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9. ABSTRACT

Presents the personal reflections of a participant at the Agricultural Development Council conference in 1976. The conference concerned how risk and uncertainty about the outcome of production and investment decisions by individuals affect the development process of developing countries. The basic concern is how risk and uncertainty affect the efficiency of production and investment decisions by individuals, firms, and governments, how risk and uncertainty affect the distribution of income and wealth among households, and how risk and uncertainty affect policy prescriptions and the effectiveness of policy tools. The conference was unable to reach conclusions on the role of risk and uncertainty in many development problems because there is a scarcity of empirical evidence on probability distributions; evidence on attitudes towards risk of development actors is still scarce, and there are few risk specific policy alternatives to deal with possible adverse consequences of risk aversion. For decision theory to be more useful, it will be necessary to improve the enpirical knowledge in the area and to simplify and standardize the methodological tools.

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RISK AND UNCERTAINTY IN AGRICULTURAL DEVELOPMENT

NOTES ON AN A D C SEMINAR

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Risk and Uncertainty in Agricultural Development : Notes on an A.D.C. Seminar*

Hans P. Binswanger

These notes are not a summary of the Conference. Rather they are a set of personal reflections of one participant whose interest was primarily in the area of risk and adoption of technology. In parts these notes overlap with Roumasset's more elaborate Conference summary, although I have tried to avoid redundancies.

The Seminar was indeed an excellent place for exchanging ideas and making up one's mind where major knowledge gaps exist. I would like to thank the organizers for providing this opportunity.

The Conference had set as its task the furtherance of understanding of how risk and uncertainty about the outcome of production and investment decisions by individuals affect the development process of developing countries.

In trying to understand the role of risk and uncertainty, we are basically concerned with (i) how risk and uncertainty affect the efficiency of production and investment decisions by individuals, firms, and governments (i.e. what are the growth implications), (ii) how risk and uncertainty affect the distribution of income and wealth among households, and (iii) how risk

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* Agricultural Development Council, Research and Training Network Seminar on Risk and Uncertainty in Agricultural Development, held at CIMMYT, Mexico, March 9-13, 1976.

and uncertainty affect policy prescriptions and the effectiveness of policy tools.[1]

In Table 1 these basic reasons are further broken down into question complexes or concerns in which the attitude towards risk of the actors or decision-makers involved may potentially have a major influence. All these question complexes and actors were considered at the Conference although some received much less attention than others.

Among the actors whose attitudes towards risk might matter, only farmers received much attention at the Conference. The areas receiving most attention were the consequences of attitudes towards risk for the adoption of technology (Area 1), for price and stabilization policy (Area 7), and for rural institutions such as share-cropping (Area 6). Little was said about regional investment strategies (Area 3), which may explain why attitudes of planners and policy makers did not receive much attention. While distributional effects (Area 2) figured prominently as a concern, little formal analysis has yet been done on this topic.

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1 Anderson at the outset of the Conference distinguished between (1) normative, (2) predictive, and (3) analytical uses of models of decision-making under risk (Anderson, Table 1). For developing countries normative uses will for a long time to come be confined to the analysis of large investment decisions. Such models will not become a farm management tool for use in planning individual farms or even for groups of farms. Analyst's time investment for that is simply too large for the payoffs which can be expected from such applications.

The main applications can therefore be expected to occur in trying to predict future actions of groups of individuals and in analytical uses with a goal of either improving methodology or influencing policy. These notes will therefore pay little attention to normative uses of models of behavior under risk, with the exception of potential uses in regional or national planning exercises.

