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RISK AVERSION, RISK PERCEPTION, AND CREDIT USE : THE CASE OF SMALL PADDY FARMERS IN NEPAL

Krishna Bahadur Hamal

A/D/C

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HMG - U.S. AID - A/D/C PROJECT
STRENGTHENING INSTITUTIONAL CAPACITY IN THE
FOOD AND AGRICULTURAL SECTOR IN NEPAL

Foreword

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One of the most important components of this project is advanced training, at the Masters and Ph. D. levels, of young professional staff of agricultural agencies of the MOA and other related institutions. ADC Fellows have been selected for advanced training in Asia, Australia and the U.S.A. Most of them have written a thesis based on their research of a particular problem area in Nepal's agricultural and rural development. In addition, this project sponsors problem-oriented research activities which are carried out by the staff of agricultural agencies of the MOA and other related institutions with the cooperation of ADC staff.

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RISK AVERSION, RISK PERCEPTION, AND CREDIT USE: THE CASE OF SMALL PADDY FARMERS IN NEPAL

Krishna Bahadur Hamal*

ABSTRACT

This study measures farmers' risk aversion and their perception of risk with respect to new technology and relates these factors to the use of credit provided for adopting new technology. Farmers' degree of risk aversion and perception of risk are calculated by eliciting their utility functions for wealth and their subjective probability distribution functions. A subjective utility model, simple regression, and other statistical techniques are used to test the hypotheses of the study.

Most small Nepalese paddy farmers are risk-averse, and the degree of their absolute risk aversion is relatively high. Absolute risk aversion is negatively related to present wealth, which is closely related to land holding and annual income. Farmers' perceive higher risks in adopting new technology than continuing with traditional methods. Risk perception is significantly related to farmers' knowledge and experience with new technology. Farmers' absolute risk aversion and perception of risk play significant roles in their use of credit to adopt new technology.

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INTRODUCTION

Agricultural credit is given mainly for the adoption of new technology, and it thus may be associated with high risks, because farmers are uncertain about the outcomes of new methods. Farmers are more confident about traditional methods because they have been practising these methods for generations. Several studies, such as Schluter (1973) and Rokaya (1979), have shown that small farmers do not take loans because of the higher risks involved in new technology.

In this study, risk is measured in terms of the variance of paddy yields and related returns. New technology -- that is, one which uses recommended amounts of HYV seed and chemical fertilizer -- is risky because outcomes with new technology are uncertain as a result of farmers' lack of knowledge and experience. Moreover, new technology is usually developed in experiment stations with a controlled environment, and may not perform as predicted in actual farm situations. Yields may fall below expectations or crops may fail as a result of mis-irrigation or untimely fertilisation, and there is always uncertainty in the return on capital invested in new technology. Therefore, risk may be perceived in using new technology and this risk may play an important role in farmers' decisions about adopting this technology (Porter 1959; Schultz 1964; Eidman, Dean, and Carter 1967; Wharton 1969; Roumasset 1971; O'Mara 1971), especially in the case of farmers in traditional agriculture (Anderson 1974). Credit alone is not sufficient to induce farmers to adopt new technology. It is the perceived certainty and profitability of the technology that act as pre-conditions for their decisions to adopt (Schluter 1974; Onchan 1979). Only when these two pre-conditions are fulfilled does credit become significant in determining willingness to adopt new technologies.

The objective of this study is to identify the factors, especially those relating to risk, that influence farmers' use of credit for the adoption of new technology and to suggest policies to reduce the degree of risk perceived. In addition, the following hypotheses are tested:

(a) Farmers' risk aversion is negatively related to wealth factors such as income and arable land area.

(b) Risk perceived in new technology decreases with increasing experience and knowledge gained in using the technology.

(c) Use of credit for adopting new technology increases as risk aversion and risk perception decrease.

METHODOLOGY

Study Area and Sampling Procedure

This study covers small paddy farmers owning less than 0.27 ha of arable land in Dhanusha and Mahottary districts in Nepal's eastern Tarai. Dhanusha, a major paddy producing district, was one of the two districts where the Small Farmer Development Project (SFDP) was first launched in Nepal. Mahottary, another major paddy producing district, has no SFDP, and it was chosen to determine whether the SFDP has changed small farmers' attitudes towards new technology and credit use. As Mahottary is next to Dhanusha, it was ensured that differences in farmers' elicited subjective beliefs were not the result of climatic or geographical differences.

