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RAPPORTEUR'S REPORT

ON

NATURE AND ROLE OF RISK AND UNCERTAINTY IN AGRICULTURE

Rapporteur : DR. J. P. BHATTACHARJEE*

When the field of risk and uncertainty in Indian agriculture was selected for attack at this Conference, the uppermost feeling, at least in some minds, was not the riskiness of the venture but the uncertainty of outcome. With eighteen papers in hand including the late entries, one cannot but be impressed with the magnitude of response to the challenge. While the approach roads followed, and the tools fashioned by these eighteen explorers are different, the risks of the journey do not seem to have acted as a deterrent.

Risk and uncertainty in agriculture covers a wide and relatively little explored area of economic analysis. In fact, the paucity of attempts in this field is almost as great as the importance of these elements in the actual practice of farming. The statement that "Agriculture in India is a gamble in the monsoons" has become proverbial. Fluctuations and instability in weather and other environmental factors have, for decades, been emphasized as the greatest hazard that farmers have to face in India. Prices and market have also been important areas of instability. And to these have been added in recent years the uncertainty caused by technological changes and Government policies and action. The economic effects of these fluctuations and instability on production, income and resource allocation, have not, however, been analysed in any great depth. In fact, for most parts of the country, even the problems remain to be defined and formulated in a systematic framework.

It is against this general background that the scope of contribution to this subject was formulated for this Conference. Recognising the need for both methodological and substantive studies in this field, papers on three broad aspects were specially invited. In the first place, different types of instability and variability that farmers have to contend with in different regions of India was suggested for analysis from the point of view of their significance to an understanding of risks and uncertainties. It was felt that knowledge gathered through such analysis would help in defining the nature of such fluctuations and instability and might enable us to differentiate the elements of risk from those of uncertainty in different situations. Secondly, in any region under known sets of fluctuations and variability, the farmers' adjustments to these, if properly analysed, could give an idea of the economic dimensions of the field. From this point of view was suggested attempts at assessment of the effect of such instabilities on the farmers' choice of enterprises and allocation of resource. Thirdly, the possibility was recognised of studies of different models of decision-making in situations of risk and uncertainty. It is against this suggested scope of contributions to this subject that the papers we have received are proposed to be analysed.

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Broadly speaking, the papers received can be classified into five groups for purposes of convenience in assessment. One group of about four papers deals with the topic in general and at least two of them without any reference to Indian agriculture at all. The second group of papers (approximately eight in number) deal with fluctuations in factors like weather, price, yield in different areas or regions and a few of these try also to link these fluctuations with allocation of acreage of crops. The third group of about five papers deal mainly with decision-problems like use of fertilizers, credit, etc., in situations of risk and uncertainty. Finally, there is also one paper dealing with the special problems of tea plantations.

GENERAL ANALYSIS

In a Conference like this, it can safely be presumed that the participants are well aware of the conceptual advances made in the economic analysis of risks and uncertainties. It is not, therefore, proposed to cover the general ground, as two or three authors have tried to do. It is by now generally accepted by all economists that fluctuations which are measurable in a probabilistic sense and can be fitted to statistical distribution functions should be classified as risks and their expected value suitably incorporated in the cost function. Fluctuations which do not lend themselves to such treatment and analysis lead to uncertainty situations. F. H. Knight still carries the last word in this conceptual analysis.

There is, however, one point on which some of the contributors do not seem to be very clear. This is the distinction between variability or instability which is a physical fact and the uncertainty arising out of it, which is a matter of individual perception and understanding of these. Uncertainty is, therefore, a subjective assessment and in its logical extreme is a disaggregative concept. This point may be discussed further when we come to the application of models of game theory.

Of the authors who have attempted a general analysis of the role of risks and uncertainties in agriculture, Shri S. N. Jatar has tried forcefully to make the point that risk and uncertainty elements do not enter into the calculus of most farmers in India since their production is primarily for home consumption. Even in respect of crops grown mainly for the market (cash crops), such farmers are guided, according to him, by habit "the rock of routine" and, perhaps, marginally by the demonstration effect of progressive farmers. He sees the relevance of these elements only to the decisions of wholly commercial farmers (producing wholly for the market), like the sugarcane farmers in Maharashtra. One can agree with him that uncertainty relates to a dynamic situation and that in a predominantly non-monetised economy the economic or market forces will have relatively smaller effect on uncertainty calculations of farmers. But the physical, biological and natural forces will be there; and the variability of output caused by these has, in fact, been the basis of the so-called traditional or "routine" practices. While each such farmer may not consciously evaluate uncertainties, he relies on the strategy adopted by the group. The individual assessment of uncertainty in such situations can be equated to the group or traditional recommendation. And there are ways of changing these as Shri Jatar seems to admit when he talks of demonstration effect.

