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LOGIT ANALYSIS OF TECHNOLOGY ADOPTION BY RICE FARMERS IN DHANUSHA DISTRICT, NEPAL

Parashar Bhakta Malla

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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.

The purpose of this Research Paper Series is to make the results of these research activities available to a larger audience, and to acquaint younger staff and students with advanced methods of research and statistical analysis. It is also hoped that the publication of this Series will stimulate discussion among policy-makers and thereby assist in the formulation of policies which are suitable to the development of Nepal's agriculture.

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LOGIT ANALYSIS OF TECHNOLOGY ADOPTION BY RICE FARMERS IN DHANUSHA DISTRICT, NEPAL

ashar Bhakta Malla*

ABSTRACT

The objective of this study was to identify the variables associated with the adoption of modern seed and use of fertilizer for rice in Dhanusha district. Maximum likelihood logit analysis was the main analytical tool.

Schooling, family size, paddy area, proportion of land area irrigated, extension visits, and fertilizer use influenced farmers' decisions to adopt modern seed, while age, family size, non-farm income, paddy area, proportion of land irrigated, radio listening, extension visits, and modern variety use influenced decisions about fertilizer use. However, schooling was negatively related to decisions regarding adoption of modern varieties and use of fertilizer. Other things equal, farmers who were co-operative members and who were exposed to extension activities were more likely to adopt modern varieties of rice and use fertilizer than farmers who were not co-operative members and who were not exposed to any extension activities.

Ensuring the availability of fertilizer, strengthening extension services, providing credit and bringing more land under irrigation are possible policy mechanisms for increasing the adoption of modern seed and use of fertilizer.

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INTRODUCTION

Agricultural development has been given priority by Nepalese policy makers since efforts for planned development began. This strategy is necessary because the agricultural sector contributes 62 percent of the GNP and 80 percent of export earnings, and 94 percent of the labor force is employed in agriculture (HMG Nepal 1981). However, agricultural productivity is low and has remained stagnant for some time. Yields per hectare are estimated to be 1.5 to 4.5 times higher in developed countries than in Nepal (Pant and Jain 1979).

The government of Nepal has recognized that food production increases have not kept pace with population growth. To meet this short fall and to fulfill rising expectations about the standard of living, the productivity of the land must be increased. Agricultural production can be increased by using modern inputs such as fertilizer, improved varieties of crops, and irrigation.

With this in mind, the government has opened extension offices and established institutions such as the Agricultural Inputs Corporation, the Agricultural Development Bank, and the Food Corporation. These institutions, which have networks at district and village levels, provide farmers with technical guidance and serve their input, credit, and marketing needs. At the village level, co-operatives have been organized to serve farmers. Efforts have also been made to bring more land under irrigation.

Rice constitutes a major portion of the diet of the majority of the population, and constituted 56 percent of cultivated land in 1977-78. At that time, maize covered 20 percent and wheat 16 percent of the cultivated area. However, while about 85 percent of wheat acreage is sown with improved varieties, only 18 percent of rice acreage is under improved varieties. Between 1970 and 1975, the use of chemical fertilizer rose over two fold (FAO 1978). In view of this, this study aims to identify the technical and socio-economic factors which influence the adoption of new and improved practices, specifically modern variety rice and the use of fertilizer.

METHODOLOGY

Sampling

Dhanusha district, a traditionally food-surplus area, was selected for this study. In 1979-80 this district produced a surplus of 16,481 tons of foodgrains, and agricultural and infrastructural support facilities are reasonably good in the district. This district was selected because it is personally familiar to the author, and because there are a sufficient number of farmers using modern seed and fertilizer to allow the analysis to be carried out. Information was collected for the 1981 paddy crop.

The study sample was drawn from eight rice growing panchayats of the district. The current voters' list was obtained from the District Panchayat Office and used as the sampling frame, and respondents were selected by systematic sampling. There were 147 respondents in the survey, split fairly evenly among eight village panchayats. A summary of sample characteristics is given in Table 1.