In Dhanusha district the SFDP project area, Hariharpur and Sakhuwa Village Panchayats, was selected for this study. This area had a total population of 9000 in 1978/79, average family size was six, average household land holdings were 1.2 ha, and 73 percent of the families owned less than one hectare of cultivated land (APROSC 1979). In Mahottary district, Bandibash Village Panchayat was selected because it was similar to the SFDP project area with respect to population distribution, land holding patterns, and climatic and geographic conditions. Its total population was 3000, average family size was 5.5, and 70 percent of the families owned less than one hectare of cultivated land (Bandibash Village Panchayat 1979).

Simple random sampling was used to select 30 farm families from each sample area. These selected farmers were separately interviewed to obtain information on their subjective beliefs about paddy yields, wealth, education, experience and knowledge of new technology, credit, prices, and input use.

Model

The subjective expected utility model is appropriate for this study because it relates a farmer's subjective beliefs about new technology through his subjective probability distribution function and utility function to his risk attitude toward income that might be generated from the new technology.

The triangular distribution method was used to elicit subjective beliefs because it is simple and can be easily depicted in both probability distribution function (PDF) and cumulative distribution function (CDF) forms. Moreover, this distribution can be checked by comparing a triangular CDF with an elicited judgemental CDF at several points (Anderson et al. 1977).

Measurement of Risk

Bernoulli's principle, also known as the "expected utility theorem," is a generally accepted concept for describing decision makers' risk preferences. On the basis of Bernoulli's principle, a decision maker's risk preference can be obtained by locating an indifference point between a sure payment c and a 50-50 gamble on a or b, and the utility of that indifference point is

$$(1) \quad U(c) = 0.5\,U(a) + 0.5\,u(b).$$

A utility function is only unique up to a positive linear transformation, and an arbitrary scale can be chosen to plot the decision maker's preference curve with various indifference points at which he is indifferent between a sure payment and a 50-50 gamble.

There are two major methods to elicit a preference function with respect to Bernoulli's principle, the interview method and the experiment method (Binswanger 1978). The experiment method is a practical and reliable way to elicit an individual's preference function, but its key limitation is the need for money to play "real" gambles. When funds are not available, there is no choice but to apply standard interview methods in as realistic a setting as possible. Farmers' risk preferences were elicited using an interview technique, the Equally Likely but Risky Outcomes (ELRO) method. Following this method, farmers' preferences were elicited by letting them choose between two acts with equally likely but risky outcomes, and these preference functions were used to estimate farmers' risk aversion.

Local (or absolute) risk aversion is defined as the negative ratio of the second and first derivatives of a utility function (Pratt 1964; Arrow, 1965) that is,

$$(2) \quad r(W) = -U''(W)/U'(W)$$

where $r(W)$ = absolute risk aversion,

and $U(W)$ = utility of wealth.

Relative risk aversion is the product of absolute risk aversion and its respective wealth level in a particular segment of a utility function. Risk aversion is measured in terms of utiles, an arbitrary utility value. Risk perception is measured by the variance of expected gross margins with respect to a technology, in terms of Rs/ha.

To determine if the slow adoption rate of new technology was related to yield uncertainty or relative profitability, a simple model relating the mean and variance of gross margins of the traditional and new technologies was used. The mean and variance of the PDF with respect to the gross margin of paddy production was calculated using the following formulae for the triangular distribution (Anderson 1976):

$$(3) \quad \text{Mean } (E) = (A+M+B)/3$$

$$(4) \quad \text{Variance } (V) = [(B-A)^2 + (M-A)(M-B)]/18$$

where A = lowest point, M = mode, and B = highest point.

The gross margin of paddy production with respect to the traditional technology and new technology were calculated at three different levels of nitrogen use corresponding to the three key points of the triangular distribution: the lowest point, the mode, and the highest point:

$$(5) \quad GM = Y(P-YC) - VC$$

where Y = paddy yield in ton/ha, YC = unit variable cost in Rs/ton, P = price per unit of Y in Rs/ton, GM = gross margin in Rs/ha, and VC = other variable cost in Rs/ha. YC was calculated including the cost of labor and bullocks used in threshing and the cost of labor used in storing. VC included the opportunity costs of seed, fertilizer, labor, bullocks, insecticides, and irrigation tax.