That the traditional farmers are guided by many of the words of wisdom or local sayings purporting to forecast weather or crop prospects is common knowledge. In effect, such proverbs or adages tend to reduce uncertainty elements to risk factors. Dr. Bidyadhar Misra mentions a few of these and generally concludes that the so-called conservative farmers may actually be behaving quite rationally under the circumstances. While he does not try to establish this in any quantitative way, he holds that the recent years have marked an increase rather than reduction, in the range of uncertainties of the farmer. It is a debatable issue.

ASSESSMENT OF INSTABILITY VIS-A-VIS RISK AND UNCERTAINTY

Attempts have been made in at least eight papers to obtain a measure of the degree of variability in weather, or prices or yields or income or a number of these in selected areas. Miss M. Meenakshi Malya and Shri R. Rajagopalan have analysed the rainfall, crop acreage and yield data for 47 years (1905-1952) for the Kurnool district of Andhra. Failing to find any recognisable periodicity and distribution pattern inspite of randomness in the data, they have characterised the situation as one of uncertainty and concluded that the farmers have shown a high preference for survival by devoting a large proportion of their acreage to low yielding inferior millets. It is a commendable piece of work that seems to end rather abruptly. The uncertainty-approach to the analysis could have been pushed further.

Dr. A. S. Kahlon and Shri S. S. Johl have shown with the help of data for the decade 1951-52 to 1960-61 for the Ludhiana district (Punjab) that variance in post-harvest prices has a much higher degree of correlation with the variance in the acreage of different crops than with that of rainfall or yields. Price variance is, however, of a lower order than the other two. By analysing the contingency reserve that the farmers carry (which they have termed, somewhat questionably, the 'risk fund'), they have concluded that the total risk money increased with the introduction of improved techniques and that "unduly large proportions of liquid capital are reserved and kept back by the cultivators mainly because of their conceptual uncertainties and risks." This analysis seems to show that the farmers in Ludhiana have a method of bearing innovation uncertainties. Significant in this connection is the authors' contention that the variability in rainfall is not considered much of a hazard. This seems to be an ideal situation for a researcher to go deeper for a probe into the relationship between variations in the natural and biological factors and those in yields. The discounting procedure used by farmers with varying capital availability could also have been gone into. In fact, here, there is a possibility of separating the risk elements from those of uncertainty.

The analysis by Dr. V. S. Vyas and Shri K. R. Rakhral of the variation during the 'fifties in acreage, yield, price and gross income from different crops in Bhavnagar district (Gujarat) shows price variability to be generally of a lower order than that of yield or gross income. Their attempts to derive the farmers' uncertainty calculus from such aggregative calculations of variability are, however, hypothetical, as they themselves admit. The large magnitude of the shift in crop acreages provides a good case for a deeper probing at the micro level.

Dr. S. B. Lal Gupta calculates the variability indices for yield, prices and gross income in respect of different crops grown in Varanasi district (U.P.) over the decade of fifties. Here also, the index of price variability is lower than that of yield or gross income variability for all the crops. But the author is cautious and does not try to draw any inference.

Dr. N. P. Patil and Shri S. L. Hiregoudar attempt to estimate the effect of rainfall on the yield of paddy in Bangalore district (Mysore). They use a production function of the Cobb-Douglas type to estimate the regression of seed rate, manure, rainfall, number of irrigations, labour input and date of planting on the yield rate of paddy. Unfortunately, the regression co-efficient for the number of waterings emerges as much more significant than that for rainfall. In the absence of other statistical details, it is not possible to draw any meaningful inference from this analysis. One is left with a number of nagging questions.