Table 1. Sample Characteristics

Characteristics	Mean	Standard Deviation
Age (years)	41.00	11.75
Schooling (years)	1.99	3.34
Family size (number)	7.17	3.45
Farm size (ha)	1.64	N.C.
Irrigated own land (ha)	0.77	1.84
Irrigated leased land (ha)	0.07	0.25
Unirrigated own land (ha)	0.75	1.63
Unirrigated leased land (ha)	0.05	0.20
Plots per farm	7.16	7.80
Paddy area (ha)	1.57	2.39
Fruit area (ha)	0.07	0.11

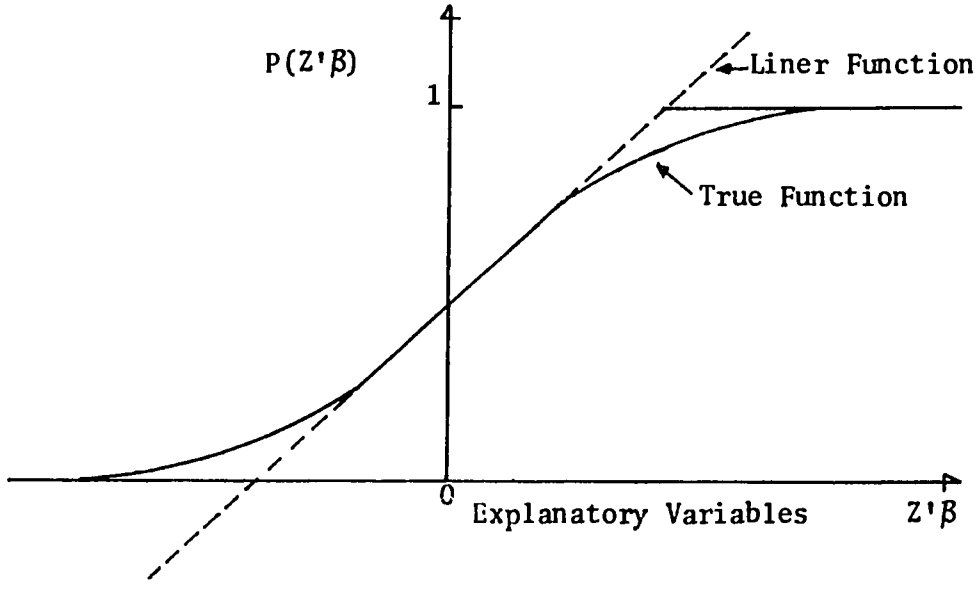
N.C. = Not Computed

Logit Analysis

Relationships between socio-economic variables and the adoption of modern techniques was examined by the use of frequency tables and logit analysis. For the logit analysis, the dependent variables (adoption of modern variety or use of fertilizer) take 1 and 0 values depending on whether the respondent is an adopter of modern techniques or not. The usual method of analysing the relationships between dependent variables and a set of explanatory variables is ordinary least squares (OLS). However, OLS estimation, though it yields unbiased and consistent estimates, is inefficient because the error terms are heteroscedastic, and the usual tests of significance are not applicable because the error terms are not normally distributed.

Predictions based on OLS estimates can also result in negative values or values exceeding 1, even though the dependent variable must lie between 0 and 1. The true probability function, expressed as a cumulative distribution function (cdf), is generally assumed to have an S or sigmoid shape as it must lie between 0 and 1 and must be non-decreasing if the probability of the dependent variable being equal to 1 increases with larger values of the explanatory variables. This is illustrated in Figure 1.

Figure 1. Liner Approximation of a Probability Function



Source: Nerlove and Press (1973)

Generalised least squares (GLS) has been suggested as one way to overcome the problem of heteroscedasticity (Goldberger 1964), but with this method the predicted value of the dependent variable may still be greater than 1 or less than 0. To overcome this problem in analysing binary data, Nerlove and Press (1973) suggest the use of maximum likelihood logit analysis. The logistic function is:

$$P_i = \frac{1}{1 + e^{-z_i' \beta}}$$

or

$$\ln \quad [P_i/(1-P_i)] = \beta' Z_i$$

where P_i = Probability that ith farmer will adopt the modern technique

β = Column vector of coefficients

Z_i = Column vector of independent variables

The left-hand side of the second equation is known as log odds or logit of modern technique adoption. The computational procedure involves the maximization of the likelihood function with respect to the coefficients of the independent variables.