RESULTS

Risk Aversion

All the elicited utility functions of farmers' wealth were smooth and concave and it was concluded that most farmers are risk averse. The regression coefficients of local risk aversion (RA) for five segments of each utility functions were regressed

on the respective expected wealth levels (W) associated with each of the two-point risks to determine whether risk is an increasing, constant, or decreasing function of wealth. Similarly, the relative risk aversion coefficients (RAxW) were used as dependent variables to learn whether each empirical utility function exhibits decreasing, constant, or increasing relative aversion. The results of these regressions are summarized in Table 1.

At significance levels between 0.05 and 0.20, from 3 to 52 percent of the sample farmers have utility functions showing decreasing absolute risk aversion with increasing wealth, while the utility functions of the others have constant risk aversion. At these significance levels, no farmers have utility functions with increasing risk aversion. Thus, most farmers are either risk-averse or risk-neutral.

Table 1. Risk Aversion with Respect to Wealth

Type of risk aversion	Absolute risk aversion		Relative risk aversion	
Decreasing	Number	Percent	Number	Percent
-- Significant at 0.05 level	2	3	1	2
-- Significant at 0.10 level	8	13	6	10
-- Significant at 0.20 level	31	52	13	22
Constant (not significantly decreasing or increasing at 0.20 level)	29	48	40	67
Increasing				
-- Significant at 0.05 level	-	-	4	7
-- Significant at 0.10 level	-	-	7	11
-- Significant at 0.20 level	-	-	7	11

Risk Perception

The mean and variance of the gross margin were calculated on the basis of equations (3) and (4), and are presented in Table 2 for selected farmers. The new technology has a higher mean gross margin than the traditional technology, but it also

has a higher variance. Variability in yields is likely to be the cause of slow adoption, rather than low profitability, because risk-averse farmers prefer the technology with less variability. In other words, farmers do perceive higher risks in the new technology. Moreover, even with a subsidised credit program new technology has neither a very high mean nor a very low variance.

Table 2. Mean and Variance of Gross Margin of Traditional and New Technology for Selected Farmers

(Mean in Rs'000/ha and variance in Rs^2'000/ha^2)

Farmer No.	Traditional Technology		New Technology with Subsidised Credit and at 44 kg/ha of Nitrogen	
	Mean	Variance	Mean	Variance
1	3.04	837	4.48	2496
4	3.87	1304	5.40	4505
18	2.20	442	3.14	1809
36	3.17	526	3.63	856

Thus far no assumptions have been introduced about the nature of preferences, and the assumption of triangularity in the probability density functions has been sustained. Under these assumptions, it is difficult to vary several related parameters -- such as the coefficient of risk aversion, mean, and variance -- in order to analyse their impacts on the adoption of new technology. To analyse the impacts of each of these parameters, it was assumed that the probability density functions were approximately normal and the utility functions were approximately negative exponential (constant risk aversion).

Under these two assumptions,the maximisation of a farmer's expected utility is equivalent to maximising the function $U = E - (RA/2) V$, where U = expected utility, E = mean, V = variance, and RA = coefficient of local risk aversion (Freund 1956). With this simplified expected utility maximisation model, the key features of farmers' decisions about the adoption of new technology are illustrated by varying each of the three parameters of the model in separate analyses. For simplicity, analyses were done of four farmers with different degrees of risk aversion and wealth levels.

First, risk aversion was varied, holding E and V constant at their calculated subjective values. Three alternative technologies -- traditional, new with subsidised credit and new without subsidised credit -- were compared by varying risk aversion. The results are summarised in Figure 1, which shows the breakeven level of risk aversion at which farmers are indifferent between new and traditional technology. Farmers having above breakeven levels of risk aversion prefer (that is, the expected utility is higher for) the traditional technology, even when they are provided with subsidised credit for the adoption of new technology. However, new technology with the subsidised credit program is always preferable to new technology without it. The reason is that the opportunity cost of farmers' own capital invested for the adoption of new technology is higher than the cost of capital borrowed from institutions at subsidised rates.

