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

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CONVEX SET STOCHASTIC DOMINANCE: A DISCUSSION

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Generalized stochastic dominance is rapidly becomg a widely used analytical tool for applied agricultural economics research. A review of recent literature reveals generalized stochastic dominance or stochastic dominance with respect to a function (SDWRF) techniques applied to the evaluation of crop plans, rent strategies, risk preferences, commodity program participation and weed control methods. The convex set stochastic dominance technique which has been presented by Cochran, Lodwick and Raskin (CLR) represents one of the theoretical, operational and empirical modifications to SDWRF which will be forthcoming in the near future. But before presenting some specific comments on their paper, I would like to first address a concern and an opportunity I see in this proliferation of applied stochastic dominance research.

The concern lies with the mechanical ease with which these techniques can be used (Wilson and Hwang). Interpretation of stochastic dominance results demands only a superficial knowledge of the programming algorithms involved. Computer output tells the operator which action choices dominate under the given assumptions, in almost a "black box" fashion. Other algorithms used in risk management research such as quadratic programming and MOTAD models lend themselves to a far greater level of substantive interpretation of shadow prices, slack variables, constraints, alternative specifications of the objective function, etc. The researcher using SDWRF should be encouraged to incorporate print statements into the program to gain insights from intermediate output summarizing the ranking process. Capabilities for graphing the cumulative probability distributions used in the analysis should also be considered seriously. With these adjustments, the mechanical nature of stochastic dominance analysis would represent an advantage and not a possible shortcoming. In any case, an understanding of the theoretical foundations, programming algorithms and limitations of stochastic dominance analysis is crucial to the appropriate use of this research tool. This brings me to a brief discussion of the opportunity.

I perceive a future need to consolidate the stochastic dominance literature, as applied to agriculture, into one source. Such a monograph, technical bulletin or book would contain the theoretical, applied and empirical treatments of the subject. The researcher who is unfamiliar with the subject would consult one source for an

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introductory treatment of the subject matter without being forced to review six or seven journal articles, two books and several technical bulletins. Possibly such an effort is in progress of which I am not aware. Zentner and others made an attempt at summarizing this literature, but their presentation is lacking in empirical applications and the computerized implementation of the techniques. The technical committee of S-180 might consider a consolidation of this literature within its purview and the responsibility of a subcommittee in the not too distant future. A historical precedent for this type of work is Doug Young's risk preference subcommittee in W-149.

Cochran, Lodwick, and Raskin's paper has provided a catalyst for thinking about the need for some summary work because the authors begin their paper with a review of stochastic dominance techniques. I question whether a summary this detailed is needed, especially for first, second and third degree stochastic dominance which are adequately explained on a theoretical level in one or two sources. The sources on SDWRF are far more diverse but should be known to the researcher in this field. Again, CLR's review section which takes nearly eight pages could be shortened considerably if the literature were consolidated.

The discussion of Type I and Type II errors is valuable, especially for those using generalized stochastic dominance techniques. Specification of the width of Arrow-Pratt intervals and the shape of the risk aversion function contribute significantly to the determination of the dominance results. Care must be taken to develop a rationale for the interval width and function selected. Rejection of a true hypothesis is a real danger with SDWRF. A sensitivity analysis of the rankings can provide insights into the importance of these errors. Although King and Robison have initiated this research effort, definitely more work is needed on the importance of Type I and Type II errors, how to measure them and determine when these errors are most likely to occur in applied research.

Reducing the size of efficient sets of action choices has long been an objective of decision scientists using stochastic dominance. Portfolio analysis traditionally has generated large, efficient sets. CLR argue that it is possible with generalized stochastic dominance to reduce the set to one action choice. Empirical evidence demonstrates that a narrow Arrow-Pratt interval handles this task quite well. The authors state that narrow intervals generate high levels of Type I errors when SDWRF is used. However, my experience with generalized stochastic dominance demonstrates that the shape of the cumulative probability distributions may be a more determining factor than the width of the interval. This point will be explored more fully towards the end of this discussion.