The model used in this study is summarized by the following equations:

$$Y_1 = f \ (Z_1, Z_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Z_{14}, Y_2)$$

$$Y_2 = f \ (Z_1, Z_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Z_{14}, Y_1)$$

where Y_1 = Modern variety seed use (yes or no)

Y_2 = Fertilizer use (yes or no)

Z_1 = Age of farm operator (years)

Z_2 = Education level of farm operator (years of schooling)

Z_3 = Family size (members living with farm operator but not paid wages for farm work)

Z_4 = Non-farm income per year (Rs 000)

Z_5 = Paddy area cultivated (ha)

Z_6 = 1 for pure owners, 0 otherwise

Z_7 = 1 for semi-tenants, 0 otherwise

Z_8 = 1 if the farmer listened to agricultural programs on the radio, 0 otherwise

Z_9 = 1 if the farmer had been visited by an extension worker in the previous year, 0 otherwise

Z_{10} = 1 if the farmer had taken part in an agricultural training program in the previous year, 0 otherwise

Z_{11} = 1 if an agricultural demonstration had been conducted on the respondent's farm in the previous year, 0 otherwise

Z_{12} = 1 if the farmer is a member of a co-operative society, 0 otherwise

Z_{13} = 1 for an institutional credit user, 0 for a non-user

Z_{14} = Proportion of area irrigated to area cultivated.

Because use of modern seed may affect use of fertilizer and vice-versa, Y_1 and Y_2 are endogenous variables in the system, and are jointly determined. Tenure dummy variables Z_6, Z_7 and credit dummy variables Z_{13} were subsequently dropped from the equations because there was the problem of non-convergence.

It was hypothesized that age would be negatively related to adoption of modern techniques, the relationship between non-farm income and adoption was not predicted, and all other variables were expected to be positively related to adoption of modern techniques.

RESULTS

The farmers in the sample cultivated a wide range of traditional rice varieties, which may be divided into fine and coarse categories. Popular fine quality varieties include Jasawa and Basmati, and the more important coarse varieties are Harinker, Ujari, Dolan, and Dudhkalam. In the main season, with which this study was concerned, the only modern variety cultivated was Masuli, which is gaining popularity in the area because it is a fine rice having both high potential yield and good taste. Altogether 56 of the 147 sample farmers cultivated Masuli rice, and in the main season, 13 percent of the total paddy area in the sample was under this variety.

Overall, the sample farmers applied 9.7kg/ha of nitrogen and 2.2kg/ha of phosphorous on their rice fields. The average application on modern varieties was 30.96kg/ha of nitrogen and 10.30kg/ha of phosphorous, while the average application on traditional rice varieties was 7.53kg/ha of nitrogen and 1.36 kg/ha of phosphorous. These doses are far below the recommended dose of 75:20:20 (N:P:K, kg/ha) for modern varieties and 30:15:15 for traditional varieties in the district.

In all, 92 farmers (62 percent of the sample) used fertilizer. All users applied nitrogen fertilizer, some applied phosphorous, and none applied potash fertilizer. Table 2 gives general characteristics for modern variety rice adopters and non-adopters, and fertilizer users and non-users.