The level of farmers' risk aversion is thus likely to cause slow adoption of new technology in the Small Farmers Development Project (SFDP) area. This analysis highlights the importance of eliciting farmers' preference functions in order to know the present level of risk aversion in the community.

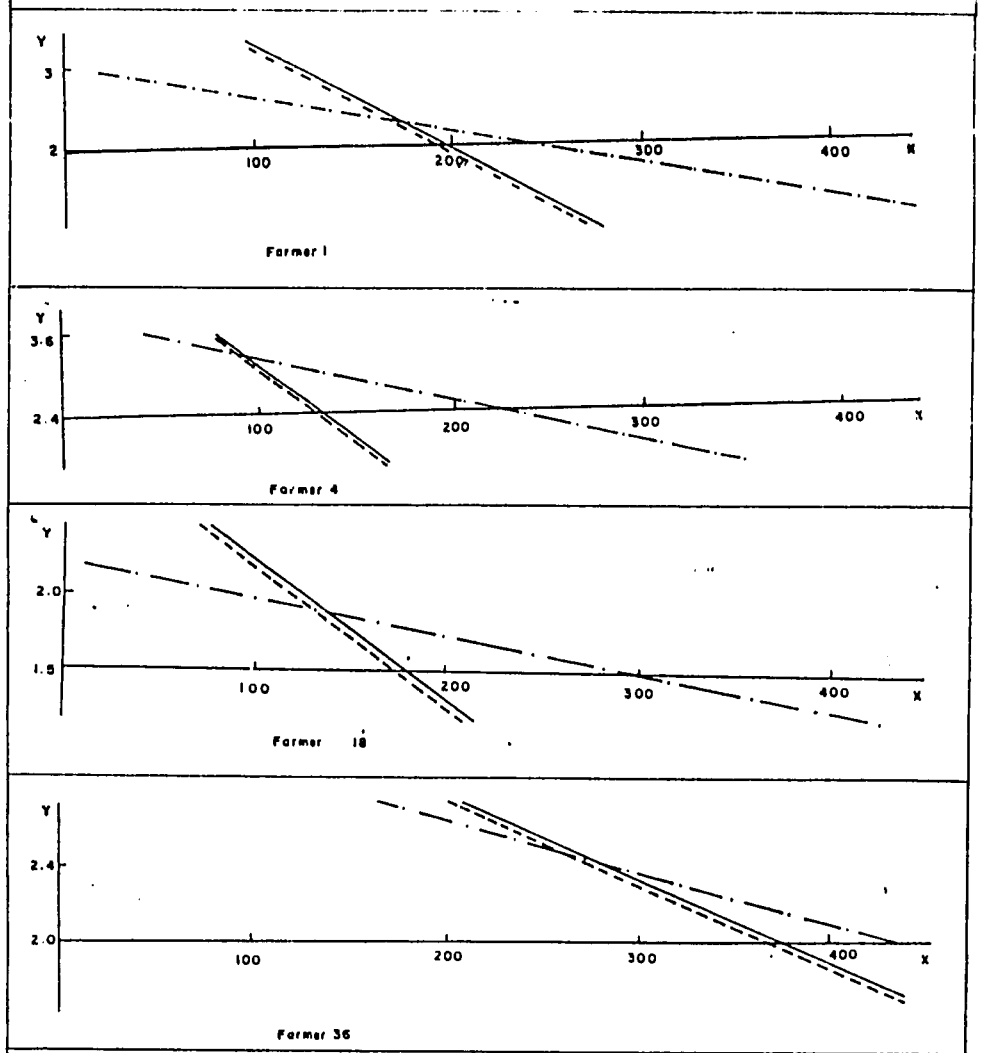
Farmers' present levels of risk aversion were calculated at their current wealth levels by using the estimated regression coefficients of local risk aversion for the five segments of their respective utility functions (Hamal 1981). They are presented in Table 3, which also provides the breakeven levels of risk aversion estimated from Figure 1. Farmers' present levels of risk aversion are often higher than breakeven levels -- that is, the traditional technology has a greater expected utility and thus it is presently preferred.