Table 1. Reasons to be concerned about attitudes towards risk of various actors in the development process

Concerns	Actors whose attitude towards risk are involved
1) Adoption of profitable but risky technology by farmers (with emphasis on efficiency implications)	Farmers Money lenders Credit institutions
2) Income-distribution implications of differential risk aversion and its implication for crop choice, adoption behavior, and credit use (who will grow/survive in a dynamic environment)	Farmers Money lenders Credit institutions
3) Regional planning and investment strategies, e.g. whether to concentrate investment on high-potential/low-risk regions or not	Policy makers Administrators Donor agencies
4) Agricultural research strategy, e.g. on which regions to concentrate research investment, or what emphasis to give on stability of technology as against productivity	Farmers Researchers Research Administrators
5) Attitude towards risk as determinants of rural institutions (e.g. share cropping)	Farmers/Landowners Laborers (Potential share Croppers) Leaseholders
6) Take account of attitudes towards risk in output supply analysis	Farmers
7) Increase utility by reducing fluctuations in outputs, prices, and incomes (price and output stabilization)	Farmers Consumers Government

In none of the areas was the Conference able to clearly come to an agreement as to whether risk and uncertainty had a strong influence on actors' behavior. If adverse growth or equity implications were likely to result from the influence of risk and uncertainty, the Conference was not able to agree on policy measures either. This paper is an attempt to understand the reasons why agreement was not reached on any of these questions.

In doing research on policy questions in which risk aversion might play a role, the following four problems have to be solved:

(1) How should the decision process of the actors involved be modelled?

(2) What are the probability distributions of the outcomes of the alternatives available to the decision makers? (Depending on the context or the model, these will be objective or subjective probability distributions.)

(3) Are the decision makers sufficiently risk averse (or risk preferring) to make it necessary to take divergences from expected profit maximization into account in predictions and policy recommendation? Who are the decision makers whose risk aversion counts?

(4) If risk aversion has adverse efficiency or distributive consequences, what can be done in terms of policies to redress these consequences, i.e. what are the policy instruments available?

In the remainder of this paper, I will try to trace the disagreements which surfaced at the Conference to more specific disagreements on the above four questions. I will use the concern about the effect of risk aversion on adoption of technology as the main example, and not give much emphasis to any other question complex discussed at the Conference. It is not that the other questions are unimportant, but my own interest is primarily in the area of adoption.

1) Modelling Questions

On the methodological side, the Conference concentrated heavily on maximizing methods [see Anderson (1976), Table 2, or Roumasset's review paper (1976a)]. In particular, two groups of models were strongly contrasted:

(a) Models based on a utility function (Bernoullian, Baysian decision models);

(b) Models based on simpler safety criteria (Safety first, lexicographic safety first, and cautious optimizing, etc.)

Much of the time was spent on differentiating these models, but in order to make further progress it seems to be necessary to emphasize their common aspects and the common methodological problems which confront them at this time.

One point which has been emphasized several times is an apparent similarity of predictions of the two classes of models. Of course, this is still a somewhat casual impression. In few cases have models from both classes been applied to the same problem on the same agricultural data set from developing countries. Identification of most researchers with either of the approaches usually prevents such comparisons.

A second similarity of the approaches is that both require some knowledge about the attitudes towards risk of the decision-makers whose decision is modelled. The utility-based approaches require the elicitation or estimation of the utility function, with all the potential

misgivings one might have about any actual procedure to do this. The simpler safety-based approaches typically require the elicitation of disaster levels of income, focus losses, flexibility constraints, or safety zones.

Unless one chooses these simpler representations of attitudes arbitrarily, or bases them on some past observed income requirements, I cannot see why their elicitation or econometric estimation should be easier or less hazardous than elicitation of utility functions.[2]

Most importantly, all the major approaches are now based on personal or subjective probabilities of outcomes of different choices. In comparison to the emphasis placed on attitudes towards risk and their determinants, little was said at the Conference about personal probabilities, except that Dillon's paper listed the difficulties encountered in eliciting them and there was agreement that eliciting probabilities is indeed more difficult than eliciting attitudes towards risk. However, it seems to me that many methodologies, disputes, and many important empirical questions will remain unresolved until more knowledge exists about how personal probabilities are formed and how they are revised.[3]

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2 See Kennedy's paper presented at the Conference.

