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ferred before the completion of a tenure of at least three years".[7] Apart from the need to keep the Project Officer and the APOs at the SFDA for the duration of the Agency, it is necessary to consider methods of compensating this staff if they put in sufficient efforts to successfully carry out the programmes of the Agency.

The SFDA has so far touched only a small fraction of the problem. However, the number of small farmers will increase at a faster rate in the years to come. Hence, the Government will have to take steps to increase the efficiency of the SFDA to enable it to cater to the growing number of small farmers. The choice of appropriate programmes and their planning and appraisal is very important for the success of the Agency. As adequate information is not available on planning and appraisal it is necessary to take up specific studies to throw more light on the process of project formulation and appraisal of the SFDA.

STATISTICAL RISK ANALYSIS IN PROJECT APPRAISAL

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With the present Government's emphasis on rural development, an increasing number of agricultural projects are being undertaken. The Sixth Plan document envisages an investment of Rs. 1,825 million on agricultural development. Therefore, it is imperative that the scarce resources are utilized in an optimum manner in agricultural projects. This calls for a scientific approach to proper identification, appraisal and evaluation of agricultural projects. This paper, therefore, utilizes the concept of probability theory in measuring the risk at the time of project appraisal. Most projects, at present, are being appraised on the basis of single estimate of project return, *viz.*, rate of return, benefit-cost ratio or net present worth. For the purpose of this paper, we would measure the project benefits in terms of financial rate of return. In arriving at this estimate, the most likely (average) value of input variables, *viz.*, yield, prices, cost of cultivation, etc., are assumed. No consideration is given to the variations around these most likely values of input variables. Thus, for the most part, there is a difference between the rate of returns estimated at appraisal and that obtained at evaluation. This difference is due to two reasons: one, due to sampling errors and the other due to uncertainties involved in the values of input variables. The difference due to sampling errors can be tested for its significance by tests of hypotheses,

7. Government of Punjab: *op. cit.*, p. 19.

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while the differences due to uncertainties can be considered only by the use of risk analysis. To some extent, sensitivity analysis deals with these uncertainties in an *ad hoc* manner. This method consists of increasing or decreasing the input variables by 10 per cent to 20 per cent, one at a time, and record the corresponding change in the rate of return. It only pinpoints the most crucial input variables. Therefore, the most efficient method to account for variations in input variables is the use of probabilities in project appraisal and evaluation. This analysis is termed as Statistical Risk Analysis (SRA).

In the following sections, we consider the concepts of SRA, deal with the methodology and present a case study of a farm mechanization project. We then enumerate the limitations and advantages of SRA and present the conclusions of the study.

CONCEPTS OF STATISTICAL RISK ANALYSIS

The essence of this approach is to presume that many of the variables affecting the outcome of a project are not controllable by the planner. Hence instead of assuming that future outcomes are known, it is presumed that chances for a future event to occur are known.

It may be recalled that sometimes we choose all input variables in such a way that they yield a conservative estimate for the rate of return. In other cases, we may select the best estimate (most likely) value. Both these solutions imply a subjective decision. In the first case, we look at the project with a conservative eye; in the second, we disregard the consequences of any variations around the best estimate value. Both can lead to biased decisions. For example, if we combine only conservative estimates of our variables, our results are likely to be over-conservative. On the other hand, by using only most likely values we fail to take into account that, other values of the variables we combine might result in substantial variations in the final estimate. Thus the purpose of risk analysis is to estimate the need for restricting our judgement to a single optimistic, pessimistic, or 'best' evaluation, by carrying throughout the analysis a complete judgement on the possible range of each variable and on the likelihood of each value within this range. At each step of analysis these judgements are combined at the same time as the variables themselves are combined. As a result, the product of the analysis is not just a single value of the decision variable, but a judgement on the likelihood of each value within this range. These judgements take the form of probability distribution. That is to say, each possible value of each variable is associated with a number between 0 and 1 such that for each variable the sum of all these numbers, or probability is equal to one. These probabilities are called subjective probabilities because they represent some degree of belief or subjective judgement. They follow all the rules of traditional probability theory. It may be pointed at this stage that the subjective judgement that we are likely to obtain from experts are based on some sort of objective experience from the past records.

METHODOLOGY

First of all, from the most likely estimates of project input variables, a single estimate of financial rate of return is obtained. Next, to reduce the number of variables to be used for SRA, a sensitivity analysis is undertaken, *i.e.*, it is observed what would happen to the rate of return if other values of the input variables were substituted. The other values are most pessimistic estimates, best optimistic estimates, and a few intermediate values of input variables. The rate of return obtained from most pessimistic estimates would tell us whether the project is risky or not. The rates of returns from most pessimistic estimates and most optimistic estimates would tell us the range of variations in the rate of returns. While calculating the rate of return from intermediate values of input variables, we hold all other variables at their most likely estimates. However, the exceptions to this rule are those variables whose variations, in the real world, are correlated. Observation on the changes in the values of the input variables with corresponding changes in the rates of return pinpoints the variables which affect the rate of return significantly. Thus, using the criterion of ABC analysis of inventory control, we may restrict the number of input variables which we wish to consider for our SRA.