Next, the mean profitability of the new technology was varied, holding the level of risk aversion and the variance of

Table 3. Present and Breakeven Levels of Risk-Aversion ($RAx10^{-5}$)

Farmer	Present level of risk aversion	Breakeven level of risk aversion
1	178	174
4	344	97
18	29	138
36	42	28

Figure 1 Farmer's Expected utility at different level of risk aversion



X = Absolute risk aversion in 10^{-5} utiles

Y = Expected utility in 10^{3} utiles

—·— Traditional technology

——— New technology with subsidised credit

– – – – New technology without subsidised credit

the gross margin constant (Figure 2). At low levels of risk aversion, farmers require only a small difference in means to prefer the new technology, but at high levels of risk aversion the new technology is preferred only when the difference in means is considerably higher.

Finally, the variance of the gross margin of the new technology was varied, holding risk aversion and mean profitability constant (Figure 3). At high levels of risk aversion, a small difference in variance between the two technologies results in the new technology not being preferred. On the other hand, at low levels of risk aversion, the new technology is preferred unless the different in variance between the technologies is quite high. Thus, risk aversion and the mean and variance of gross margins clearly affect the adoption of new technology.

Testing the Hypotheses

The hypothesis that farmers' local risk aversion is negatively related to wealth factors such as income and arable land area is weakly confirmed by the results shown in Table 1. This hypothesis is further tested across farmers by regressing farmers' local risk aversion on their current wealth level:

$$(6) \quad RA^* = \underset{(t = 11.6)}{216} \quad \underset{(t = -4.12)}{21.2\ W^*} \qquad n = 60 \quad \bar{R}^2 = 0.21$$

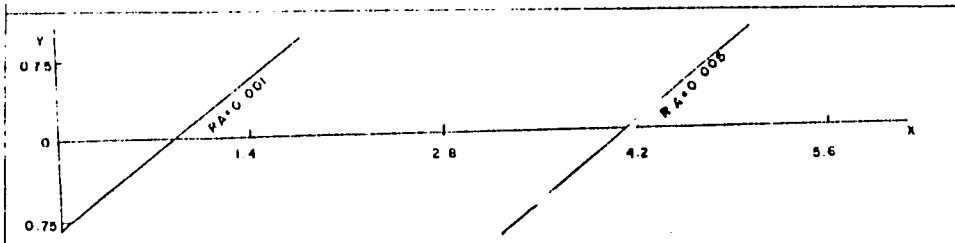
where RA* = local risk aversion at current wealth level times 10^{-5} in utiles and W* = current wealth level in Rs'000.

This equation shows that farmers' current wealth is significantly negatively related to absolute risk aversion. Together with the individual analyses, this indicates that as farmers get wealthier, they are less risk averse. This is consistent with economic theory, but it contrasts markedly with the empirical findings of O'Mara (1971).

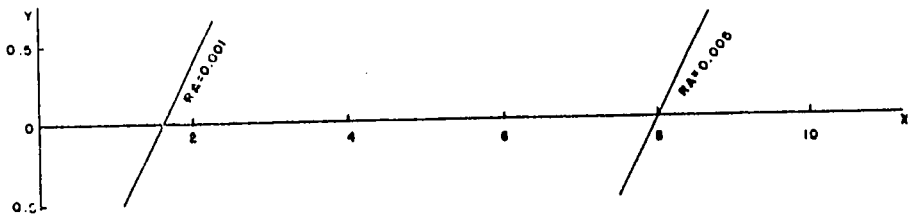
The hypothesis that risk perceived in the new technology decreases with increasing experience and knowledge was tested using simple regressions and a multiple comparison test. Farmers' experience was examined by regressing risk perception (variance of gross margin of paddy production) of new technology (V (GN*)) on their years of experience with it (K). The results are:

$$(8) \quad V(GN^*) = \underset{(t=23.3)}{3.32} - \underset{(t=-5.90)}{0.36\ K} \qquad n = 60 \quad \bar{R}^2 = 0.36$$

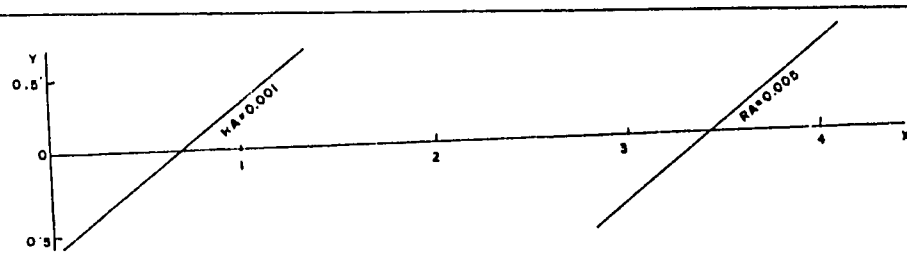
Figure : Farmer's expected utility at different level of mean profitability of 'new' technology and for a given level of risk aversion.