3 Two models of learning were presented at the Conference, one based on Bayesian theory which fits well into the utility-based theories (see Dillon), and the other on Day's model of learning by a cautious optimizer.

For the adoption question the manner in which subjective probabilities are formed makes a great deal of difference in the distributional outcomes of a sequence of innovation cycles. The capacity to learn new probability distribution accurately is crucial for successful early adoption. In a modernizing agriculture, innovators' rents to early adoption of new technology may have major effects on intrafarm income distribution and survival, and who captures them is an important distributional question.[4]

The interaction of risk and learning is important and is emphasized by the conclusions of Hazell and Scandizzo's paper. The authors state that optimally distorted prices of risky commodities may improve aggregate welfare over the levels reached at competitive equilibrium. However, this conclusion is totally dependent on the process by which expectations about risky outcomes are formed, as Newbery (1976) has shown. Hazell and Scandizzo assume a simple distributed lag process

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4 Risk aversion and learning speed affect adoption in two different ways. Fertilizer adoption may be permanently below the profit-maximizing level because the utility maximizing level which takes risk aversion into account, is lower than the former. In terms of efficiency considerations, this is the most important question. If risk aversion is negatively associated with wealth, it will also affect income distribution since the poorer groups would remain further away from profit maximizing levels than the richer groups. These effects would be permanent whereas learning speed has only temporary effect. If capacity and incentive to learning are also negatively associated with wealth, the poorer groups will not share in innovators' rents, even if they accept innovations--such as fertilizers--upto their utility maximizing level after a lag.

of expectation formation with independence of price expectations from quantity expectations. When this model of expectations is replaced by a rational expectation mechanism of profits, which takes covariances between marketed quantities and prices into account, no aggregate welfare gains accrue from distorting prices in the way proposed by Hazell and Scandizzo.

Since the utility-based models and the "safety" models lead to similar predictions, encounter similar problems in eliciting information about the actors' attitudes, and both need to take better account of learning behavior, little will be gained from further model differentiation at this stage. For further progress we will require empirical rather than theoretical answers. We therefore turn to empirical questions about probability distributions of outcomes and extent of risk aversion which are germane to the whole adoption question and many policy issues.

2) Probability distributions of outcomes[5]

Most of the models of behavior under risk are built in terms of personal probabilities of outcomes. No paper was presented at this

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5 The discussion of how to define risk in the first place is reviewed in Roumasset's summary. Boussard, in following Shackle, raised the issue that farmers cannot be expected to hold well-defined probability distributions of outcomes and that some simpler devices such as focus loss deserve more attention. Our experience in India suggests that as far as yields are concerned, farmers themselves reason in terms of "so many years out of so many," which is a well-defined probability concept. Distributions of prices and therefore gross returns may be much less well defined and simplified approaches may be more appropriate there.

Conference in which elicitations of subjective probability distributions on substantial numbers of farmers had been done. However, Gerald O'Mara, in a study not reported at the Conference, elicited personal probability distributions for two maize-growing techniques under irrigation in Mexico from 84 farmers and did not report unusual difficulties. In most cases the modern methods did not seem to be subjectively more risky than the traditional one. Note, however, that several studies have shown that analysts can influence to a large extent the subjective probability distributions elicited.[6]

Roumasset (1976b) developed an approach of combining personal probabilities of certain "disasters" such as major pest outbreaks and typhoons with experimentally derived production functions to arrive at subjective expected production functions for fertilizer on rice. His approach is an advance since it is simpler to elicit probability distributions of disasterous events than of yields. For example, most farmers are able to specify the number of severe drought years they expect in a 10-year period.

Using this approach for a well developed area in the Philippines, he found that fertilizer applications do not substantially increase financial risk and therefore risk aversion cannot be the primary cause of fertilizer applications which fall seriously short of profit-maximizing levels, regardless of whether farmers are risk averse or not.

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6 See Dillon for a discussion on elicitation studies and Kunreuther for the special problems associated with low probability events.