Sarvashri Baidyanath Misra, H. Das Gupta and Jagannath Mishra have tried to prove the hypothesis that in villages susceptible to floods in Cuttack district (Orissa), the cultivators take precautionary measures against depressed incomes by going in more for supplementary enterprises like dairy, fishery and poultry. Variability of incomes, etc., has not been analysed in any functional way; its effect is assumed to be manifest in the lower level of income. The practices followed by the farmers show clearly the intensification of diversification as a protection against the flood hazard.

Shri S. N. Sen has presented a lot of historical data on rainfall, floods, droughts, cropping pattern, yields, etc., for the State of Bihar. He has not, however, tried to focus his data on any specific problem.

The analyses attempted in these papers throw up some common findings which do shed some new light on this field. In the first place, the variability of rainfall in all the areas taken up for study has been found to be of a much higher order than that of acreage, yield, prices or gross income. Secondly, of all these variations, the fluctuation in prices in all the areas has been of the lowest order. Yield and gross income have been subject to a much higher order of variance. Thirdly, the crop acreages are also subject to fluctuations which are in many cases much greater for commercial crops than for foodgrains. Fourthly, whatever data have been presented indicate that the variability of the different forces could not be measured in risk terms. Though the paper by Miss Malya and Shri Rajagopalan is the only attempt to discover any distribution pattern in the fluctuations, indirect evidence given by some of the others tend to show that the farmers' behaviour in the face of such instability is characterised considerably by uncertainty. These are points that may be taken up for further discussion at the Conference.

RESOURCE ALLOCATION UNDER UNCERTAINTY

Against the background of fluctuation and instability which cannot be predicted or the incidence of which cannot be readily translated in terms of expectations, it is worthwhile considering how the farmers in India allocate their resources among different enterprises. Shri D. P. Apte, Shri M. L. Patel and Sarvashri B. V. S. Baliga and S. B. Tambad deal essentially with this question. Dr. Kahlon and Shri Johl and

Sarvashri Misra, Das Gupta and Mishra have also dealt with some aspects of this question in their papers discussed earlier.

In an interesting paper on the role of risk and uncertainty in Kangra tea plantations, Shri M. L. Patel shows that mostly the tea growers experience psychological uncertainties. Contractual and technical uncertainties as well as those arising from Government action are also experienced by them, but to a much smaller extent. The interesting finding is that the medium and large growers do not seem to experience the last three types of uncertainties. The basis of all these uncertainties, according to him, lies in fluctuations in yield, rainfall, prices, fluctuations in labour supply, market and tenancy. It is apparent that in the case of the Kangra tea growers, physical, natural, biological, economic and Government forces all are acting together to create a full-fledged uncertainty situation. Different is, however, the position of typical cultivators engaged in grain or mixed farming.

As far as the general run of cultivators, particularly in Maharashtra are concerned, Shri Apte's paper shows that decisions on crop acreages are governed by three main considerations, namely, desire to achieve self-sufficiency in cereals, availability of seed for cash crops and incidence of pests and disease. It is interesting to read his conclusion that considerations of labour input or prices did not weigh with the farmers in their decision-making, particularly in respect of acreage under cotton and groundnut which declined heavily because of pests and disease. If any further conclusion is to be drawn from Shri Apte's analysis, it is that these farmers tend to discount very heavily the income from high-return cash crops like cotton and groundnut on account of biological hazards.

In an excellent paper, Sarvashri Baliga and Tambad show that in Bangalore district, the majority of the farmers have preferred diversification, though not to an extreme degree. The general preference is for lower incomes with a low variability rather than for higher incomes associated with the much larger variability. Another interesting finding is that farmers' decisions have been influenced not so much by average net incomes of crops and their variability as by high gross returns, its variability as well as the variability of prices. In short, farmers seem to have been guided in crop planning by high gross returns, low variability of gross returns and low price variability. The farmers' uncertainty calculus have thus led them to decisions in favour of crops with relatively low variability, which has involved a compromise with the objective of profit maximation.

Relevant in the context of resource allocation is the effect of risk and uncertainty on the use of credit. In many cases, these elements tend to impose what has been called "internal capital rationing," sometimes almost to the point of avoidance of the use of credit. The problem has been discussed in a very general way by Shri V. Tirupati Naidu. Dr. B. L. Agrawal in a fairly long paper has surveyed the literature on this topic, dealing in particular with capital investment, cost of credit, security requirements, purpose and terms of borrowing. Both Shri Naidu and Dr. Agrawal have drawn on the findings of the Rural Credit Survey to the extent these are relevant and have suggested areas for further research.