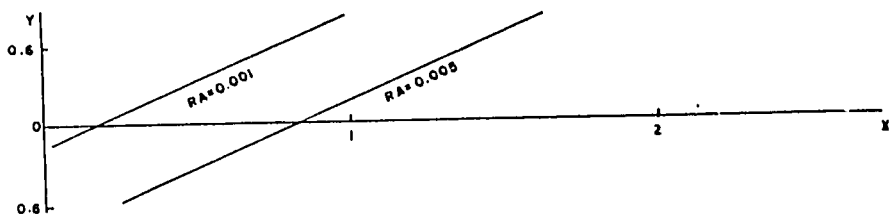
Farmer I



Farmer 4



Farmer 18

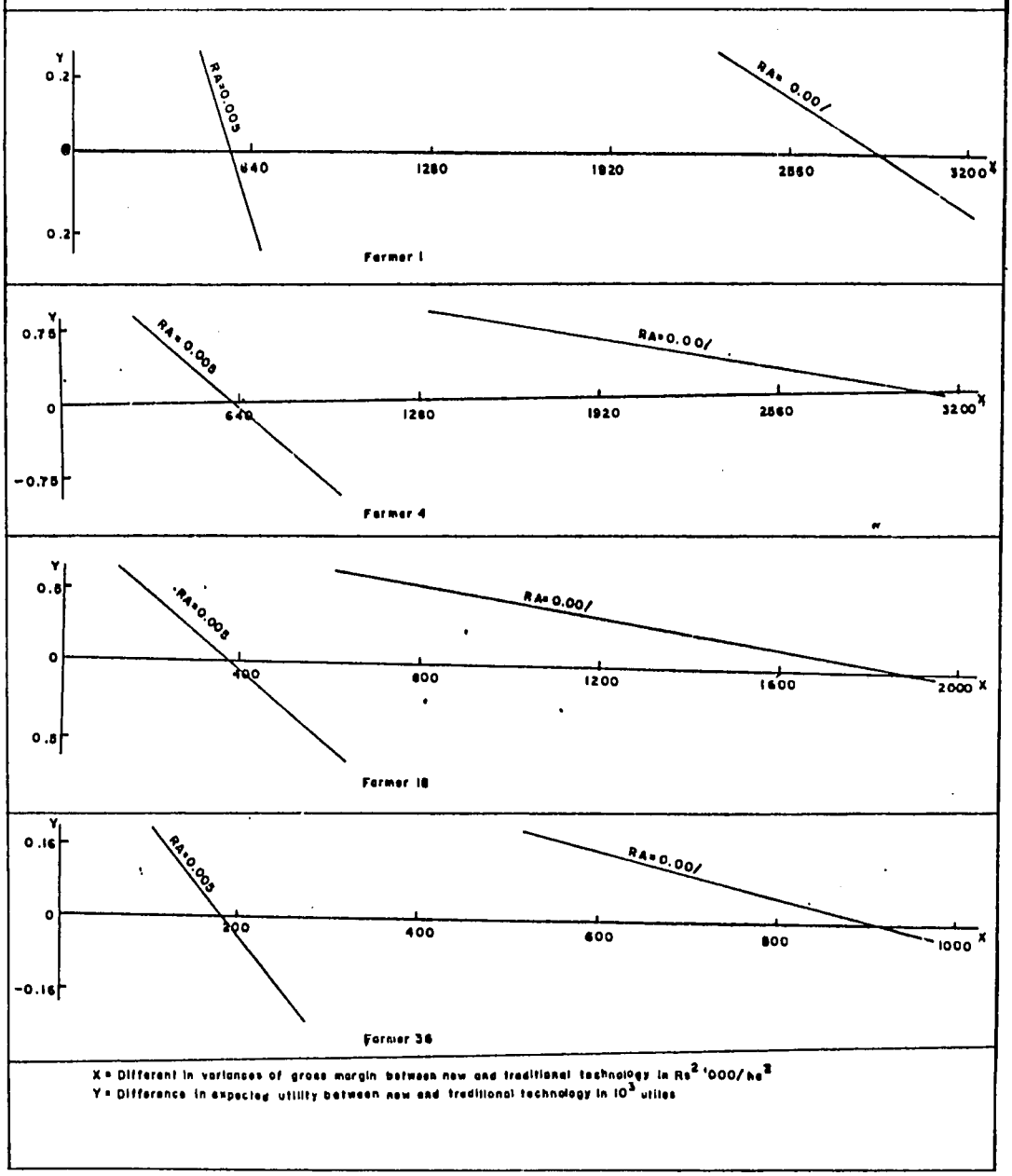


Farmer 36

X = Difference in mean gross margins between new and traditional technology in Rs'000/ha

Y = Difference in expected utility between new and traditional technology in 10^3 utiles.

Figure 3: Farmer's expected utility at different level of variance of 'new' technology and for given level of risk aversion



X = Difference in variances of gross margin between new and traditional technology in Rs^2 '000/ha^2

Y = Difference in expected utility between new and traditional technology in 10^3 utiles

This shows that farmers' risk perception with respect to the new technology decreases with increasing experience with the technology. As a farmer acquires experience, he becomes acquainted with its associated problems and solutions, and this leads to less variability in the gross margin.

To analyze the relationship between knowledge and risk perception, farmers were divided into four groups: Group I = know nothing about the recommended doses of either HYV seed or chemical fertilizer (nitrogen), Group II = know recommended doses of either seed or fertilizer but not both, Group III = know recommended doses of both seed and fertilizer but failed to achieve expected yields, and Group IV = know the recommended doses of seed and fertilizer and succeeded in achieving expected yields. A multiple comparison test (Bancraft 1968) using the Scheffe method and the Least Significant Difference (LSD) method were conducted to measure significant differences in risk perception among the groups. The results are summarised in Table 4.

Table 4. Comparisons of Risk Perception Using Scheffe Method and LSD Method

Group	Significant at 0.05 level	