However, most empirical studies will continue to work with objective probability distributions and even in this our empirical knowledge is very limited. An exception is the little-known study by Ryan and Perrin in which they derived a response function for potatoes in Peru, using data from 90 experimental trials conducted over 65 sites between 1960 and 1970.[7] The response function included soils and weather variables. Riskiness of different fertilizer doses was derived by combining the response functions with more than 40 years of weather data. Risks from other sources were not considered. The conclusion reached is that weather risk does increase with increased fertilizer doses on average and deficient soils, but on soils containing high levels of organic matter risk first decreases and then only increases with higher levels of fertilizers. The conclusion thus differs from O'Mara and Roumasset. One of the reasons might be that potatoes are a rainfed crop and thus much more subject to rainfall variations than irrigated maize or rice.[8]

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7 This massive data gathering effort had been done by R.E. Mc. Collum, Carlos Valverde S. and Sven Villagarcia. It is most unusual that the data were collected in a form which allowed its retrieval for the response-function analysis.

8 This explanation of the difference in findings is strengthened by the Ryan and Perrin finding of lower riskiness in soils with high organic matter, which usually implies high moisture holding capacity and less risk of drought.

Apart from the evidence of O'Mara,,Roumasset and Ryan and Perrin, there remains a very large gap in our knowledge about objective or subjective probability distributions. For objective distributions this might be attributed to the following reasons:

(a) *Ex ante*, i.e. before a new practice is adopted anywhere, the information available is experiment station data. These experiments are usually conducted under conditions so far superior to the average farmer that they largely overstate the expected response of yield to fertilizers or other practices.[9] In a few countries experiment station data are supplemented by trials in farmers' fields but again the better farmers are usually included in those and, due to the small number of years of these trials, it is relatively difficult to separate the time series component of variability from the cross section component. However, the recent trend towards more and prolonged experimentation in farmers' fields is the avenue by which advances must come.

(b) The most frequently used approach to derive probability distributions of yields is to simply assume that aggregate regional or district level data correctly reflect yield variabilities at farmers' fields levels. Apart from problems of aggregation, probability distributions of new practices (say fertilizer levels) or new varieties cannot be derived in this way without the strong assumptions

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9 In the Philippine rice study of Roumasset (1976b), most of the inefficiency in farmers' fertilizer use disappears once the experiment station production function is corrected to reflect farmers' situations.

Even the analysis of experiment station data over time has not frequently been pursued much beyond Janvry's and the Ryan and Perrin contribution. One of the reasons is that few experiments are carried out for more than 2 or 3 years, which is insufficient for reliably estimating such distributions (For the difficulties encountered, see Anderson, 1973). More promising may be the use of variance component models on experiments at several or many locations over a number of years. In an unpublished paper Minhas and Srinivasan have started in this direction. The Evenson *et. al.* paper at the Conference was a further attempt in this direction. Evenson and I are continuing in this direction with the goal of getting more precise estimates of general adaptability and time series stability for varieties by using the widespread and relatively long duration experiments of international and some national research organizations.

of either additive or multiplicative shifts in production functions. This is not so much due to the well known fact that aggregate regional data underestimate year to year variability in farmers' fields than to the difficulty of getting aggregate data by variety and fertilizer level.

(c) Farm level data for both old and new practices for many years are almost nonexistent in developing countries because few farm record schemes have been in operation long enough.[10] Furthermore, one cannot get data on new practices from historically recorded farm-level data.

Given these difficulties, more indirect methods may have to be used to test the "risk retards adoption" hypothesis. For example, income variability from cash crops usually exceeds income variability of subsistence crops, due to the usually higher price variability of the former. Wolgin uses this fact to establish and test the hypothesis that risk-averse farmers should allocate inputs to cash and subsistence crops in such a way that the value of marginal products of any input in a high risk crop should be lower than in a low risk crop. Such a finding supports the hypothesis of risk aversion of farmers without requiring much information about the precise distributions of yields or net returns.

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10 In India certain Farm Management Studies are an exception, and with access to the original data, probability distributions of existing practices could be estimated.

