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**RISK ANALYSIS FOR AGRICULTURAL  
PRODUCTION FIRMS: CONCEPTS,  
INFORMATION REQUIREMENTS AND POLICY ISSUES**

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SAFETY-FIRST MODELS BASED ON  
SAMPLE STATISTICS: A DISCUSSION\*

by

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\*A paper presented at the S-180 meeting, March 24-27, 1985.

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SAFETY-FIRST MODELS BASED ON  
SAMPLE STATISTICS: A DISCUSSION

The paper by Atwood, Watts and Helmers (hereafter AWH) addresses an important problem. At a time when the economic prospects for farmers were brighter, Kliebenstein et al. concluded that cash grain farmers appeared to have "threshold" security levels. Presumably, they are no less concerned about ensuring that minimum income goals are satisfied now than they were then.

One technique which can be used to compute enterprise mixtures for decision makers who have concerns of this sort is Target MOTAD. The additional constraint proposed by AWH should make Target MOTAD more useful for many decision makers. Tauer notes that Target MOTAD is a two attribute model. The two attributes are (using AWH's notation) a target income level,  $t$ , and (the absolute value of) expected negative deviations,  $\theta(1,t)$ , from target income. The concept of a target income is an appealing one. It is reasonable to expect that most decision makers can select a target income level. However, it may be more difficult for them to specify a maximum acceptable level of expected deviations. Simply selecting a target income does not guarantee that income will always be at least that large. The set of enterprise mixes associated with a given target income level can be quite diverse. For example, the solutions associated with a target income of \$126,587 includes the vector (160.8, 25.3, 150.3, 28.3, 35.3, 279.9) as well as the "L.P." solution (165.4, 195.4, 10.0, 13.0, 16.2, 128.4). Many of the enterprise mixes associated with a given target income can yield, for some states of nature, incomes much lower than the target income. Thus, both a target income level and an upper limit on expected deviations must be selected to determine the appropriate enterprise mix.

Imposing the safety-first constraint does not reduce the number of questions which the decision maker must answer but the questions may be easier to answer. They must now select an income goal,  $g$ , and the (maximum acceptable) probability of failing to meet that goal,  $\lambda$ . Making these choices reduces the set of target income and expected deviation levels to be considered. In Figures 1 and 2, the region ABC includes all of the combinations of target income and expected deviations which would need to be considered to determine the complete set of Target MOTAD solutions. (To avoid excessive clutter only three of the twenty "corners" of this region are labelled.) Selecting a goal of \$90,000 and a probability of .1 restricts consideration to those combinations of target income and expected deviations which lie on or below line segment DE. Within ABC, the derivatives of income with respect to  $t$  and  $\theta$  are negative and positive, respectively. Therefore, the AWH model selects some combination of  $t$  and  $\theta$  (the one at point  $\overset{D}{Z}$  in this case) lying on DF.

We are impressed by AWH's method even though, and in fact partly because, it will not always find the solution which maximizes expected income subject to an upper limit on the probability of receiving an income lower than the goal. It may fail to find this solution because the safety-first constraint involves a trade-off between a target level and expected deviations from that target level. For a decision maker who is concerned only about controlling the probability of below goal incomes and not with the size of any deficiencies, a different approach would be appropriate. Although the most efficient way of solving this problem may not be apparent, we are confident that the reader knows the characteristics of its solution. The results presented by AWH suggest that their method may approximate the solution.

