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Farm income and employment can be substantially increased by adopting improved farming system along with appropriate package of practices and inputs.

In order to enable the communities to derive full benefits from such lands, appropriate institution(s) need to be created for proper planning and management of these lands.

IMPACT OF RISK AND UNCERTAINTY ON FARM PRODUCTION AND INCOME IN THE HILLS OF THE NILGIRIS, TAMIL NADU

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Risk is now widely recognized as a critical factor in nearly all farming activities, and has become a major concern especially in relation with the adoption of new technology by farmers. Spurred by the recent violent fluctuations in prices of farm products, there has been an upsurge of interest in risk and uncertainty in farming. Economists realise that recognition of differing risk preferences of farmers may explain and perhaps even justify what appears to be economically irrational behaviour—holding reserves, diversification of production, attempting to minimize the probability of loss and such decision behaviours.

CONCEPTS

Uncertainty is a state of mind in which an individual perceives alternative outcomes to a particular action. Risk, on the other hand, has to do with the degree of uncertainty in a given situation. Defining risk is more than a semantic problem. One conclusion that emerged from the controversy over definitions, in a recent seminar,[1] was that precisely because there is no consensus about the meaning of risk and risk aversion researchers should specify which definition they are using. The measures of risk most commonly used by agricultural economists is the statistical measures of dispersion: Standard Deviation and Variance. Accepting this measure, risk is defined for this study as the variance in aggregate net farm income. There are several factors causing this risk in farm business.

Family health, and managerial ability to adopt new enterprises/technology are sources of risks internal to the business. Many other agricultural risks are external to the business: price risk, yield risk, technological change, changes in legal and institutional framework and changing monetary and fiscal conditions. These business risks interact with financial risks associated with operating, and financial leverages. Operating leverage

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1. James A. Roumasset, " 'Risk and Uncertainty' in Agricultural Development", A/D/C/Seminar Report No. 15, October 1977.

reflects the proportion of a firm's total cost, that is fixed. Firms with relatively high fixed costs will incur large variations in net returns to the total capital for a given variation in the total revenue. Over time, technological developments and rising land values have caused fixed costs to rise relative to the total revenue for most farms. Similarly, greater financial leverage tends to magnify variations in returns to equity capital for a given variation in the total revenue. Financial risk arises from the obligations associated with interest and principal payments to lenders. Therefore, decision behaviour of farmers is vastly influenced by the expected impact of risk.

OBJECTIVES

Agriculture in the hills is mainly rainfed and exposed to natural hazards like hail storm, frost, etc. Therefore, risk and uncertainty have an important influence in the hill farming system. Interest in increasing farm income, therefore, calls for a careful study of the impact of risk and uncertainty on farm production and income. There are few formal and informal means of minimizing the impact of risk and uncertainty on farm production and income. Among the informal means are mixed cropping and mixed farming. Among formal means are insurance against loss, institutional credit, improvements in marketing, particularly storage, transport and market intelligence services, trade regulations, hedging and contract sale of crops in preference to the sale of products. To study the economic feasibility of some of these formal and informal means is the overall objective of this study. The specific objects are (*i*) to measure risk in farming, (*ii*) to measure the impact of technology on farm risk and (*iii*) to evaluate the economic benefits of formal and informal methods of risk management.

METHOD

Of the several types of risks discussed earlier, many are difficult to measure and most studies on risk management are confined to the risk in farm income only. So does this study. In the present case, limiting the scope of the study to income risk only is not so restrictive as it appears. First, the farms in the hills of the Nilgiris are not subject to much of natural hazards like hail, frost, etc. Secondly, the impact of technological risk is evaluated by comparing optimal plans of traditional and modern farms. Thirdly, operating leverage is not a serious problem because most of the hill farms cultivate vegetables and the share of fixed cost in the total cost of the farm business is small. Therefore, risk in farming arises from variations in productivity, prices and cost and these three together define the variation in farm income—the variable selected for the study. Behaviour responses of farmers to the variations in aggregate net farm income are studied in detail. Farmers are assumed to be risk averters and therefore, given a level of expected income, they are expected to act rationally to minimize risk. The validity of this assumption concerning decision behaviour of hill farmers is first tested.

For the study, two farms are selected from the development block of Ootacamund in the Nilgiris district. One farm is purely rainfed and it is called 'traditional farm' for this study. Another farm is having sprinkler type of irrigation. Investment in this new method of irrigation and consequent improvement in production makes this farm a 'modern farm'. For both the farms, optimal plans are prepared for minimizing risk in aggregate farm income, given a level of expected income. Several tools are available for such an analysis.[2] For the present study Quadratic Programme was the choice. The model used for the study is:

$$\text{Minimize } Z = X' \phi X$$
$$\text{Subject to } AX \gtreqless B$$
$$\text{and} \quad C'X = E^\circ$$
$$X \geqslant 0$$

where

X is a column (m × 1) vector of activities,
ϕ is an (m × m) matrix of variance-covariance of unit income of activities,
A is an (n × m) matrix of technical coefficients,
B is (n × 1) vector of resource constraints,
C is a (n × 1) vector of expected net income per unit of activity,
E° is the given level of expected net income for the farm.