At ICRISAT we are experimenting at the present time with using data from crop cutting surveys for 5 years collected by the Andhra Pradesh Government to estimate aggregate yields and production. We had access to the original questionnaires which provide a certain amount of information on varieties, soil quality, and input use. We will try to use variance component production function models to estimate variability over time and by practice.

Similarly, it may be possible to push the analysis of the "risk retards adoption" hypothesis further by some broad classifications of technologies into different groups according to how they affect yield and gross or net return distributions. Clearly, practically all new technologies which are likely to be adopted increase expected outputs or yields, i.e. shift and/or change the shape of the yield distributions to increase expected yields. Furthermore, most of the new technologies result in shifts which may not increase yield risks be very much. However, what happens to riskiness of net returns depends on (a) the investment levels associated with the new technologies (the smaller the less risky) and (b) how the yield distributions shift or change their shapes. With respect to (b) it should be possible to classify technologies into three groups (two of which were well recognized at the Conference, see Carlson).

(1) Nonprotective inputs such as new seeds or fertilizers shift the probability distribution of yields without necessarily decreasing probability levels at the lower tail of the yield distribution.

(2) Protective inputs such as pesticides and varieties introduced specifically for disease resistance (and not for increases in yield potential) increase expected yields primarily by reducing probability levels at the lower tail of the distribution but do not tend to increase yields under favorable circumstances.

(3) Inputs with dual role: investments such as irrigation which increase potential maximum yields as well as reducing frequencies at the lower end of the distributions (by avoiding drought, for example).

The paper by Richard Just and Rulon Pope at the Conference suggests econometric methods based on production functions which for the first time would allow the testing of this classification empirically if good data are available.

If farmers are risk averse, they should overinvest in protective inputs and dual role inputs and underinvest into nonprotective inputs.[11] If we observe underinvestment into protective inputs (when valuing capital at an institutional interest rate) we must conclude that credit constraints are at the root of the problem (unless we assume risk preference or information gaps). Underinvestment relative to the expected profit-maximizing point for risk averters can thus only be a problem with respect to nonprotective inputs, primarily fertilizers, labor, or machinery inputs for better agronomic practices such as weeding, land-smoothing, etc. (In the case of seed varieties, riskiness of net returns will generally not increase due to the small investment required for seeds relative to the increase in expected yields).

In the case of the nonprotective investments the fine balance between the size of the investment and the shift in the probability distribution will determine whether risk of net returns is increased or not. Clearly, the smaller the capital investment relative to a given expected gross return, the smaller probabilities that a nonprotective input increases risk.

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11 Carlson reports a case of overinvestment in pesticides in cotton in Central America.

One of the major competing hypothesis for explaining lack of adoption, especially of fertilizers, is the existence of credit constraints or extremely high costs of borrowing to small holders.[12] The other major competing hypothesis is Roumasset's "Fertilizers do not increase risk if probability distributions are properly measured."

One way of testing whether the risk or credit constraint explanation is correct is to see whether adoption of all three classes of inputs fall below the expected profit-maximizing level or whether only the levels of nonprotective inputs falls short of it (note that the comparison should include only inputs requiring cash outlays).[13] If underinvestment occurs for all inputs equally, credit will be the overriding constraint whereas risk is more important if underinvestment is restricted to the nonprotective inputs.

3) Risk Aversion

Suppose it can be established for many nonprotective modern inputs that they do indeed increase riskiness of net returns. Whether this is of any consequence then depends on the extent of risk aversion amongst farmers. Hence for this question, as for many others, empirical estimations of risk aversion (or safety zones, parameters of caution, etc.) becomes crucial. Measurement of attitudes becomes more important as it

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12 Bliss discussed these alternative explanations in detail at the Conference.