	Scheffe Method	LSD Method
I vs II	No	No
I vs III	Yes	Yes
I vs IV	Yes	Yes
II vs III	Yes	Yes
II vs IV	Yes	Yes
III vs IV	Yes	Yes

Except for the comparison of Groups I and II, there are significant differences between the means of risk perception for these groups of farmers. Farmers' risk perception decreases with increased knowledge about the new technology, but knowing about only one input of the new technology does not make any difference because the new technology is considered to be "indivisible."

Simple regressions were used to explore the relationships between farmers' education level, the mean and variance of

gross margin, and absolute risk aversion. The results are presented below:

(9) $E(GN^*) = 4.44 + 0.0152\ ED$ $\quad n = 60$
$\quad (t=57.1)\ (t=0.96)$ $\quad \bar{R}^2 = -0.001$

(10) $V(GN^*) = 2630 - 18.7\ ED$ $\quad n = 60$
$\quad (t=24.9)\ (t=0.87)$ $\quad \bar{R}^2 = -0.004$

(11) $RA^* = 149 + 0.863\ ED$ $\quad n = 60$
$\quad (t=10.1)\ (t=0.29)$ $\quad \bar{R}^2 = -0.016$

E(GN*) and V(GN*) are the mean and variance of the gross margin of the new technology (with subsidised credit and 44 kg/ha of nitrogen) measured in terms of Rs'000/ha and Rs^2'000/ha^2 respectively, RA* is the present level of absolute risk aversion in 10^{-5} utiles, and ED is years of schooling.

According to these equations, there is no significant relationship between small farmers' education level and the mean and variance of the gross margin or the present level of absolute risk aversion. This might be because the proportion of illiteracy was high (53 percent) among the sample farmers. Among the literate group, the average years of schooling was only 6.6 years, which may not be sufficient to change farmers' attitudes towards risk.