Given E°, the objective is to minimize variance in aggregate net farm income ($X' \phi X$), subject to resource constraints $AX \gtreqless B$ and an income equality constraint $C'X = E^\circ$ and non-negativity constraints $X \geqslant 0$. E is parametrically varied within a feasible range of farm income and the corresponding value of Z is determined. The results yield Expected income-Variance (E-V) frontier for the farm business. The estimated E-V frontiers for the two farms are compared and inferences drawn.

RESULTS

For the two sample farms, *viz*., traditional and modern farms, separate quadratic programmes were formulated and solved. The problem is to find the optimum combination of nine activities that minimize risk, given the level of aggregate net farm income. For the problem profit (net income) levels of the activities are not known with certainty; however, the expected net income levels are known and variance-covariance matrix of net income per unit is given. These parameters are estimated from time-series data for prices and farm level data for yield and cost for a period of five years ending 1976-77. The resource requirements are worked out for both traditional and modern farms. The variance-covariance matrices for the two farms are presented separately in Table I and II.

Before going into programming details, it is interesting to analyse the resource requirements. Only land and capital constraints are specified as

2. For an excellent summary and critical comments, see Agricultural Research and Education related to Decision-Making under Uncertainty—An Interpretative Review of Literature, Research Report No. 747, Agricultural Experiment Station, Oklahoma State University, March 1977.

TABLE I—VARIANCE-COVARIANCE MATRIX FOR NET INCOME PER QUINTAL IN SAMPLE TRADITIONAL FARM

(*Rs.*)

Activities		Potato-I X_1	Cabbage-I X_2	Potato-II X_3	Cabbage-II X_4	Carrot X_5	Radish X_6	Potato-III X_7	Cabbage-III X_8	Milk X_9
Potato-I	X_1	12·4549	11·8533	7·7184	—13·6357	8·8683	9·1683	6·3745	5·6482	8·7523
Cabbage-I	X_2		25·8078	5·2395	—4·7785	7·1083	—6·4909	2·6707	5·5454	6·9176
Potato-II	X_3			7·4630	—1·9547	2·5529	13·3746	1·6134	2·5396	3·9686
Cabbage-II	X_4				2·4183	—0·4500	—2·2383	0·0239	0·0683	0·2275
Carrot	X_5					10·7814	0·2211	8·6709	6·0621	9·1455
Radish	X_6						36·3871	1·5233	0·0326	2·7597
Potato-III	X_7							7·4624	4·3028	7·0324
Cabbage-III	X_8								6·2784	7·0054
Milk	X_9									9·1709

TABLE II—VARIANCE-COVARIANCE MATRIX FOR NET INCOME PER QUINTAL IN SAMPLE MODERN FARM

(*Rs.*)

Activities		Potato-I X_1	Cabbage-I X_2	Potato-II X_3	Cabbage-II X_4	Carrot X_5	Radish X_6	Potato-III X_7	Cabbage-III X_8	Milk X_9
Potato-I	X_1	31·9225	9·7168	7·7215	—11·6351	8·8641	10·2168	8·1488	4·9879	8·3527
Cabbage-I	X_2		31·3600	5·1185	—5·7180	9·1383	—5·8176	3·1863	5·5145	7·3727
Potato-II	X_3			9·9225	—2·1105	2·6532	15·7117	2·7146	3·8147	4·3686
Cabbage-II	X_4				3·0625	—0·7160	—3·2310	0·0568	0·2617	0·4217
Carrot	X_5					21·3444	—0·4565	10·6169	8·1220	10·9476
Radish	X_6						32·4900	1·6550	0·0716	3·1875
Potato-III	X_7							70·5600	5·3148	8·0624
Cabbage-III	X_8								11·9025	8·0836
Milk	X_9									7·5625

N.B.: Matrix is symmetric—only upper half is reported.

there is no labour constraint reported in the study area. In land, two seasonal constraints are recognized for dry land and an irrigation constraint separately for activities 7 and 8 only. For activities 1 to 6 there is no need for irrigation as the rainfall is sufficient in most of the years. Being a hill area only vegetable crops are grown. To keep computational burden within manageable limits plantation crops like coffee and tea are excluded from the study. Financial resource available on the farm consists of self-finance and borrowed funds. Though no borrowing activity has been specified in the programme, the cost of borrowing is included in the variable cost in working out the net income. In fact this cost adds to much of the variation in the cost of production in the modern farm where sprinkler irrigation is installed with borrowed finance.