13 Wolgin makes such a comparison for fertilizer and family labor and finds that input levels are much closer to profit-maximizing optima for labor than for fertilizer. But this divergence can again be due to either credit constraints or risk or both since labor is largely a noncash input.

becomes more difficult it is to precisely measure subjective or objective probability distributions of outcomes of choices, because one may sometimes be able to infer the subjective probabilities if one knows the actual behavior and the attitudes.

The discussion on risk attitudes at the Conference is extensively reported in the summary by Roumasset. He rightly stresses the substantial progress made with econometric approaches by Just and Pope, using systems of factor demand equations which take risk into account. None of these models has yet been applied in developing countries.

Scandizzo and Dillon reported good success on eliciting risk attitudes with interview methods of about 130 farmers in Northeastern Brazil. This is an unusually large sample and it seemed feasible to use trained investigators. I have recently used the Scandizzo-Dillon approach on 240 households in semi-arid tropical India and tested the replicability of the methodology by reinterviewing 200 of the households one or two months later. Some were reinterviewed by the same investigators, but in most cases investigators were switched. The reinterviews led to evidence of nonreplicability of the methodology over time and to massive evidence of investigator bias. These findings will be reported in a forthcoming paper.

At the Conference Kennedy reported on a new interview method using the focus loss approach which requires more sophisticated interviewers and farmers than the Scandizzo-Dillon approach. Before his approach can be accepted it will also be necessary to test for its replicability over time and across interviewers.

Another approach (not reported at the Conference) is also econometrically based, but with cross section data from individual farms in mind. It consists of a more systematic comparison of the marginal product of a factor at the expected profit-maximizing optimum with the marginal product at the observed farmer's position, using an econometrically measured production function. Moscardi defines a residual "risk" measure out of this difference and uses it to study fertilizer applications in the Puebla project area in Mexico. Wolgin looks at these discrepancies for many inputs across crops in Kenya without explicitly deriving a risk measure out of it. However, these differences or residual "risk" measures may have other causes, such as varying credit costs to sample farmers. This shortcoming is especially severe if only one input on one crop is considered.[14]

4) Policy Alternatives to deal with Undesirable Consequences of Risk Aversion

Even if we had much more empirical knowledge about probability distributions, risk aversion coefficients, and the behavior of development actors under risk, and if we knew more about consequences for the development process, what could be done with such knowledge? One would, of course, want to incorporate it into government policies to deal with

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14 Wolgin gets most of his conclusions from comparing the discrepancies in marginal products across crops of the same farmers, which eliminates many other explanations than risk, since credit costs for the same input will be the same on two crops for the same farmer. Moscardi argues that his residual is not confounded with credit-constraints because all farmers had equal access to credit in the Puebla Project area.

the concerns of Table 1 and ultimately to achieve greater efficiency or equity. Table 2 lists some of the policies and policy instruments which one may want to use to alleviate undesirable consequences of risk aversion (if one knew enough about the importance of these consequences).

This list, which is not exhaustive, has been subdivided into two classes on the basis of whether agricultural risk reduction or risk spreading is the primary goal of a policy. It is recognized that there is some arbitrariness in the classification. A policy is classified as risk specific if it reaches its ultimate efficiency or equity goals primarily via the effect which its risk spreading or reducing impact has on farmers' behavior towards the choice among risky production processes. A policy is classified as nonrisk specific if its main effect on efficiency or equity is not reached primarily as a consequence of risk-spreading or reducing, but in a more direct way. For example, land distribution achieves its equity implication primarily because it gives more assets to the poor. As a consequence, the risk level of these people may be reduced, which in turn may allow them to makn decisions closer to the expected profit-maximizing optimum; this is a secondary effect.

The most obvious risk specific policy is crop or credit insurance, but as both Oury's and Gomez's papers have shown, pure insurance schemes based on individual loss assessment are almost infeasible in countries with low levels of income and small landholdings. Administrative costs of individual loss assessment become just too high. Even in developed

Table 2 : Policy alternatives to deal with undesirable consequences of risk aversion

A) Policies specific to agricultural risk:

A-1 Crop/Credit insurance, loan guarantees, etc.