The Rapporteur is personally interested in the relationship between uncertainty preference or aversion, and capital position of farmers in their bearing on the

rate of discounting of uncertainty. In a paper on farm planning prepared in 1957¹ he presented a theoretical approach to the determination of the rate of discounting of uncertainties. Data for testing it are not available in any of the papers. It is hoped that further studies in this field would enable the application of this or other models to this problem.

DECISION-MAKING UNDER UNCERTAINTY

What are the general inferences on decision process, that can be drawn from the findings of these papers? It appears to the Rapporteur that most of the findings are either of the comparative or of the negative type. In the first place, decision-making by farmers is not a unique process followed in all parts of the country. Thus, price or technological uncertainty does not appear to be as important to the average farmer in Maharashtra as to his counterparts in Ludhiana or Bangalore or to the tea growers in Kangra. Secondly, the farmers tend to go invariably for diversification in the face of uncertainty. Such diversification extends to mixture and combination of crops as well as of livestock and other enterprises. Thirdly, the general tendency in uncertainty situations is to go for low variability enterprises. Fourthly, in extreme situations like Kurnool (Andhra), survival may be the goal and uncertainty aversion is at its extreme. Lastly, there is no evidence to show that a method of discounting of income or returns will not be an appropriate tool for taking into account the effect of uncertainty.

It has been mentioned in the earlier part of this paper that uncertainty relates to an individual's subjective assessment of an unstable or variable situation. If this is so, the criterion of decision-making is likely to vary among individuals, and recommendations based on aggregative analysis may not be very useful for advice to farmers. The individual approach to farm and production planning needs, therefore, to be even more strongly emphasized in areas of high variability in agricultural conditions. While this may be the ideal solution, for operational purposes one has, perhaps, to go by some decision criteria that may be followed by the largest number of farmers or by some dominant group. It is from this point of view that the application of the game theory models holds out considerable promise. Dr. Jai Krishna and Dr. D. K. Desai have, in their excellent paper, illustrated this approach. Though the lead in this direction was given earlier by Dr. N. S. Randhawa and Prof. Earl O. Heady in a paper published in this Journal,² Dr. Jai Krishna and Dr. Desai's illustrations are more elegant and detailed. A good part of their paper is, however, devoted to a simplified presentation of economic models so far developed for handling problems of farm planning in uncertainty situations; and the rest of it is illustrative of the way in which allocation problems like fertilizers and crops can be solved.

No one should try to draw any substantive conclusions from this paper. The models presented by them cannot handle planning problems under conditions of constrained profit-maximization, as they have rightly admitted. It needs hardly

1. J. P. Bhattacharjee, "Soil Conservation, Farm Planning and Management, Ministry of Food and Agriculture, 1958.

2. "Decision Making under Uncertainty with special reference to Agriculture (in India)," this *Journal*, Vol. XVIII, No. 3, July-September, 1963.

any stressing that much greater knowledge of the decision-criteria used by different categories of farmers will have to be acquired before meaningful inference can be drawn on optimal strategy. The evidence presented in the different papers discussed above does show that a straightforward method of profit-maximization prescribed through static analysis is not what the cultivators follow in their decision process. This is about all we can infer. It is indeed a bold step to jump from this negative position and adopt the maxi-min principle. It is true that the general tendency in many discussions or recommendations is to prescribe the Laplace or Bayes' criteria. While the Wald criterion looks better Hurwicz' pessimism-optimism index or Simon's theory of the Satisficer seems *a priori* better suited to the Indian situation. Unfortunately, the data requirements for the latter two principles are more exacting than those for the Wald criterion.

One of the ways in which the application of game theory models may be facilitated is through a more detailed specification of different natural, biological and economic situations with which each outcome of an experiment or action is associated. In other words, what is needed is a detailed specification of "nature's strategies." Unfortunately, we do not have such data even for research station experiments ; and in their absence all that can be done is to use each year as a strategy of nature. The need for such data was initially emphasized very strongly by the Programme Evaluation Organisation in its report on "Study of Multiplication and Distribution Programme for Improved Seed" in 1961. One can only hope that agronomists, meteorologists and other scientists working in the field of agriculture would help in the assembling of such data.