Table 2. General Characteristics of Technology Adopters and Non-Adopters

Characteristics	Modern Variety Adopters		Modern Variety Non-Adopters		Fertilizer Users		Fertilizer Non-Users	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age (years)	41	13	41	11	40	11	42	12
Schooling (years)	2.16	3.31	1.89	4.38	2.29	3.45	1.57	3.16
Family Size	7.00	3.39	7.29	3.50	7.78	3.80	6.33	2.70
Non-Farm Income (Rs)	1484	1803	1973	1708	1691	1931	1921	1477
Paddy Area (ha)	2.19	3.11	1.18	1.73	1.78	2.41	1.28	2.36
Proportion of Area Irrigated (percent)	62	40	45	46	55	43	46	47

Table 3 shows the frequencies of modern variety rice adopters and fertilizer users according to different categories of tenure and credit use. None of the pure tenants, 9 of 26 semi-tenants, and 47 of 115 pure owners cultivated modern variety rice Over three-fifths of the owners and semi-tenants applied fertilizers on their rice crops, but only one of the six tenant farmers used fertilizers. Eight of the nine institutional borrowers were owner-operators and one was a semi-tenant. Eight of the nine credit users planted modern seed, and all nine of them used fertilizer in their paddy fields.

Table 3. Technology Adoption by Tenure and Credit Use

Farmer Category		Modern Variety Adopters	Modern Variety Non-Adopters	Fertilizer Users	Fertilizer Non-Users	Total
Owner	Credit User	7	1	8	0	8
	Non-User	40	67	67	40	107
	Total	47	68	75	40	115
Semi-Tenant	Credit User	1	0	1	0	1
	Non-User	8	17	15	10	25
	Total	9	17	16	10	26
Tenant	Credit User	0	0	0	0	0
	Non-User	0	6	1	5	6
	Total	0	6	1	5	6
Grand Total		56	91	92	55	147

Logit Analysis

Tables 4 and 5 show the results of logit analysis of the adoption of modern variety rice and use of fertilizer.

Table 4. Logit Analysis of Adoption of Modern Variety

Explanatory Variables	Coefficient	Asymptotic "t"
Constant	- 0.312	- 0.664
Age	- 0.002	- 0.263
Schooling	- 0.043	- 1.051
Family Size	- 0.061	- 1.889
Non-Farm Income	- 0.036	- 0.653
Paddy Area	0.115	1.706
Proportion of Land Area Irrigated	0.003	1.162
Radio Listening	0.040	0.135
Extension Visits	0.584	2.101
Agricultural Training	0.459	0.961
Agricultural Demonstrations	- 0.031	- 0.074
Co-operative Membership	0.167	0.580
Fertilizer Use	0.391	3.288
Log of Likelihood Function	- 157.90	

Table 5. Logit Analysis of Fertilizer Use

Explanatory Variables	Coefficient	Asymptotic "t"
Constant	- 0.096	- 0.207
Age	- 0.012	- 1.300
Schooling	- 0.026	- 0.681
Family Size	0.091	2.409
Non-Farm Income	- 0.081	- 1.307
Paddy Area	0.146	1.634
Proportion of Land Area Irrigated	0.003	1.119
Radio Listening	0.498	1.293
Extension Visits	0.431	1.183
Agricultural Training	- 0.090	- 0.130
Agricultural Demonstrations	0.155	0.240
Co-operative Membership	0.200	0.747
Modern Variety Use	0.391	3.288
Log of Likelihood Function	- 157.90	

Ideally, one would like to look at the magnitude, direction, and certainty of influence of a variable while interpreting results. However, because the magnitude of coefficients depends on the unit of measurement, coefficients are not necessarily comparable with each other. The variables included in the equation for logit analysis have different units of measurement, and hence the discussion of results focuses on the direction and certainty of the influence of these variables. Attempts will be made to take magnitude into account wherever possible.

The signs of age, paddy area, proportion of land area irrigated, radio listening, extension visits, agricultural training, and co-operative membership were as expected in the case of adoption of modern variety, but the coefficients of schooling, family size and agricultural demonstrations had

unexpected signs. In the case of fertilizer use, all the variables except schooling and agricultural training had the expected signs. Non-farm income had negative coefficients in both cases.