A-2 Relief and Famine policies.

A-3 Pure buffer stock or price stabilization schemes.

A-4 Plant protection by groups of farmers.

A-5 Flood protection.

A-6 Breeding for crop yield stability.

B) Policies which are not risk specific:

B-1 Subsidization of inputs and/or credit.

B-2 Agricultural price support as income policy.

B-3 Allocation of investment and research resources to regions.

B-4 Reduction in Background Risk

- Irrigation investments
- Increase efficiency of markets (roads, market information, etc.)
- Improve access to information about technologies (extension, demonstration, etc.)
- Improve nonagricultural job opportunities
- medical and other welfare policies.

B-5 Legislation, regulation, institutional reform in areas such as credit and land tenancy.

B-6 Land reforms and other income/wealth distributions.

countries generalized crop insurances (except for very specific risks such as hail) have only recently become self-liquidating. In many cases they still depend on heavy government subsidies. And in developing countries, where they have worked at all, they are better described as income support and distribution schemes towards poor areas than as insurance schemes.[15] Furthermore, such schemes seem to work only when they are compulsory, which immediately leads to the question whether they improve welfare at all.[16]

In the absence of insurance, most developing countries deal with the consequences of the worst disasters which hit their populations by more or less *ad hoc* relief policies, which range from land tax concessions to rural works and direct shipments of foods, feeds, and supplies. Despite heated debates about the adequacy and appropriateness of specific efforts, these policies may be the only effective insurance and risk-diffusion schemes available to poor countries to alleviate the effects of disasters. A more thorough investigation of the ability of these schemes to meet risk-reducing goals is surely called for.[17]

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15 They are likely to be inefficient distributive devices and direct resource investments may be more appropriate to deal with regional disparities.

16 See for example the Mexican Credit Insurance Case discussed by Gomez.

17 In the Indian subcontinent, where such relief measures are most important, the debates usually revolve around whether the relief is really reaching the worst affected areas or groups and how to improve the efficiency impact of public works undertaken in famine situations (see N.S. Jodha). Morris David Morris has added a new dimension by arguing that in India drought-prone areas receive relief so frequently that farmers choose too-risky crop mixes and input levels relative to the expected profit-maximizing levels, thus resulting in another inefficiency. However, if farmers are risk averse, there is probably little reason to fear such overshooting.

Buffer stock schemes and other price-stabilization schemes are another often advocated policy tool. However, their effect on aggregate welfare and their distributional consequences are still open to a debate which requires empirical answers. As previously discussed one can build theoretical models where everything is possible.[18] Advocating them now to deal with risk problems seems to be quite ahead of our knowledge.

Another risk-specific policy is plant protection by groups of farmers and government support of individual plant protection by information, etc. The experiment in Central America reported by Carlson will help understand more clearly the feasibility of such approaches in developing countries. However, it is likely that such group actions will be confined to areas with high concentration of very susceptible cash crops such as cotton,etc.

Another example is the introduction of new varieties into entire areas rather than leaving adoption up to individual farmers. Introducing varieties of different maturities on a few farms only often increases risks of pests and birds for the newly introduced or the traditional varieties or both. Areawise introduction of varieties spreads and minimizes these risks. India is experimenting with this approach on a large scale.

Flood protection by the building of dams and other disaster protection or warning systems are also risk specific policies in which the analytical tools of decision making under uncertainty are surely most appropriately used to guide policy decisions.

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18 See Newbery (1976b)

Plant breeding decisions definitely have to take farmers' attitudes towards risk into account, especially if it should turn out that risk aversion is high. It is therefore important to quickly get a better understanding of possible tradeoffs between stability and yields.