SUMMARY OF GROUP DISCUSSION

Chairman : DR. J. P. BHATTACHARJEE

Following the lines suggested in the Rapporteur's paper, the field was divided for convenience in discussion, into the four areas that were implicit in the initial formulation of the scope of this Conference topic. These are applicability of the concepts of risk and uncertainty in Indian agriculture, statistical assessment of variability and instability in agriculture, resource allocation and decision-making by farmers under uncertainty situations. The analysis presented in the papers and the views and comments offered by the Rapporteur provided the starting point from which discussion took the course of clearing the methodological hurdles and uncertainties, examining the inferences, their consistency and validity and finally going beyond the immediate findings to their wider implications. There was, happily, a fairly wide area of agreement on the methods of analysis of variability, risk and uncertainty as well as the economic implications of these on decision-making by farmers. What is presented here is a brief summary of some of the more important points that were emphasized in the course of the discussions. There were also references to points mentioned in the Rapporteur's paper. In the interests of brevity, these have not been repeated in this report.

The need was recognised for clearly distinguishing the variability in natural, biological, economic and institutional factors from the assessment of these in terms of risk and/or uncertainty. The popular meaning of the latter terms often

gets the better of their economic connotation. A question that attracted some attention was whether or how far the average "subsistence" farmer operating in the framework of traditional beliefs and behaviour made a conscious assessment of instability or variability in terms of either risk or uncertainty situations. One point of view expressed by a few persons was that since these farmers did not primarily produce for the market and were generally guided by set patterns of behaviour in respect of acreage allotment among crops and resource allocation, the risk or uncertainty calculus had no real relevance for him. This point of view was challenged by many members who felt that even the poorest of the "subsistence" farmers had to, and did indeed go to the market. To that extent, they were affected by market instability arising out of variability of prices and market mechanism. They might not consciously face any uncertainty in respect of innovations, even though there is evidence of change even in this direction. But they certainly faced all the natural and biological hazards; and most of them faced in a very large measure the insecurity arising from tenancy and similar contractual arrangements. The assumption that farmers in India operated under static conditions and were not subject to uncertainties which arose only in dynamic situations was not considered valid. Their behaviour under such circumstances could not but be conditioned by some strategy for meeting situations, on the incidence or even effect of which they had imperfect knowledge. In fact, even the strongest of the tradition-oriented farmers in reality followed a group decision based on past experience of instability, insecurity and fluctuations. Traditional recommendations and practices could, in a sense, be looked at as strategies for facing uncertain situations; and such strategies were not necessarily irrational. To talk of helplessness of farmers or their inaction is to stop short of analysing their strategy for survival.

Another issue that came up for discussion was that many farmers tended in their mind to associate some probability though of a subjective nature, to major events of the past, which might or might not have an objective probability distribution. The important question was whether such behaviour would be considered consistent with risk calculus or with uncertainty analysis. Most of the members felt that this would still be behaviour under uncertainty since the basic assumption was that risks were predictable in a probabilistic sense and their effect could be incorporated in cost. The distinction between risk and uncertainty in agriculture could thus be made out to the extent that instabilities and fluctuations were measurable in terms of probability distributions and their incidence made in some sense predictable. This led finally to the general position that Indian farmers faced a sequence of decisions and because of the length of their production process and relatively high incidence of hazards, their initial decisions were characterised by uncertainty calculus. But there might be attempts on their part to approach subsequent decisions in risk terms. There was not, however, sufficient knowledge on this point which could be taken as a hypothesis at this stage. The attempt to separate out risks from uncertainties in the calculus of commercial farmers or plantations seemed to be much more conscious and systematic. A point raised but not pursued very far was how far it was possible to relate risks and uncertainties attached to specific situations in a functional way.

Data requirements for an adequate and meaningful analysis of variability in natural, biological and economic factors call for long, homogeneous time series.