The hypothesis that farmers' credit use increases as their risk aversion and risk perception decrease was tested by regressing farmers' amount of credit used for adopting new technology (C) on their risk perception and risk attitude. This regression was run using only 36 observations because the other 24 sample farmers (including six farmers who never used credit for adoption) were not using credit for adoption during 1980/81. The results are summarised in equations (12) to (14).

(12) $C = 355 \quad 0.01\ V(GN^*) \quad - 1.27\ RA^*$ $\quad n = 36$
$\quad (t=11.1)\ (t=-0.37) \quad (t=-11.7)$ $\quad \bar{R}^2 = 0.81$

(13) $C = 308 \quad 0.05\ V(GN^*)$ $\quad n = 36$
$\quad (t=4.33)\ (t=-1.56)$ $\quad \bar{R}^2 = 0.04$

(14) $C = 345 - \quad 1.28\ RA^*$ $\quad n = 36$
$\quad (t=26.0)\ (t=-12.3)$ $\quad \bar{R}^2 = 0.81$

When credit use was regressed on both risk perception and risk attitude, there was not a significant relationship between

risk perception and credit use. When credit use was separately regressed on risk perception and attitude, risk attitude was observed to have a more significant impact than risk perception on farmers' decisions about credit use for the adoption of new technology.

This hypothesis was also tested by examining Figure 1. At high levels of risk aversion, farmers prefer the traditional technology because it yields higher expected utility, and the new technology is preferred only when risk aversion is low. Similarly, from Figures 2 and 3, the new technology is preferred only when the difference in means between the traditional and the new technologies is high, or the difference in variances between the technologies is negligible. Thus, as risk aversion and risk perception decrease, farmers are more likely to prefer the new technology and to use more credit for adopting this technology.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusion

Risk aversion is the most prevalent risk attitude among small Nepalese paddy farmers, and the average degree of risk aversion is relatively high. Small farmers' levels of absolute risk aversion depend on their present wealth levels. Farmers with high levels of risk aversion and perception are less likely to adopt new technology, and use less credit than others.

Farmers' risk perception is significantly related to farmers' knowledge of and experience with new technology. Most farmers with relatively high absolute risk aversion perceive greater risk in the new technology. Education does not seem significantly associated with attitude towards risk.

Most farmers present levels of absolute risk aversion are higher than their respective breakeven levels (the levels below which expected utility maximising farmers would prefer new technology). A risk-averse farmer requires a higher mean return to prefer the riskier new technology, and this required difference in mean returns increases with higher risk aversion. A small difference in the variance of the technologies is sufficient to make a farmer with high risk aversion not prefer the new technology, whereas a farmer with low risk aversion requires a considerably higher difference in variance to switch preferences.

Policy Implications

Credit programs for small farmers can be made productive only when farmers' perceived risks are reduced. Merely increasing the supply of credit will not necessarily lead to increases in adoption and thereby productivity. Policies and programs that may decrease risk aversion and perception include redistribution of wealth through further land reform, group farming, and extension.

Land redistribution has been underway in Nepal for more than 17 years. Unfortunately, any further extension and improvement of the program may be infeasible because of the shortage of arable land. Moreover, in the absence of a developed industrial sector, the increasing population leads to farm fragmentation, further increasing the difficulties of land redistribution. Thus, development of the non-agricultural sector should be emphasized.

Group farming is another way of reducing risk aversion among small farmers. If resources can be shared in a group, so can risks (Bartholomaeus 1981). However, traditionally independent small farmers may find it hard to understand the idea of group farming. Before starting such a program, it may be necessary to change farmers' concepts about group farming through education or extension programs.

Extension and education programs which increase farmers' knowledge about new technologies may change farmers' perception of risk.

A policy of extending short-term loans in the case of crop failure may help farmers use credit for adopting new technology. In addition, a crop insurance program for purchased inputs may be appropriate for quick diffusion of new technology among small farmers. Any scheme that assures farmers a return is likely to change their attitudes toward the adoption of new technology, and perceptions of risk should decrease. The low level of education of small farmers may result in a slow understanding of the scheme, but an efficiently managed scheme should attract farmers if compensation payments are made at the time of crop damage and if the premium is initially subsidised by the government. With such a scheme, farmers may discount the higher variance of the new technology, and adopt this technology because of its higher yields. However, such a scheme may be costly, and a thorough analysis is necessary before implementation.

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