To the extent that one believes that risk-specific policies are effective means of achieving the ultimate efficiency and equity goals, the investment of scarce economic research resources into questions related to these policies is surely warranted. Even in the case of crops insurance, more research may be useful. The main reason for disenchantment with insurance schemes is the excessive cost of writing policies and of assessment of losses in individual fields. V.M. Dandekar for India has recently revived a suggestion to provide insurance where the indemnity payment does not depend on the loss in an individual field but is based on the shortfall from their normal levels of average yield across farms in a homogenous crop growth zone. This would enormously reduce administrative costs and overcome the moral hazard problem. Economists usually insist on the superiority of insurance over all other forms of risk dispersal, and research on such area-based insurance schemes may be highly fruitful.

As matters stand at present,with respect to adoption of new technology, we are left with few policy handles. Especially for overcoming a possible permanent discrepancy in fertilizer applications from an expected profit-maximizing level, no risk specific policy seems to exist, except making fertilizer-responsive varieties more

stable genetically, which has become a major breeding goal in many national and international breeding efforts.[19]

This leaves us with policies which are not specific to risk, but whose primary goals of growth or equity are achieved more directly. However, these policies do usually influence the general risk situation of their target groups, either by increasing income levels of the recipients or reducing exposure to risks in areas other than agricultural production or both. It is clear that any increase in income or any reduction in risk in areas other than agricultural production (say reduction of health risk) should increase the ability of the recipients to bear production risks and therefore allow them to choose production activities which are closer to maximizing expected returns. This is what Michael Lipton called at the Conference the reduction of background risks, although he primarily had in mind the policies specifically mentioned under that heading. Of course, how strongly the reduction of health risk affects the production decision of risk-averting farmers is an empirical question which has not been investigated so far.

On the whole, for all the policies which are not risk specific, it will <u>at this stage</u> be difficult to explicitly incorporate secondary risk reduction effects into a policy analysis framework. This is primarily because quantitative knowledge on side benefits in terms of risk

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19 Roumasset's "Risk is Unimportant" statements stem as much from his evidence that fertilizer does not increase risk in irrigated rice as from his despair of lack of direct policy handles to deal with any potential risk problem.

reduction is simply nonexistent for most of these policy tools. Furthermore, such empirical knowledge will be difficult to generate and as long as the basic controversies in the risk area are not settled, concentrating research on this aspect may be a misallocation of professional capacity. This to some extent disagrees with the position of Michael Lipton who would like us to take such risk-reducing effects explicitely into account in cost-benefit analysis.

In many instances, however, the side benefit of risk reduction might be investigated in a somewhat *ad hoo* manner by considering whether or not there is a conflict between the primary goal of these policies and the subsidiary goal of risk reduction. In the case of irrigation investment, both the increased production levels and the risk reduction will benefit the same target groups of farmers or regions and no goal conflict arises. This may be the case for many other policies as well. Therefore rates of returns to all irrigation investments would be higher than those measured by increases in expected output. The addition of benefits would be the largest in those regions with the highest weather instability. Furthermore, irrigation investments, as a class, are likely to have higher risk reducing side benefits than, say, road construction. Such unrefined knowledge might be sufficient to help choose among investment strategies when simple rate of return calculations without risk reduction benefits are unable to force a clear choice.

Conclusions

The inability of the Conference to reach conclusions on the role of risk and uncertainty in many development problems and to formulate policies to deal with any possible adverse consequences of risk aversion stems primarily from three causes: First is the scarcity of empirical evidence on probability distributions of the decisions which are considered in the context of a particular development problem. Progress in this area will be slow and requires painstaking and often unrewarding empirical enquiries at the farm level. Second, the evidence on attitudes towards risk of development actors may be better but is still sufficiently scarce and shaky to allow few generalizations. Third, it appears that there are very few risk-specific policy alternatives with which to deal directly with possible adverse consequences of risk aversion, and on some of the obvious risk-specific policies such as price stabilization, much more evidence is needed before one can really recommend them.

Given this state of knowledge and the complexity of the issue, the problem area of the Conference will for some time remain a specialized research area for a limited number of people. Decision theory under uncertainty can start to make an impact on development policy and development only if these researchers are able to improve the empirical knowledge in the area and to further simplify and standardize the methodological tools used to acquire empirical knowledge.

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