Having restricted the number of variables to be considered, the first step of SRA is to assign each variable a probability distribution. This is done by dividing the range of variation of each input variables into a number of intervals, and assigning a number between 0 and 1 to each of these intervals in such a manner that the sum of the assigned number of all the intervals is equal to one. It may be mentioned that these numbers, so also the best optimistic and most pessimistic estimates of variables, are determined on the basis of information obtained from the appraiser. The second step is to 'simulate' the result. The simulation can be done either manually or with the help of a computer. The process is repeated until enough values of rate of return are obtained. These values are either fitted into a distribution or summarised by the cumulative probability distribution curve, with the rate of return on X axis and the cumulative probabilities (the probabilities that these values will not be exceeded) along Y axis. This curve can also be utilized to determine the probability that the rate of return will fail within a given range.

CASE STUDY

In this section we give a case study of a farm mechanization project. Keeping the essence of the project in tact, the project data have been hypothesized.

The project consisted of financing a large number of tractors. As tractor investment is capital intensive in character, a large sum was involved in this project. Apart from this, farm mechanization was controversial in nature and optimum use of this investment was doubtful. As a result of these factors, an appraisal of this project was undertaken from the viewpoint of SRA. The input variables for this project are life of investment, number of hours of tractor use, investment cost, operating and maintenance cost, area irrigated, yield per hectare and price per unit of output.

From the sensitivity analysis the significant variables were found to be cost of cultivation, prices of output, yield per hectare. For the purpose of our analysis, to make it amenable to manual simulation, we assume the cost of cultivation and price per quintal to be variable, though the rigorous treatment requires fitting probability distribution to these two variables. We further simplify our procedure by dividing the range of variations into five intervals and assigning probabilities to each of these values. The assignment of probabilities to each of these variables was based on the past records and, also, on the likely trends in the values of these variables, obtained from the experts in the field. For appraising the project, a farm model of ten hectares was chosen. Based on the interviews with the farmers and with various authorities of the State Government, it was gathered that the principal crops in the project area were jowar, maize, barley, wheat, rice and sugarcane.

For our purpose we have assumed variations in the prices of sugarcane, wheat and rice only. Other crops, as seen from the past records, were stable in nature and, therefore, their prices are not likely to change. On the basis of field experience and the judgement of experts, the total cost of cultivation per hectare and the prices of sugarcane, wheat and rice were assumed to be distributed as in Table I.

TABLE I—FREQUENCY DISTRIBUTION FOR COST OF CULTIVATION AND PRICE

Cost of cultivation (Rs./ha.)		Probability
	900	0·10
	1,000	0·10
	1,100	0·30
	1,200	0·30
	1,300	0·20
Price of crops (Rs./quintal)		**Probability**
(*i*) Rice		
	80	0·3
	85	0·2
	90	0·3
	95	0·1
	100	0·1
(*ii*) Wheat		
	100	0·2
	105	0·3
	110	0·3
	115	0·1
	120	0·1
(*iii*) Sugarcane (*gur*)		
	110	0·3
	115	0·2
	120	0·2
	125	0·2
	130	0·1

The farm budget of a ten-hectare farm model with and without the project is given in Table II. The minimum and the maximum internal rate of return (IRR) from these data works out to 5.1 per cent and 29.4 per cent respectively. The hand simulation of the data was undertaken to get 100 values of IRR (Figure 1). The average value of IRR is around 14.7 per cent. Had we restricted ourselves to the average value of the input variable the IRR would have come to 17.4 per cent. This difference can be accounted from the fact that the combination of averages of a number of variables is not the average of the combination of the same number of variables, *e.g.*, the sum of averages of a number of variables need not be equal to the average of the sum of the variables.

TABLE II—FARM BUDGET OF TEN-HECTARE FARM MODEL WITH AND WITHOUT PROJECT

Crop	Investment: Tractor									
	Area (ha.)		Yield (quintal/ ha.)		Price (Rs./ quintal)		Cost of cultivation (Rs./ha.)		Gross produce (Rs.)	
	Without	With	Without	With	Without	With	Without	With	Without	With
Kharif										
Jowar	0·40	0·40	Used as fodder		—	—	—	—	—	—
Maize HYV	3·00	1·20	5·2	5·2	70·0	70·0			1,092	1,092
Rice HYV	3·00	4·50	20·0	20·0	25·0	Variable			5,100	Variable
Rabi							Rs. 900/ha.	Variable		
Wheat HYV	4·60	6·00	22·0	22·0	105·0	Variable			10,626	Variable
Barley local	1·40	—	15·0	—	75·0	—			1,575	—
Perennial Sugarcane	1·00	2·00	45·0	45·0	120·0	Variable			5,400	Variable
Total	13·40	14·10					12,060		23,793	

Notes:— 1. Life of a tractor is assumed to be ten years.
2. The cost of tractor and its implements Rs. 60,000.
3. O & M cost of tractor Rs. 15·00 per hour.
4. Custom-hiring for 200 hours per annum at the net rate of Rs. 25 per hour (excluding O & M cost).
5. The investment on tractor results in the sale of one pair of bullocks.
6. For the first year, the farmer gets only 75 per cent of the net incremental income.