Convex set stochastic dominance (CSD) provides the flexibility in other efficiency criteria (e.g., second-degree stochastic dominance) to avoid Type I errors. This is a significant contribution, particularly when forecasting applications are required. By generating an "envelope" or convex distribution, CSD insures that the efficient set "contains only the action choices that at least one decision maker would actually prefer...". The usefulness of this procedure is clearly seen in extension work. Risk efficient variety, fertilizer, and cropping recommendations now can be made for a group of decision makers with a reasonable degree of assurance that the efficient set would contain the preferred choices. A wide Arrow-Pratt interval range could produce a similar ranking but not provide the inclusiveness of the convex set. Of course, even in CSD the Arrow-Pratt interval range must be relevant to the group of decision makers. But CSD provides a check and a balance so generalized stochastic dominance does not eliminate those choices which would be selected by at least one individual.

The formal model and algorithm for implementing CSD are presented in the paper in a straightforward manner for those who are familiar with the SDWRF algorithm. For the uninitiated, the simple example using three distributions gives the reader an intuitive understanding of the convex combination process. The example would be clearer, however, if the authors discussed the influence of the Arrow-Pratt coefficient or function in this ranking.

CSD is applied by the authors to a pest management problem faced by Michigan apple producers. Alternative scab control strategies were generated using simulation techniques and distributions of expected net revenues were ranked using generalized stochastic dominance and CSD. The results demonstrate the additional flexibility of CSD as an efficiency criterion. Several questions come to mind in reviewing their results. What effect does CSD have on SDWRF when the absolute risk aversion interval is constant? Does CSD increase the size of the efficient set? Why was a mixed absolute risk aversion function chosen when theoretical claims, supported by some empirical work, are that decision makers exhibit decreasing absolute risk aversion (Wilson and Eidman)? How sensitive are the results to alternative forms of the risk aversion function? These types of questions should be answered in future CSD research.

Toward the end of an earlier draft of their paper, the authors identify the accurate specification and measurement of probability density functions as a major task for decision scientists. I agree with the authors that further work needs to be done on the distributions we use. Distributions of net worth, net income, and after-tax cash flows present decision choices to the individuals, but do they represent the correct decision variables? Can the concepts of business and financial risk be incorporated into these formulations? Do we have a clear understanding of what the decision makers' subjective probability distributions look like? As mentioned earlier, the analysis of the shape of cumulative probability distributions is a vital research step for the analyst using stochastic dominance techniques. Errors in choosing data sources, type of probability distribution (e.g., normal vs. gamma), and the economic variables to be used in the model influence distributional shape and hence, the final ranking of action choices even with CSD.

Figure 1 represents three recent examples of simulated cumulative probability distributions of action choices which were ranked using SDWRF. Panel A and Panel B represent obvious candidates for CSD. Distributions are overlapping and the probability of a Type I error is high if a narrow Arrow-Pratt range (R) is used. For example, in Panel A one action choice (Number 4) was preferred over all the others for $0.000092 \leq R(\cdot) \leq 0.0035$. CSD combined with SDWRF should expand this efficient set to reduce the probability of discarding a preferred action choice. Panel C represents an empirical example where CSD may not be necessary. With these action choices the efficient set is constant over a wide range of Arrow-Pratt values and functions. So I would reword the authors' statements to read that "the potential for CSD to reduce efficiency sets should be greatest for situations involving large <u>and similar</u> choice sets and large classes of decision makers with heterogeneous preferences." The most significant contributions of CSD is that it enables us to begin to concentrate on these distributional and modeling questions in our research instead of dwelling on the probabilities of Type I and Type II errors.

Finally, if the stochastic dominance techniques discussed above are going to prove themselves to be meaningful research tools, practitioners of decision analysis under uncertainty must demonstrate how well these tools predict <u>a priori</u> the actual decisions made by our clientele group. To date our efforts have concentrated on the generation of efficient sets of action choices. But do these sets actually contain those choices selected by the decision maker? Can we use these tools to predict farm behavior to new government commodity legislation such as PIK and the new dairy herd reduction program? A Lin, Dean and Moore-type study where predicted and actual decision choices are compared appears to be a needed and fruitful research effort. Only then will we gain assurance that the stochastic dominance path we are on will yield lasting and beneficial results to society.

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