The differences in the cost of operation of the farm and productivity of crops explain the differences between the farms in the expected net profit (C_j) per unit of product. It may be observed that all the activities are defined and measured in quintals of products: resource requirements are defined per quintal and expected profit and variance are worked out per quintal.

A comparison of cash expenses per quintal in the two farms reveals that they are uniformly lesser in the modern farm. It is as expected because of the impact of technology. However, a more interesting observation is that the variance in unit profit has also increased with the adoption of new technology. To demonstrate this the coefficient of variation (CV) of expected profit per unit is worked out for each activity. It is observed CV is larger in the modern farm than that in the traditional farm except for activity 6 and 9, *i.e.*, production of radish and dairying.[3] In these two activities the CV is less. It must, however, be made explicit that the farmer's concern is not with the variance in profit of individual activities *per se*, but rather he wishes to minimize the variance in aggregate income. For this he has the freedom of choosing a suitable mix of the activities. What must be the composition (or structure) of this mix (crop pattern) is precisely the question he has to answer in decision-making. Given his preference to risk, it is assumed that he works rationally to minimize risk.

Matrices in Tables I and II show variance and covariances of expected profit per unit of the nine activities. Multiplied by the levels of activities, these matrices give an estimate of total variance in aggregate farm profit for a given level of expected net farm income (E). Square root of this, *i.e.*, $(X' \phi X)^{\frac{1}{2}}$ is defined as Expected risk (σ^{-}). By parameterising E within a reasonable range of values, the corresponding value of σ^{-} can be estimated.

To begin with, the average levels of aggregate farm incomes realised in the sample farms during the five years covered by the study were used to estimate the risk minimizing crop mix. The estimated levels are the levels of activities expected if the given levels of profit, *viz.*, Rs. 10,300 and Rs. 16,900, respectively are to be realised with minimum of variance and hence called

3. The data for comparative analysis of radish production were not adequate to draw any meaningful conclusion. However, in the case of milk, reduction in CV was mainly due to differences in the levels of borrowing.

TABLE III—A COMPARISON OF ACTUAL AND OPTIMAL PLANS IN TRADITIONAL AND MODERN FARMS

Activities		Traditional farm			Modern farm		
		Actual[a] (quintals)	Expected[b] (quintals)	Deviation[c] (per cent)	Actual[a] (quintals)	Expected[b] (quintals)	Deviation[c] (per cent)
1. Potato-I	X_1	130·00	132·00	1·52	78·00	75·00	3·85
2. Cabbage-I	X_2	24·00	25·00	4·17	20·00	21·00	5·00
3. Potato-II	X_3	190·00	181·00	4·74	65·00	62·00	4·62
4. Cabbage-II	X_4	112·00	110·00	1·79	100·00	125·00	25·00
5. Carrot	X_5	47·20	40·00	15·25	20·00	—	—
6. Radish	X_6	10·00	—	—	—	—	—
7. Potato-III	X_7	15·75	18·00	14·29	315·00	320·00	1·59
8. Cabbage-III	X_8	50·00	52·00	4·00	112·00	124·00	10·71
9. Milk	X_9	24·80	28·00	12·90	32·50	34·00	4·62
10. Net farm income	(Rs.)	10,300·00	10,291·47	0·08	16,900·00	16,928·45	0·16

N.B.: *a* = Actual level of production in 1976-77 as observed.
b = Expected level of production to minimize variance in net farm income, given the expected level of net farm income equal to actual income.
c = Percentage deviation of expected production from actual levels, *i.e.*, $\left(\frac{b - a}{a}\right) \times 100$.

TABLE IV—COMPARISON OF RISK IN SAMPLE FARMS

(*Rs.*)

Traditional farm			Modern farm		
Expected income (E)	Expected risk (σ)	C.V.	Expected income (E)	Expected risk (σ)	CV
		1. *Without Dairy*			
7,200·25	1,536·53	21·34	10,025·93	2,480·42	24·74
8,704·43	2,329·31	26·76	14,885·05	4,327·08	29·07
10,208·61	3,345·36	32·77	16,928·45	5,596·54	33·06
		2. *With Dairy*			
8,266·11	1,525·01	18·46	12,069·33	2,610·48	21·63
10,291·47	2,499·80	24·28	16,928·45	4,421·71	26·12
12,316·83	3,660·56	29·72	21,787·57	6,394·65	29·35

N.B.: CV = (σ/E) × 100.

expected levels. These estimates are compared with the actual levels of activities observed in the farms in Table III. Surprisingly, it is observed in the table that the actual and expected levels of activities are very close. Except for the absence of activities 5 and 6 in the expected mix, the differences in the levels of other activities are small. This supports the basic assumption of this study that the farmers are risk averters and their objective function is to minimize risk, and hence the choice of minimum variance. Thus, the choice of quadratic risk programming as the tool for this analysis is justified.

