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RISK AND RICE TECHNOLOGY IN NEPAL

Farmers are necessarily uncertain about the outcome of 'new' methods. Many farmers, especially those with small holdings, do not take up loans linked to new methods because of higher risks perceived in such technology. According to Schulter (17), borrowing greatly increases uncertainty for a small farmer who may well fear losing his land, which is usually mortgaged. Rokaya (14) found that 85 per cent of small farmers and 33 per cent of large farmers in the Nuwakot district of Nepal did not use agricultural credit because of the higher risks they believed were involved in the associated new technology.

Farmers' risk perception depends in part on their knowledge and experience [Hiebert (8)]. New technology is usually developed in an experiment station under a relatively 'controlled' environment. Uncertainty inevitably pervades the return on capital that is invested in new technology on farms. Risk may thus play an important role in farmers' decision-making about adoption of new technology [Eidman, Dean and Carter(4); Anderson (1)], especially in the case of farmers in traditional agricultures [Porter (12); Schultz (18); O'Mara (10)]. Many studies have shown that adoption is **strongly influenced by uncertainty [Schluter (17); Wolgin (19); Moscarcardi and de Janvry (11); Brink and McCarl (3)].**

Risk may be perceived in new technology because, under adverse weather conditions, a new technology may benefit a farmer even less than a traditional technology that has evolved over time and under wider extremes of climatic conditions [World Bank (20)]. A modern variety may yield twice as much as local varieties, but only when appropriate amounts of fertilizer and irrigation are applied. With limited knowledge and experience, small farmers may be reluctant to use a technology that does not appear to them to offer low risk as well as higher net income [Lipton (9)].

From this perspective, Hamal (6) interviewed 60 Nepalese small holding farmers to obtain data on their personal (including attitudes towards risk) and farming circumstances, as well as their subjective beliefs about paddy yields. Their major farm enterprise is the growing of rice (paddy), mainly for their own families' subsistence consumption. The primary purpose of the study was to examine the impact of risk and risk aversion on the adoption of special-purpose lines of credit for the purpose of assisting such small farmers to adopt technologies believed to be superior, at least in the sense of inducing higher average yields of this important grain.

ELICITATION OF FARMERS' PROBABILITIES AND PREFERENCES

The 60 farmers come from two adjacent villages in South Central Nepal. Being small farmers, they are not wealthy, have only their small plots (average of 0.1 ha. of rice per farm) and generally suffer from a very slight educational background. To facilitate the elicitation of subjective probability information, most emphasis was placed on using the easily

elicited triangular distributions [Anderson, Dillon and Hardaker (2, pp.26, 268)] in the first round of questioning of subjective yield distributions. The adequacy of the triangular assumption was checked by asking further questions using the 'judgemental fractile' method (Raiffa 1968) of elicitation. In general, the triangular distributions seemed to capture adequately the nature of the yield distributions. It takes its name from the shape of the probability density function and is elicited by asking for the lowest possible value (A), the most likely value (M) and the highest possible value (B).

Farmers' risk preferences were elicited using an interview technique based on preferences expressed among pairs of hypothetical lotteries involving equally likely rewards [Anderson, Dillon and Hardaker (2, pp.75-76)].

For instance, a lottery whereby a wealth position of Rs. 2,000 results if a coin lands heads and Rs. 20,000 results if tails, might be written as **(.5, .5; 2,000, 20,000). The method then depends on establishing through a** series of questions a sum b* such that the respondent is indifferent between the first lottery and, say, (.5, .5; b, 10,000). With the responses to a structured sequence of such determinations of indifference, it is then possible to smooth a utility function to the data.

The elicitation was confined to a range of levels of wealth that it was believed that respondents could identify with fairly readily. The low end of the range was at the threshold of subsistence (in terms of areas of rice) and the upper level was the proclaimed legal limit to the extent of land holding in Nepal.

The elicited utility functions, reported in detail by Hamal and Anderson (7), are all concave and, as a result of employing the practice of plotting the functions and checking consistency as the interview progressed, smooth. Absolute risk aversion over different segments of the utility functions was calculated to determine the nature of any change with wealth. The 7-data points for each function were used directly by taking them in contiguous groups of 3 (making 5 triplets), fitting a negative exponential (constant risk aversion) utility function to each set of 3 points (making 5 triplets, a two-point risk and associated certainty equivalent), thus yielding 5 segments, each with an assumed constant absolute risk aversion co-efficient $(R_A)^1$

DISCUSSION AND INTERPRETATION OF THE DATA

Risk aversion is the prevalent risk attitude among these Nepalese paddy farmers. Farmers' levels of absolute risk aversion are highly dependent on their present wealth which, in turn, is obviously closely related to such things as area of arable land and average annual income. Partly because of the prevalence of risk aversion, these farmers may be less likely to participate in the adoption of new technology. Another potentially

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1. The utility function is $U(W) = -exp(-R_A W)$, where U is utility, W is wealth and R_A is, in this special case both the single parameter of the function and the coefficient of absolute risk aversion defined as $R_A = -U''(W) U'(W)$ where the primes denote derivatives [Pratt (13)]. The parameter is titled by an iterative approximation procedure.

important contributing impediment to adoption is the perception of risk in the various technologies.

