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Risk Modeling in Agriculture: Retrospective and Prospective

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PROGRESS IN RISK ANALYSIS IN REGIONAL PROJECTS

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This meeting is the final one of Regional Research Project S-232. As no new regional project is being initiated currently by the members of this Project, this meeting appears to terminate regional research on production risk. This project was preceded by two other regional research projects on risk — W-149 and S-180 — with considerable overlapping membership. The members of S-232 have elected to apply for an Information Exchange Group that will continue the tradition of annual meetings on risk in agricultural production. The contributions of these three regional projects are worth noting and that is the purpose of this paper and the others associated with this panel discussion. This discussion first briefly discusses the context of the beginning of these regional projects. The focus of the projects is then discussed, and major accomplishments overviewed. Then, the emergence of interests in environmental and resource economics, the focus of the proposed Information Exchange Groups, is reviewed. The final section briefly reviews continued issues for future research.

Initiation of the Research Project

The first meeting of W-149 was held in Fall, 1975. It was largely an organizational meeting and featured non-academic speakers. The first meeting with numerous research presentations was in Denver in 1977. I attended this meeting as did the other two participants on the panel discussion, Rulon Pope and George Patrick. The turnover in the group over time and perhaps our age are indicated in that only one other person, Harry Mapp, attended both the 1977 and this meeting.

That initial meeting and subsequent meetings were exciting times for all of us. Widespread risk analysis in agricultural economics was just being initiated. Most of us had limited experience on the topic, and the theoretical and empirical risk concepts had great promise in applications to problems in agricultural economics. Many early participants had the reaction that Paul Samuelson recalled in 1946 to Keynes' General Theory publication:

> "I have always considered it a priceless advantage to have been born as an economist prior to 1936 and to have received a thorough grounding in classical economics. It is quite impossible for modern students to realize the full effect of what has been advisably called 'The Keynesian Revolution' upon those of us brought up in the orthodox tradition. What beginners today often heard as trite and obvious was to us puzzling, novel, and heretical.
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> To have been born as an economist before 1936 was a boon—yes. But not to have been born too long before! ? 'Bliss was it in that dawn to be alive, but to be young was very heaven'!

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> The General Theory caught most economists under the age of thirty-five with the unexpected virulence of a disease first attacking and decimating an isolated tribe of south sea islanders. Economists beyond fifty turned out to be quite immune to the ailment. With time, most economists in-between began to run the fever, often without knowing or admitting their condition."

Similar to Samuelson's reflections, the excitement about W-149 reflected emerging agricultural economics issues and increasing availability of theory and methods for risk analysis. While unstable production and prices are defining characteristics of the agricultural economy, agricultural prices and incomes became much riskier in the 1970's. Earlier, substitution of income payments for high price supports in federal commodity programs resulted in major crop prices being determined with markets rather than policy price floors. Increasing international trade on U.S. agricultural commodities in the 1970s resulted in output prices being subject to supply and demand shifts throughout the world in addition to this country. Crop output prices therefore became much more risky. As crop outputs are major inputs into animal production, costs of production and therefore supply and prices of livestock products also became more risky. Fluctuations in output prices were also matched with fluctuations in prices of inputs from outside the agricultural sector. The formation of OPEC caused energy prices, a major direct and indirect component in crop cost of production, to rise and then decline as the cartel was alternatively effective and not effective. Other input prices were also increased with the general increasing inflationary process during this period. In addition, some evidence also exists that crop outputs were becoming more variable (Hazell 1984). Overall, this pattern made net farm income much more risky. This risk also was felt among other economics agents in the agricultural sector including consumers. Agricultural economists were interested in research and education on these problems both at the farm management and the public policy level.

Fortunately, theories and methods had been developed in economics to analyze risk problems. The most systematic effort had been in finance. Copeland and Weston list six theories about risk, as the foundation of modern finance theory: (1) utility theory, (2) state-preference theory, (3) mean-variance theory and the capital asset-pricing model, (4) arbitrage pricing theory, (5) option pricing theory, and (6) the Modigliani-Miller theories. The major articles outlining these theories all were published at least by 1977. Advances in the theory of the firm under risk were also occurring — Sandmo in 1971 and Batra and Ullah in 1974 wrote articles particularly influential in agricultural economics. The theory of stochastic dominance was also being developed (Hanoch and Levy; Hadar and Russell; Meyer, 1977).