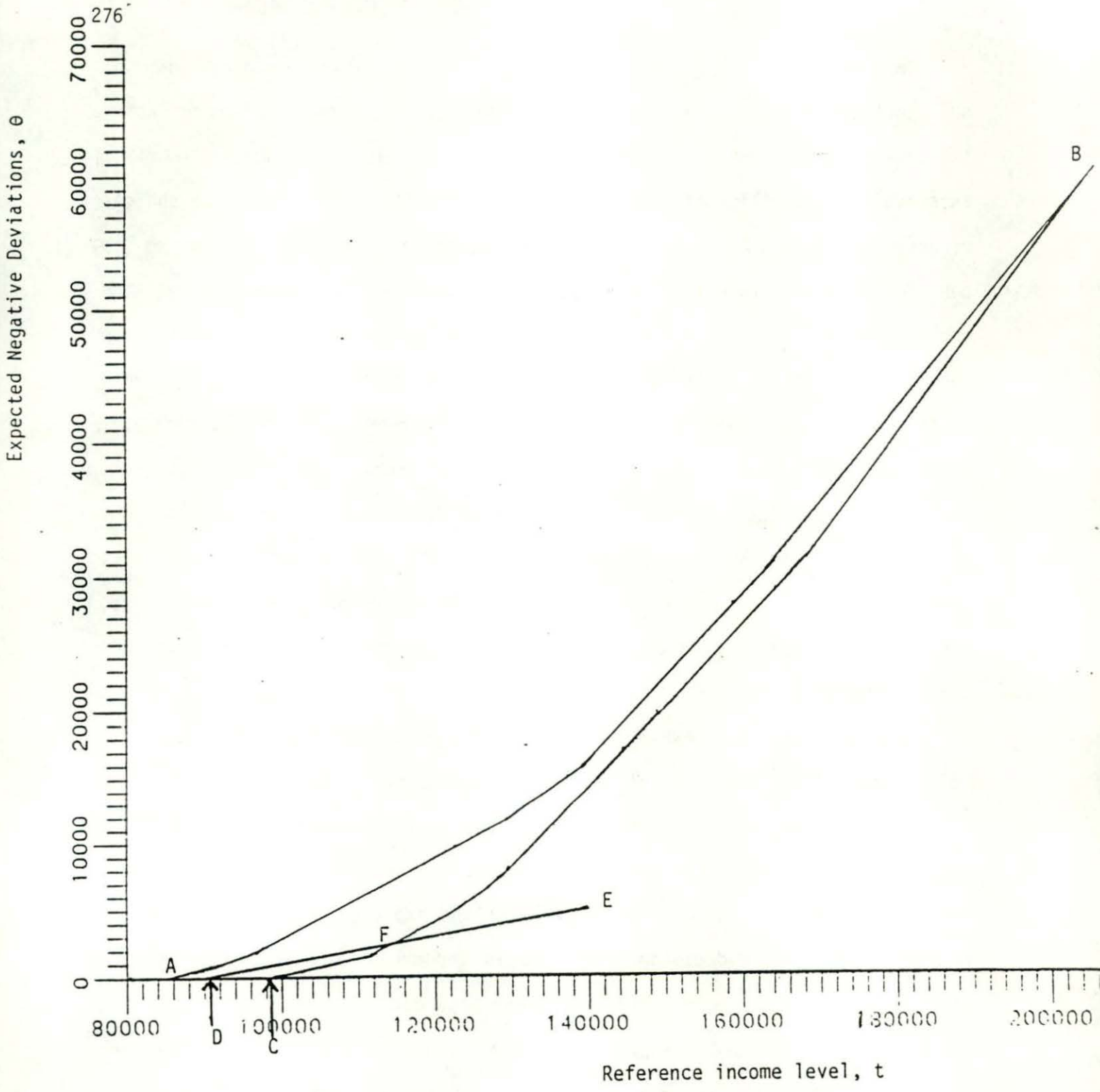


Figure 1. Relevant  $t$ ,  $\theta$  Combinations



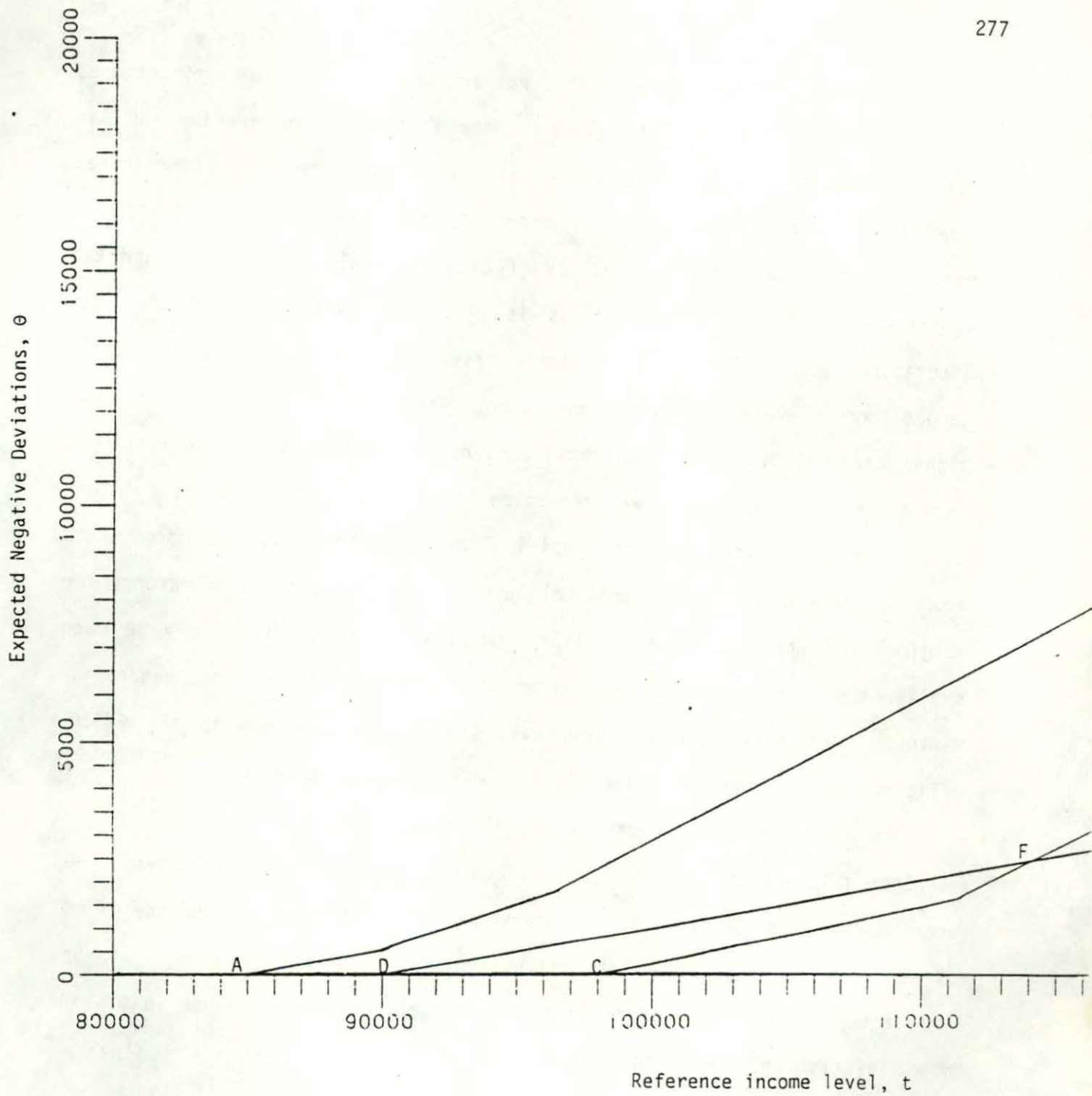


Figure 2. Relevant  $t, \theta$  Combinations (Enlarged)

Our preference for the AWH method rather than the approach just mentioned is based on two factors. The first is the fact that implementing the AWH method requires linear programming rather than some more complicated algorithm. A second factor is our belief that most decision makers are concerned about both the probability of attaining below goal income and the magnitude of the deficiency. This is consistent with most of the risk literature (e.g., Fishburn). It seems reasonable for below goal and below target income levels to be assigned (as both Target MOTAD and AWH's method do) higher marginal utilities than those assigned to above goal and above target income levels. However, we recognize that bankruptcy laws and other considerations could cause some decision makers to be relatively unconcerned about incomes below certain critical levels. For these decision makers, the marginal utility of incomes smaller than a critical threshold may be much smaller than for income levels greater than the threshold. Thus, enterprise mixtures chosen by such decision makers might only belong to the F.S.D. efficient set (rather than to the S.S.D. efficient set as well).

There are several aspects of the AWH method and paper which are not as complete as might be desired. Two of them are mentioned in their paper. They are the (absolute and relative) conservatism of inequality (5) and the effect of sampling errors. A complete discussion of the effect of sampling errors may be beyond the scope of their paper. However, it is possible to provide more information about the conservatism of inequality (5). Two kinds of information might be useful.

It should be possible to more clearly describe both those situations for which inequality (5) is an equality and those for which it is not. Very little change in the exposition would be required inasmuch as examples of both are presented in Table 4 and discussed in the text. Simply presenting the



endogenously selected target levels would be helpful. It should also be possible to provide some indication of how much less conservative the AWH inequality is than those of Chebychev or Berck and Hihn. It may not be possible to make a general statement but it should be possible to describe this difference for some or all of the solutions presented in Table 4.