Perceptions of risk were approached through the simplifying but seemingly well justified assumption that risk is confined to paddy yields and that paddy price, input prices and availabilities are all known with certainty. Probability distributions for paddy yield (Yt/ha.) were elicited by resort to the triangular distribution. Its three parameters 0.0 fractile A, mode M and 1.0 fractile B) were determined for the traditional technology ('tried and trusted' variety and no 'modern' inputs) and for 'new' technology ('high-yielding' or modern variety, insecticide, fungicide, and mineral fertilizer) at three levels of fertilizer nitrogen (N), namely, 22, 44 and 67 kg./ha. A convenient method of summary is by the first two moments, the mean, E[Y] and variance, V[Y], of yield which are determined from the elicited parameters as

(1) $$E[Y] = (A + M + B)/3,$$

(2) $$V[Y] = [(B-A)(B-A) + (M-A)(M-B)]/18.$$

To facilitate comparison of such diverse technologies, the **data** are transformed to a common basis of gross margins (G Rs./ha.) as

(3) $$G = Y(P-UC)-VC,$$

where P is farm price per unit of Y in Rs./t, UC is unit variable costs like for threshing and storage that vary directly with Y in Rs./t, and VC is other variable costs in Rs./ha. Two levels of costs were employed, namely, with and without the subsidised credit that the government is tying to the package of 'new' technology. In the comparisons reported below, attention to the 'new' technology is concentrated at the recommended level of 44 kg./ha. of N.

Nepalese small holding paddy farmers generally believe that, although there may be higher average returns, there are higher risks (measured in terms of variance of gross margin) in new technology as compared with traditional methods. This perceived variance appears to be negatively related to farmers' (subjectively scored) knowledge and (years of) experience of new technology, but in cross-sectional regressions in which only of the order of 20 per cent of variation was 'explained'. Farmers with a relatively high degree of absolute risk aversion tended to perceive greater risk in new technology. However, (years of) education was not significantly associated with their perceptions of variance of yields and gross margins.

Risk attitudinal data such as these just mentioned could be used in several ways to assist insight into questions of adoption and policy. For instance, one 'positive' application is to relate credit use to risk aversion and risk perception. Generally, farmers' with relatively high levels of risk aversion and perception tend to use less credit than others. This tendency

is captured in the cross-sectional relationship fitted for the 36 of the 60 who used the credit-technology package in 1980-81:

(4)
$$C = 360 - 5.1 \ V[G] + 1.3 \ R_A$$
$$(t = -.36) \quad (t = -11.7)$$
$$\bar{R}^2 = .81 \qquad n = 36$$

where C is credit use in Rs./ha.,
V[G] is variance of gross margin at $N = 44$ kg./ha. in $(Rs./ha.)^2 \ 10^6$,
R_A = predicted absolute risk aversion $(X \ 10^5)$ at present wealth. The risk aversion influence in credit uptake is evidently of considerable greater statistical importance than is perceived variance.

ANALYSIS OF CHOICE OF TECHNOLOGY

A normative application of such data is to model the choice between traditional and new technologies as a utility maximization problem. Several simplifications are invoked for this purpose, namely, that utility is of the constant absolute risk aversion type and that farmers' subjective probability distributions of yields and gross margins are approximately normal.[2]

Under these two assumptions, the maximization of a farmer's expected **utility is equivalent to maximizing the function, $U = E - (R_A / 2) V$, where** U is expected utility, E is mean and V is variance of farm returns [Freund (5)]. With this simplified expected utility maximization model, these few features of farmers' decisions on the adoption of new technology can be examined by systematically shifting the parameters of the model.

The level of absolute risk aversion predicted at current wealth (that is, present risk aversion) as well as the level of risk aversion at which farmers are indifferent between new and traditional technologies can be compared. The 'break-even' level is that value of risk aversion (R_A^*) that satisfies[3]

(5)
$$FE[G_T] - (R_A / 2) F^2 V[G_T] = FE[G_N] - (R_A / 2) F^2 V[G_N]$$

where F is paddy area (ha.), other variables and operators are as previously defined, and the subscripts T and N denote traditional and new ($N = 44$ kg./ha.) technologies respectively.

A dimensionless summary measure from this analysis is the ratio of R_A^* to the prevailing level of risk aversion for each farmer. This ranged over the interval 1 through 135 with a mean of 18. Excluding two high

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2. Less restrictive methods of technology discrimination are provided by the procedures of stochastic efficiency analysis [Anderson (1)]. However, the CDFs for G under the different technologies were such that, while subsidised credit was desirable if the new technology was to be adopted, traditional technology was not dominated (in the sense of first-, second- or third- degree stochastic dominance) by the new technology.

3. In an earlier version of this work, paddy area was excluded from this equation, with consequent impact on the results. The error is mentioned here to assist others using analogous models to avoid it. It is a matter of working at a consistent level in comparable units. If risk aversion is assessed at a farmer or whole farm level (as would usually be the case), mean, variance and any other statistical summary measure must be expressed at the same level and in comparable units. The coefficient of absolute risk aversion is not 'absolute' in the sense that its magnitude depends on the units in which the argument of the utility function is measured [Hamal and Anderson (7)].

outliers, the means for adopters and non-adopters of the credit-technology package were 18 and 10 respectively. This implies, for instance, that non-adopters could, on average, be ten times as averse to risk as they presently are for the technologies to be of equal utility, even with the high variance perceived in the new technology. At lesser levels of risk aversion they should, other things being equal, perceive the new technology as offering greater satisfaction. This normative statement is even more pronounced for the other group who, as adopters, have the courage of their convictions to take up the technology they perceive as so favourably beneficial.

CONCLUSION

It thus seems that perception of risk and aversion to risk provide only very partial explanations of farmers' decisions on adoption of technology and on participation in linked subsidised credit programmes. Other factors, such as attitudes towards bureaucrats and access to factor markets, or external influence such as procedures and preferences of implementing agencies, may be much more important, at least in this Nepalese case study.

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