The results indicate that schooling, family size, paddy area, proportion of land area irrigated, and extension visits are significant factors in deciding about variety because these variables have smaller asymptotic standard errors than their respective coefficients. Similarly age, family size, non-farm income, paddy area, proportion of land area irrigated, radio listening and extension visits are significant in fertilizer use decisions. The other variables considered but not mentioned above did not seem to be significant in the choice of variety and the decision to use fertilizer.

The age of the farm operator had negative signs for both fertilizer and modern variety relations. Other things equal, younger farmers were more likely to adopt a modern variety and use fertilizer. However, the coefficient of this variable had a large asymptotic standard error in the modern variety equation.

Family size seemed to be important in the decision to use a modern variety and apply fertilizer. However, this variable had a positive sign for fertilizer use and a negative sign for modern variety adoption. Similarly schooling had a negative effect on both the adoption of modern variety and fertilizer use. The negative signs were not anticipated and no explanation could be given for these "wrong" signs. Nonetheless the negative relationship between schooling and adoption of modern technology should not be understood as opposing the human factor hypothesis. It may mean that schooling does not serve as an index of the human factor as far as a particular innovation and a particular groups of persons are concerned (Mangahas 1970).

Non-farm income was not important in the decision regarding the choice of variety but was important in the use of fertilizer. As the signs of the coefficients were negative, it appears that a farmer with a higher non-farm income is likely to divert his attention from farming and be less willing to put in the time and energy required to adopt new technology.

Farm size, represented by paddy area, had a positive sign indicating that larger farms were more likely than smaller

farms to adopt a modern variety and use fertilizer. Large farmers may have higher risk bearing ability and may be able to pay the higher costs usually associated with the adoption of modern technology.

Extension visits were an important factor in the adoption of both modern variety and fertilizer. Radio listening, agricultural training, and membership in a co-operative society were positively related with the adoption of modern variety, but participation in agricultural demonstrations was negatively related. However, the coefficients of all these variables had large asymptotic standard errors.

Radio listening, agricultural demonstrations, and membership in a co-operative society had positive effects on decisions about fertilizer use, but agricultural training was negatively associated with fertilizer use. Radio listening could be important in deciding to use fertilizer because the asymptotic standard error of the coefficient was small. However, the asymptotic standard errors of the coefficients of agricultural demonstration, membership in a co-operative society, and agricultural training were large.

Availability of irrigated land increased the probability of both adopting modern variety and using fertilizer. This variable was important in both modern variety adoption and fertilizer use, as indicated by the small asymptotic standard errors of the coefficients.

Choice of variety was important in the decision to use fertilizer and vice versa. As the variety coefficient in fertilizer use and that of fertilizer use in the modern variety equation had small asymptotic standard errors, a farmer is more likely to use chemical fertilizer if he cultivates a modern variety and if he applies chemical fertilizer he is more likely to adopt a modern variety. This may indicate that farmers realise that modern variety seed and fertilizer are complementary inputs in paddy production.

We might compare the magnitudes of the coefficients of radio listening, extension visits, agricultural training, agricultural demonstrations and co-operative membership, as all of these are dummy variables. Extension visits, which has the largest coefficient of these variables, has a greater influence on modern variety adoption than other variables. For fertilizer use radio listening seemed to be more influential than the other dummy variables.

Prediction

The probabilities of farmers adopting modern varieties and using fertilizers according to various characteristics have been computed using logit analysis, and are given in Table 6. For an average farmer who is a co-operative member and a fertilizer user exposed to extension media such as radio listening, extension visits, agricultural training, and agricultural demonstrations, the probability of adopting a modern variety is 0.718. For the average fertilizer non-user who is not a member of co-operative society and not exposed to any of the extension media, the probability of adopting a modern variety is only 0.337. For an average farmer who is a modern seed user, a co-operative member, and exposed to various extension media mentioned above, the probability of fertilizer use is 0.859. For the average modern seed non-user, co-operative non-member who is not exposed to any of the extension media, the probability of using fertilizer is only 0.550.