For the programming, the actual net aggregate farm profit realised by the two sample farms was estimated for five years. Minimum, maximum and average values of these estimates were used for parametric variations in E. For each of the three levels of E, the corresponding values of expected risk and CV were estimated. To study the impact of mixed farming separate programmes were formulated and solved with, and without dairying (activity 9). The results are presented in Table IV. As observed in the table, the CV is larger for all the income levels in the modern farm than the corresponding value in the traditional farm. This conclusively indicates that modern farming is more risky than traditional farming. One plausible explanation is the larger share of borrowed funds in the total farm outlay. That is, the larger financial leverage available to the modern farm through investment credit comes only with larger risk variance in farm business. This variation in farm profit comes through the variance of cost of production (see Figure 1 also).

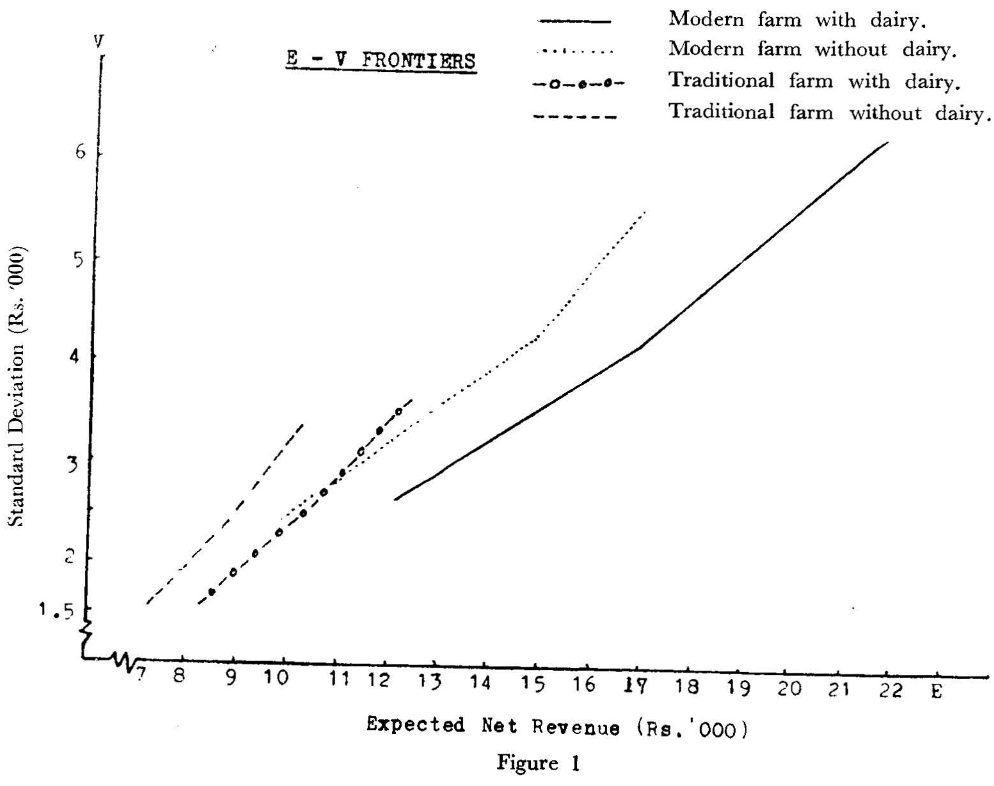

Figure 1

Another interesting result is that, as evidenced by the smaller CV for mixed farming, farming with dairying is less risky than without it. Compared to that in pure crop farms, *i.e.*, without dairying, the addition of dairy activity to the crop farms reduces the variance in farm profit by 2 to 5 per cent.

As the CV is a rough measure of risk in farm business, it may be concluded from the results presented in Table IV that risk in farm business varies from 18 to 30 per cent in the traditional farm and from 21 to 33 per cent in the modern farm. About 10 per cent of this risk can be avoided by informal methods like mixed farming, diversification of farm activities, contract sale of crops, especially medium-term contracts for 3 to 5 years, hedging and the like. Formal methods of risk management involve crop insurance, stable credit policy, price policies for farm input and improvement in marketing. However, this study cannot cover these aspects on account of its limited scope, a small sample and normative nature.

CONCLUSION

This study shows that, in hill farming with its limited scope for diversification, if efficient investment decisions are made in both traditional and modern farms, the latter is more risky than the former. There is higher expected income with higher risk associated with it. This may be a constraint in decision behaviour of farmers in adopting modern technology. Therefore, it will be relevant to minimize risk not only to protect farmers in general but also to promote the diffusion of technology. Several formal methods to minimize risk are in practice. These deserve encouragement. Notable among them are mixed cropping and mixed farming and improved marketing practices to help price stabilization.