CONCLUSIONS

In this paper we have outlined the approach of statistical risk analysis in project appraisal. Of course, the same approach can be followed for project evaluation also. As this requires considerable amount of time, it is suggested that this may be undertaken for larger projects and also for those projects which are found to be marginal *i.e.*, projects whose average rate of return is very close to the estimated opportunity cost of capital. The major advantage of this approach is that it enables us to attack the problems in a comprehensive manner and gives a complete picture of the likely rates of returns expected from the project. It is a powerful technique which permits the use

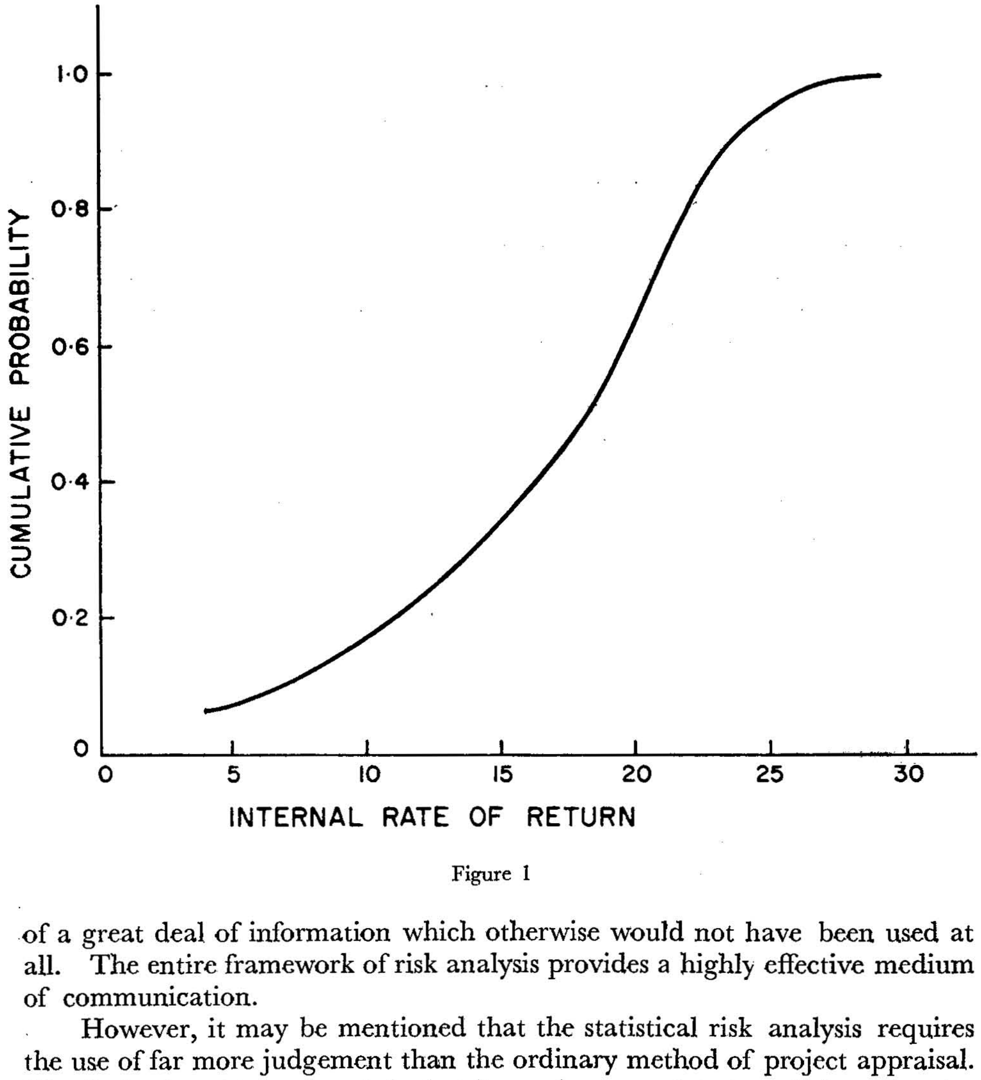

Figure 1

of a great deal of information which otherwise would not have been used at all. The entire framework of risk analysis provides a highly effective medium of communication.

However, it may be mentioned that the statistical risk analysis requires the use of far more judgement than the ordinary method of project appraisal. The limitation this approach is that it requires complete knowledge of variations in input variables and the associated probabilities of these variables. As such, it may be said to be a subjective approach. But this subjectivity emanates from the objectivity of the experts.

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