Table 6. Predicted Probability of Adoption of Technology in Rice Farming[a]

Modern Variety Seed Use			Fertilizer Use		
Farmer category		Probability	Farmer category		Probability
Fertilizer user	Co-operative member	0.718	Modern seed user	Co-operative member	0.859
	Co-operative non-member	0.429		Co-operative non-member	0.647
Fertilizer non-user	Co-operative member	0.632	Modern seed non-user	Co-operative member	0.804
	Co-operative non-member	0.337		Co-operative non-member	0.550

[a] These categories correspond to dummy variables with the appropriate 0 or 1 values. Variables not explicitly mentioned here were taken at their mean values. The formula for calculating these probabilities is the logistic equation given earlier in the paper.

Reasons for Technology Adoption

The respondent farmers were asked about their reasons for adopting or not adopting modern variety as well as chemical fertilizers. The most mentioned reason for not cultivating a modern variety or not cultivating on all their land was inadequate irrigation facility followed by lack of knowledge about the variety. Other reasons were higher input costs particularly for fertilizers, riskiness, susceptibility to insects, pests and diseases, poor performance earlier, inadequate or unsuitable land, unavailability of seed, trying for the first time and the need for timely sowing. Lack of money was the most frequently mentioned reason for not applying or not applying the recommended dose of fertilizers. Other important reasons were unavailability or uncertain availability of fertilizers and lack of irrigation facilities. Other reasons given included the lack of technical guidance and the belief that farmyard or compost manure is better.

The expectation of higher yields was the main reason for adopting a modern variety or applying fertilizers. "Seeing others do it first" was also mentioned as a reason for cultivating a modern variety, and other reasons included extension advice, higher price, good taste, curiosity to try new practices and insurance in case of failure of the traditional variety. The belief that fertilizer controls and prevents diseases, the lack of sufficient farmyard or compose manure, and extension advice were other reasons for applying chemical fertilizers to the rice crop.

SUMMARY AND CONCLUSIONS

Rice is Nepal's single most important food crop. Rice production must be increased both to sustain the growing population and to meet rising economic expectations. This must be accomplished through yield increases because there is little scope for expanding cropped area. Improved seeds, chemical fertilizers, and good cultural practices need to be adopted by the farmers to this end. With this in mind, the objective of this study was to examine the relation of various variables to the adoption of modern rice seed and chemical fertilizers using logit analysis.

Information obtained from 147 farmers in eight village panchayats of Dhanusha District formed the basis of the study. The average sample household had seven family members and cultivated 1.64 ha of land.

Variables such as schooling, family size, paddy area, proportion of land area irrigated, extension visits and fertilizer use were important in explaining adoption of modern variety, while age, family size, non-farm income, paddy area, proportion of land area irrigated, radio listening, extension visits, and modern variety use were important in explaining use of fertilizer.

Contrary to the expectations, schooling had negative effects on both modern variety adoption and fertilizer use. This variable was significant in the adoption of modern variety but not in fertilizer use. Family size was important in both modern variety adoption and fertilizer use but it had a negative sign in variety adoption and a positive sign in fertilizer use. The negative relationship between the probability of modern variety adoption and family size is difficult to reconcile with prior expectations.

An effective extension service may be essential to accelerate the adoption of production increasing innovations on farms. Similarly, the adequate and timely availability of fertilizers is important. Hence, comprehensive government programs to ensure the availability of fertilizers and to strengthen the extension services are important for the adoption of modern variety rice and use of fertilizers.

Large farmers were found more likely to adopt a modern variety or use fertilizer, perhaps as a result of risk-bearing ability or ability to pay. There thus may be a need for frequent technical supervision of small farms to minimize risks, and for credit readily available to small farmers to help them pay for modern seed and fertilizer.

Credit may be crucial in the adoption of modern rice technology because all the institutional credit users applied fertilizer and all but one planted modern variety seed. Expansion of credit may induce farmers to apply fertilizers and plant modern variety seed.

Availability of irrigation was important in the adoption of modern variety seed and use of fertilizer. Thus, encouraging farmers to buy pumpsets and exploit existing water resources as well as undertaking large irrigation schemes may be appropriate policies.

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