Besides, it is not only a gross figure like total rainfall that needs to be analysed but also its extent in crucial periods and distribution among seasons. Secondly, component analysis of time series data is also called for. Thirdly, measures of periodicity, variance and other aspects of the behaviour of a time series that does not show systematic fluctuations have to be analysed and looked at from the point of view of length and components of each series. Use of a short series is always hazardous.

There was some controversy over the use of cross-sectional data for the analysis of inter-farm variations in allocation behaviour. The validity of such analysis for understanding behaviour or action over time was questioned. While the strength of this view was recognised, it was also pointed out that this approach would be meaningful for an analysis of the predictability of weather factors on yield, if and only when the effect of input differences had been eliminated from the yield or income variations. Otherwise, this approach would not have much relevance to this area of study.

Variabilities analysed in the papers and taken up for discussion related to rainfall, crop acreages, yields, prices, and gross returns. Total annual rainfall in every analysis emerged with the highest variability; not much use could, however, be made of such variability for deriving or delineating risk situations. Prof. R. K. Mukherjee's pioneering attempt 30 years or so back to derive rainfall cycles and find the correlation between droughts and sun spot occurrence was noted in this connection, apart from the analysis presented in the papers.

That, in the short run, acreages even of foodgrain crops varied significantly on the so-called "subsistence" farms was recognised by the Group. It was also noted that in many areas such variability was more nearly associated with yield and/or gross income variability rather than with price variability, an exception being the Ludhiana area of the Punjab or tea plantations. It was clarified that relationships of this type should not be taken as evidence, one way or the other, of the importance and effectiveness of price incentives and farmers' responses to these. The indication was that the level of prices—even relative prices—was not the only factor conditioning the behaviour of farmers. Variability of these and other factors, and the subjective assessment of the uncertainty created as a result were far more important. The latter might easily nullify the incentive effects derived from a straightforward calculation of returns on the basis of the actual prices.

Discussion on resource allocation and decision-making by farmers did not result in any substantive findings. Indications of the nature of the process were looked for. Available evidence showed the tendency on the part of the farmers faced with instability or variability situations to protect themselves in four ways. Their first strategy was diversification of enterprises; the second, cost flexibility in each enterprise, the third, discounting of returns according to their subjective assessment of the consequences of different hazards; and the fourth, 'internal' or voluntary capital rationing. The last strategy came up for some attention in the context of availability and use of credit, its cost, terms and associated problems.

The game theory approach to the analysis of uncertainty situations was discussed mainly from the point of view of the decision-criteria or principles that

direct and indirect evidence suggested as approximating to the behaviour of Indian farmers. Wald or Laplace criteria were not considered as good from this point of view as Hurwicz' or Simon's ; but the data requirements for the latter were and would continue to be difficult to satisfy. Another point emphasized was the need for more detailed specification of what is called "nature's strategies," the compounding of which in annual observations made the use of yearly events somewhat arbitrary. The need for development of this tool and its application in India was recognised.

An important question raised in the Plenary Session was whether the papers and discussions had any significant implications on policy matters. It was generally felt that the studies done so far had been of an exploratory nature, with more of methodological content. Under these circumstances, no new recommendations of a strong nature could be made about changes or orientation in Government policy except some of those generally known and advocated. There was one issue that was mentioned specifically in this connection. This related to the policy followed by the Reserve Bank and the Apex Banks for recovery of co-operative loans. Assuming that all parts of the country were subject to the same degree and same order of frequency of natural hazards in agriculture, it was felt that the incentive for adequate and proper use of credit would increase if arrangements could be made to link the recovery of loans with the effect of natural hazards on crop yields. Such a policy would imply linking the proportion of recovery to be attained with some measure of crop output and fixing a proportion of overdues that would not be allowed to stand in the way of extending loan accommodation in the subsequent year.

The Group recognized the need for sustained research in different areas of the whole field of risk and uncertainty. The importance was stressed for the purpose of such studies, of co-operative and collaborative research with agronomists, entomologists and other agricultural scientists on one side, and with social psychologists, sociologists, bankers and insurance experts on the other. It was only through the findings of such studies that cases could be made out for Government and institutional programmes for protection against risks. Uncertainties would continue; but at least in one important area—Government policies on prices, land reforms, market regulation—, the Government was itself the source. It was up to it to reduce such uncertainties. The issue is not whether it should, but whether it can and will.