Although the AWH paper would have been enhanced by these additional details, their omission is not serious. Most readers who could benefit from this information could obtain it on their own. Standard texts (e.g., Mood and Graybill, pp. 148-9) and the data in AWH's paper provides all of the information which most readers would need.

The method proposed by Atwood, Watts and Helmers is a significant addition to the set of tools available for finding a satisfactory mixture of risky alternatives. Its advantages are its consistency with expected utility theory, its similarity to Target MOTAD, the nature of the questions which the decision maker must answer and the fact that linear programming algorithms can be used to obtain solutions. Its major weakness is uncertainty about the effect of sampling errors. Unfortunately, this weakness is shared by most alternative methods as well.

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## MANAGERIAL USES OF RISK-MANAGEMENT RESEARCH

Ron Raiker

My perspective on this topic is based on some academic experience and some more recent experience as a farmer. The academic experience was research and teaching in the Department of Economics at Iowa State University during 1970-78. Since then I have been farming in east-central Nebraska. The farm is a family owned operation involving about 2000 acres. We raise corn, both dryland and irrigated, soybeans, grain sorghum, and some winter wheat. In addition we feed some cattle, have a small seed and farm supply business, and do some construction work (tiling and earthmoving) both for our own operation and on a custom basis. There are two full-time employees in addition to me and some part-time help.

Farming during the last seven years has not been uneventful. As background to some comments on risk-management research let me quickly point out some of the events that have made the biggest impression on me.

### The Current Crisis

In the 1970's the farm economy was characterized by expanding export markets, high inflation, and low real interest rates. During 1970-81 exports tripled in volume. Farmers responded to the increased exports and higher commodity prices with heavy investment in land and machinery. Land values appreciated rapidly--as much as 30% in one year in Iowa--and machinery capacity increased substantially. There was, probably not surprisingly, heavy use of debt capital. Consequently debt increased by about 10% per year during the period. Although my timing was such that I got in on only the last two or three years of this, I can recall that the annual review with the lender was usually a pleasant experience. Usually you had an operating profit assuming constant real estate values. But even if you didn't you had the warm feeling that any operating loss had been more than offset by the appreciation in land and machinery values.

The situation has changed drastically in the 80's. There is lower inflation, a much higher real rate of interest, and a much stronger dollar. This has led to a sharp drop in exports and lower commodity prices. The lower commodity prices along with higher interest rates have combined to stop and sharply reverse the appreciation in land and machinery values. In our area land values are about 40% of their peak in 1981 and apparently still falling. The annual review with the lender is much less pleasant. An operating profit with constant real estate values is rare, especially if the operator has significant debt. But, even if there is an operating profit you have the sinking feeling that it is no doubt more than wiped out by the decline in land and machinery values.

The financial stress among farmers brought on by these conditions has been documented by a recent USDA study (1). The study focused on 679,000 "family sized farms" (sales \$50,000 to \$500,000 annually) which are the mainstream of family farm commercial agriculture. The level of debt is the index of stress. By early 1985, 6.3% of these family farms were technically insolvent (debt exceeds assets), 7.3% were very highly



leveraged (over 70% debt to asset ratio) and thus have extreme cash-flow problems, and 20% are highly leveraged (40-70% debt to asset ratio) with serious cash-flow problems. This implies that fully one third of the commercially sized family farms have financial stress ranging from serious to insurmountable. Further, the authors of the report on the study project that about 13% will be out of business in one year barring a miracle, and perhaps an additional 10% will succumb within two years.

This crisis has become a major national event. Both individual farmers and state and national policymakers are trying to decide what happened and what to do now that it has. Blame has been variously assessed to factors beyond the control of farmers (interest rates, strong dollar) and to farmers themselves (greedy consenting adults). To my knowledge risk management researchers have not been widely cited as villains. This is in spite of the fact that some of those in financial trouble may have made poor use of risk management research, or made use of poor risk management research, or both. But even if this isn't the case, I think this crisis has some implications for risk management research.

#### Implications for Risk Management Research

I'll begin with the following general observations. First, among the decisions a farm manager must make those concerning acquisition of productive assets appear to have been the most critical in dividing those who are facing financial stress from those who are not. Second, at least for many of those in trouble, the possibility of the current economic environment was not even perceived. That is, the possible states of nature in their decision models didn't include the combination of low commodity prices and high real interest rates that has occurred. And third, on the surface it seems that those who behaved irrationally in the 70's by underusing credit are most likely to be the survivors. Was this underuse of credit irrational or was it the rational result of some more (or less) sophisticated decision model?