These emerging economic theories were accompanied by a surge of literature on risk in agricultural economics. Eidman, Dean, and Carter in 1967 and Carlson in 1970 were early applications of decision theory in farm management. Halter and Dean completed an early textbook on risk analysis in farm management in 1971. Hazell (1971) also published his article on a linear programming approximation to quadratic programming in that year. In 1974, the influential articles by Just and Lin, Dean and Moore appeared. In 1975, Hazell and Scandizzo incorporated risk in an aggregate math programming model. Barry and Willmann, and Barry and Fraser had articles on risk management in 1976; Baquet, Halter, and Conklin also published an article on value of information under risk in that year. Activity further accelerated in 1977. Anderson, Dillon, and Hardaker's treatise on risk appeared. Robison and Barry (1977) presented and implemented a theoretical framework to analyze changes in risk. Boehlje and Trede had a managerial article on risk management, and Walker and Nelson released their survey of risk

management literature. The above review is just a sample of the surge in agricultural economics literature during this time period.

Thus, risk had emerged as a serious management and policy problem in U.S. agriculture by 1977. Research output in finance, economics, and agricultural economics on risk was accelerating. This combination provided the basis for the initiation of W-149 and the excitement among early participants.

Problem Emphasis on Projects

As risk analysis was largely a new area in agricultural economics in 1977, it is not surprising that the scope of the project was quite broad. Production, finance, marketing, and policy were all included. Research interests included both firm and aggregate analysis at both theoretical and applied levels. Participants with marketing interests were limited and did not continue throughout W-149. The Barry volume that summarized activity of the project did include chapters on all the above topics and problems with the exception of marketing.

Subsequent projects, S-180 and S-232, were much more focused. Participation by those interested in finance and aggregate policy issues dwindled. Research focus of the participants were largely on farm management and firm production issues. This further specialization of the project focus reflected the increased integration of risk in agricultural economics analysis. Consideration of marketing, finance and policy became part of more specialized research projects in these areas. Thus, part of the function of W-149 of provision of a forum for general risk analysis in agricultural economics had been accomplished. While the regional project was becoming more specialized on production, a focus on environmental and resource issues also was emerging. This focus is explicit in the proposed Information Exchange Group. This evolution is discussed in more detail later in this paper.

Major Accomplishments in Research Approach

The research approach in risk analysis also evolved considerably during the three regional projects. A major trend was the increasing emphasis on a positive rather than a prescriptive approach. Just and Lin, Dean, and Moore had began this trend with their influential articles that demonstrated that risk aversion predicted behavior. A further evolution occurred in the early phase of W-149. At an early meeting, a proposal was made that participants cooperate in eliciting utility functions of farmers. The decision was deferred for a year while a subcommittee considered the proposal. The subcommittee report was provided in Young, Lin, Pope, Robison, and Selley. Young is a more accessible article that essentially has the same content. This report was very critical of the validity of elicited utility functions. After that report, limited interest existed in empirical utility functions. Without that component, full empirical application of decision theory was not given widespread consideration.

An additional development that lessened the early optimism about risk analysis could be called the McCarl Hypothesis, in honor of one of its earliest and most constant supporters. This proposition is that risk aversion is not necessary to explain behavior if the risky choice set is fully specified. Brink and McCarl was one of the first articles to make this point. Subsequent articles are reviewed in Musser, McCarl, and Smith. While most participants do not fully accept

this hypothesis, it does provide an alternative to the standard maintained hypothesis that risk preferences matter.

Much of the empirical analysis under the projects, had a risk efficiency criteria approach. With much concern about the necessary assumptions for E-V analysis that underlay portfolio analysis, much emphasis was placed on stochastic dominance. Cochran has provided an extensive review of this literature. Stochastic dominance with respect to a function gained much popularity after the initial applications of King and Robison, and Kramer and Pope. Interestingly, the finance literature expressed less concern with these assumptions, and E-V models continued to be widely used — for example, Copeland and Weston largely uses such an approach. Perhaps, the positive tradition is stronger in finance.

It seems that part of the differences on this issue also is being resolved in agricultural economics. Robison and Barry (1987) prepared a theoretical text based on E-V analysis. Also, Meyer (1987) provided a new theoretical justification for E-V analysis that has broader appeal than the earlier assumptions.

