Wheat Farming." Unpublished paper presented at Annual Meeting of Amer. Agr. Econ. Assoc., Blackburg, Virginia, August, 1978.

Just, Richard E., "An Investigation of the Importance of Risk in Farmers' Decisions." Amer. J. Agr. Econ., 56(1974):14-25.

Klibenstein, James B. and John T. Scott, Jr., Farm Production Decision-Making Using Quadratic Programming--An Empirical Application. Agricultural Economics Research Report 138, University of Illinois, April, 1975.

Lin, William. "Measuring Aggregate Supply Response Under Instability." Paper presented at Annual Meetings of the Amer. Agr. Econ. Assoc., San Diego, California, August 1977.

Miller, Thomas A. and Warren L. Trock. "Disaster Assistance to Farmers--Needs, Issues, and Programs." Unpublished paper, Department of Economics, Colorado State University, Ft. Collins, 1979.

Nelson, A. Gene and Ted R. Nelson, Notebook for a National Extension Workshop--"Dealing with Risk in Farm Decision Making." Denver, Colorado, 1978, (Published by Oregon State University).

Niewoudt, W.L., J. B. Bullock, and G.A. Mathia. "An Economic Evaluation of Alternative Peanut Policies." Amer. J. Agr. Econ., 53(1976): 485-495.

Patrick, George F., "Effects of Debt Levels and Loan Arrangements on Farm Firm Survival and Growth." Unpublished paper presented at Annual Meeting of Western Regional Research Project W-149 Technical Committee, San Francisco, California, January 1979.

Pope, Rulon. "Econometric Analysis of Risk Models - Some Explorations and Problems." Unpublished paper presented at the Annual Meeting of the Western Agricultural Economics Association, Bozeman, Montana, July 1978.

Rae, Allan N., "Capital Budgeting, Intemporal Programming Models, with Particular Reference to Agriculture." Aust. J. Agr. Econ., (1970):39-52.

Robison, Lindon and Garth Carmon. "Aggregate Risk Response Models and Market Equilibrium." Unpublished paper presented at Annual Meeting of Western Regional Research Project W-149 Technical Committee, San Francisco, California, January 1979.

Ryan, Timothy. "Supply Response to Risk: The Case of U.S. Pinto Beans." West J. Agr. Econ., 2(1977):35-43.

Schurle, Bryan W. and Bernard L. Erven. The Return-Risk Trade offs Associated with Processing Tomato Production in Northwestern Ohio. Ohio Agr. Res. and Dev. Center Research Bulletin 1111, April, 1979.

Simmons, Richard L. and Carlos Pomareda. "Equilibrium Quantity and Timing of Mexican Vegetable Exports." Amer. J. Agr. Econ., 57(1975):472-479.

Walker, Odell L. and A. Gene Nelson. Agricultural Research and Education Related to Decision-Making Under Uncertainty: An Interpretative Review of Literature. Okla. Agr. Exp. Sta. Res. Dept. P-747, March 1977.

Walker, Odell L. and Mike L. Hardin, "Risk and Risk Control in Firm Growth - A Simulation Analysis," Paper presented to the Annual Meeting of the Western Regional Research Project W-149 Technical Committee, San Francisco, California, January 1979.

Young, Douglas, William Lin, Rulon Pope, Lindon Robison, and Roger Seeley. "Risk Preferences of Agricultural Producers: Their Measurement and Use." Paper presented at the Annual Meeting of the Western Regional Research Project W-149 Technical Committee, San Francisco, California, January 1979.

FOOTNOTES

Harry P. Mapp, Jr. is Professor, Michael L. Hardin is Assistant Professor and Extension Economist, Odell L. Walker is Professor and Tillak Persaud is Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University. Journal Article No. J-   of the Oklahoma Agricultural Experiment Station.

[1]Much of our emphasis here focuses on research being conducted under Western Regional Research Project W-149, "An Economic Evaluation of Managing Market Risks in Agriculture."