More generally, it may be helpful to try to address these questions: What sorts of decision models would have yielded successful strategies for farm operators during the late 1970's and early 1980's? In 1985?

Asset Acquisition. It seems clear that decision models need to address investment/disinvestment in productive assets head on. For land and many types of machinery there are many possible alternatives ranging from cash purchase/sale, to various purchase/sale contracts, to a host of rental arrangements. There is no doubt room for progress in identifying the pertinent alternatives and devising ways to measure and compare risk among them. In addition there is need to consider relationships between production and financial risk of certain activities. For example, an investment in irrigation equipment may significantly reduce production risk by reducing the variability (and increasing the mean) of yield. But this reduction in production risk may be more than offset by an increase in financial risk, especially if it is a cash purchase financed by debt capital.

Financial Leverage. The level of financial leverage must be monitored. But the use of an arbitrary limit is somewhat troublesome. A limit (e.g., 40% debt to assets) that everyone would have considered to be



conservative in 1979 now might be considered irresponsibly high. Even if there is some rationale for a specific limit it is likely that there would be situations in which it would be prudent to exceed it. On the other hand, unwise investments should not be given a better chance just because financial leverage is low. The limit on financial leverage should therefore be endogenous to the model. The mechanism for setting the limit should take into account that over the long pull, return on assets in agriculture has been less than in most other industries. Thus survivable levels of financial risk are probably less in agriculture than in most other industries.

Planning Horizon. Decision makers, I believe, tend to take an incremental approach; they attempt to commit themselves to as little as possible for as short a time as possible especially when they perceive the risk to be high. But a multiperiod model is necessary because, although the activity levels for only the first period are relevant, the impacts of activities in the first period on opportunities available in later periods must be considered. The multiperiod strategy must be arrived at, then, by reformulating and resolving the multiperiod model each period.

Objectives and Attitude Toward Risk. I am woefully unqualified to comment on the theoretical appropriateness of alternative specifications of decision maker utility functions. I can, however, comment with some authority on my own views about objectives and choices among risky prospects. I am comfortable with an objective of maximizing the present value of the firm's net worth. In attempting to achieve this objective I tend to make choices in the following manner. I tend to focus on what I expect the outcome to be and on what I perceive to be the worst possible outcome of an activity. Thus, for me semivariance is probably a more appropriate measure of risk than variance. I have not been a heavy user of either federal crop insurance or hedging in the futures market. In my situation it usually seems the price is high for the coverage afforded. In the case of government wheat and feedgrain programs, on the other hand, the price has seemed quite reasonable and I have participated. When comparing alternatives, other things equal, I prefer the one that requires commitment over a shorter time period (or offers more frequent opportunities to bail out or change direction). Quite often this leads to a choice of more labor rather than more capital in a production process. Also, I prefer a smaller commitment to a larger one. These two preferences usually lead me away from the least-cost production process—large scale and capital intensive. Finally, other things equal I prefer activities with which I have had some experience - on the presumption I may be able to avoid making some of the mistakes twice.

States of Nature. It may be that the success of decision makers in recent years has hinged on their abilities to recognize possible states of nature and to assign and revise probabilities. The difficulty of the agricultural production environment was first that states of nature which were assigned a zero probability by many occurred, and now there is less uncertainty especially about commodity price levels and real interest rates but the likely state of nature is undesirable. I think most farm managers are not good at incorporating all the available and relevant historical information about the economic environment into their probability distributions over states of nature. Research efforts to provide this information could make a valuable contribution.

Issues. The events of recent years suggest some issues that might be addressed by those interested in applied research. Perhaps the major issues are those that deal with acquisition and pricing of major inputs and pricing of services rendered and products produced. Some specific questions are the following. What is the best combination of debt and equity capital? How should major productive assets like land and machinery be acquired (or disposed of)? How should outputs be priced? To what extent should producers attempt to sell services (e.g., custom farming or feeding) rather than finished products?

#### Summary

I believe that risk management research has been of value to farm decision makers and those who advise them. I also believe that the current financial crisis and the events that have led up to it provide a good opportunity to re-examine what has been done and to add significantly to it. I urge you to take advantage of this opportunity.

#### References

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