Despite the interest in stochastic dominance, much progress was also made on risk programming during this period. This continued interest relates to the limitations of stochastic dominance for analyzing continuous choice variables, for which math programming is more clearly suited. Boisvert and McCarl reviewed the various model formulations and literature on applications. Several salient issues can be noted. First, limitations in computer software and hardware stimulated much interest in linear programming approximations to quadratic programming. The latter was preferred because of its direct relationship to theoretical portfolio models. However, advances in computer technology has reduced interest in this issue. Quadratic programming is now used in most applications. Advances in computer technology also increased application of discrete stochastic programming. Apland and Hauer have reviewed literature on this technique. This method extends the range of analysis from stochastic objective function to stochastic technical coefficients. A final central issue concerns safety first models. Safety first formulations of risky choice have considerable intuitive appeal despite theoretical limitations. Target MOTAD, developed by Tauer, was the most popular largely because it had solutions consistent with stochastic dominance, which was widely used in this period.

Many other issues of theory and empirical methods were issues during the research project. Two unresolved issues concern alternatives to expected utility theory and sources of risk. Besides the attention to safety first models mentioned above, generalization of expected utility theory (Machina) and psychological alternatives (Thaler) received attention. Empirical analysis of farm surveys concerning sources and responses to risk was an important activity in S-180 (Patrick, et al.). These surveys found multiple sources of risk but affirmed that price and output risk was perceived as most important. From a management problem perspective, comprehensive analysis of multiple sources of risk seems important. However, much theoretical analysis tends to focus on limited sources of risk in order to obtain tractable results. This tension between problems and theory have not been resolved.

Emergence of Environmental and Resources Interests

Analysis of the impact of environmental and natural resources, management and policy on agricultural risk began in S-180. A subcommittee on natural resources met on a regular basis

at annual meetings. One of the outcomes of this action was a symposium in 1985 (*Incorporating Risk in Analysis of Farm Management Decisions Affecting Natural Resource Use*).

This interest had several origins. Many production decisions using natural resources or having an impact on the environment have a stochastic component. The use of resources as inputs interacts with natural phenomena which are not deterministic. The initial focus on irrigation, pest management, and soil erosion reflects this interaction with random elements. It was a logical extension of the interests of this group to consider the risk at the production/resources interface. Much of the initial research used biophysical simulators that were initiated by Mapp and Eidman and reviewed in Musser and Tew and Boggess. Theoretical developments of the risk response functions (Just and Pope) were also useful in conceptualizing this research. This formulation made it quite clear that such inputs as irrigation and pest control affected both the expected value and risk of production.

Subsequently, the level of interest in resource issues and broader to include environmental problems associated with nutrient and pesticide use. An index of this emerging interest is the recent treatise, *Agricultural and Environmental Resource Economics* (Carlson, Zilberman, and Miranowski); many of the authors of this volume also participated in the regional projects. The increasing interest in this general area is undoubtedly related to increasing societal interests in agricultural externalities that resulted in increased research funding opportunities. With decreasing overall budgets for agricultural research, it is not surprising that members of this project increasingly reoriented their research to this area.

The Future?

Current economic events indicate that risk in production, resources, and the environment will continue to be important in agricultural economics. Federal budget deficits will continue to place pressure to continue the evolution to a more market oriented commodity policy. Trends to more international markets reflected in NAFTA and GATT will contribute to further price instability. Price and income risk therefore will continue to be issues. Commitments to control environmental impacts of agricultural production also seem to be increasing. For example, Clean Water Act Amendments being considered in Congress may mandate that states develop policies for agricultural pollution. This policy evolution will also provide opportunities for production-resource economists interested in risk.

Research in agricultural risk will also be interesting because a number of theoretical and methods issues are still unresolved. While listing such issues is a subjective process, I will provide my views to close this paper. Most are related to topics considered above. A fundamental issue is for which decisions is risk aversion important? Increasing understanding of this issue could simplify theoretical and empirical analysis. A related issue concerns the set of theories about choices under risk. For example, expected utility, safety first and/or psychological theories may be superior in explaining certain decisions. Sources of risk in theoretical and empirical models and in perceptions of decisions makers also warrants more research. Despite some progress, risky choices in intertemporal decisions also has not been satisfactorily resolved. Finally, the impact of environmental controls on farm income risk is largely an unexplored area.

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