MODERN VARIETIES FOR SELF SUFFICIENCY OF RICE PRODUCTION IN ASSAM – AN ECONOMETRIC ANALYSIS

Sanjoy Borthakur[1]*, B.C. Bhowmick[2] and J.P. Hajarika[3]

[1]KrishiVigyan Kendra, East Kameng district, Arunachal Pradesh-790102
[2]Department of Agricultural Economics and Farm Management, Assam Agricultural University, Jorhat-785013
[3]Department of Agricultural Economics and Farm Management, Assam Agricultural University, Jorhat-785013

Received-09.06.2015, Revised-22.06.2015

Abstract: Rice is the principal crop of Assam, which alone occupies nearly 70 percent of gross cropped area and cover around 80 percent of total food production in the state. Although, the production of rice has increased over the years especially during the recent decades, the productivity is very low as compared to other rice growing states of India. Increase in production through increase in area is not far fetching. Change in productivity is basically technological and hence, more promising. Probit model revealed that in Nagaon district co-efficient of per cent clay soil area (ha.), non-farm income (Rs.) and dummy for extension visit were positively significant. i.e., these factors had significant influence towards adoption of modern varieties in the district. While, in Golaghat district dummy for extension visit and NPK use (kg/ha) had shown significant influence towards adoption of modern varieties. Tobit model estimates revealed that dummy for extension visit and size of household had significant influence towards adoption of modern varieties in both the sample districts towards adoption of modern varieties. Factor analysis showed that amongst the factors considered in Nagaon district, dummy for credit used for production purpose, dummy for extension visit and per cent loamy sand area (ha) were the variables of importance in determining the adoption of modern varieties. Likewise, in Golaghat district Coefficient of Variation of yield (t/ha), dummy for extension visit and number of years in school attended by the household head emerged out to be the important variables in determining the adoption of modern varieties in the district.

Keywords: Modern varieties, Probit, Tobit model, Factor analysis

INTRODUCTION

Assam is one of the economically backward states of India. The state nested in the heart of India's North Eastern region has vast fertile land and plenty of natural resources providing immense potentiality for the development of agriculture. Among the food-grains, rice is the principal crop, which alone occupies nearly 70 percent of gross cropped area and cover around 80 percent of total food production in the state (Bhowmick and Borthakur, 2002). Almost 90 per cent of the population is rice eater. The agro-climatic suitability favours rice cultivation in the state. Hence, the state being one of the main rice growing states of India can contribute a lot to the national economy. In Assam, rice is mostly a rainfed crop, which largely depends on the vagaries of nature. Although, the production of rice has increased over the years especially during the recent decades, the productivity is very low (1.5 t/ha) as compared to other rice growing states of India and Indian average (2.06 t/ha). It is obvious that increase in area or productivity lead to increase in production. Nevertheless, increase in production through increase in area is not far fetching, as land is a limiting factor. Change in productivity is basically technological and hence, more promising. Hence, a quantitative assessment of adoption pattern of technologies assumes significance in the context of agricultural development.

METHODOLOGY

Database of the investigation

Cross section data pertaining to rice area and yield under different land type and soil type, input used in rice production and income obtained thereon etc. were collected from Nagaon and Golaghat districts of Assam through personal interview method for two consecutive agricultural years from a selected set of 150 households.

Analytical framework

Multivariate Probit and Tobit regressions

Multivariate Probit and Tobit regressions were conducted to identify factors determining adoption of modern variety. For the Probit model the dependent variable was adoption (Yes/No) of modern varieties in each plot. The plot-specific independent variables, land type and soil type, were specified as dummy variables. For the Tobit model the dependent variable was the percentage area planted to modern variety in each household. In this case, the land type and soil type variables were represented in terms of percentage area under each category. In both models same factors were considered in a district.

*Corresponding Author

Factor analysis

In order to identify the factor and their relationship in the influence of adoption of modern varieties, factor analysis had been performed. For the purpose SPSS 7.5 version was used. Factor analysis like principal component analysis seeks to provide reduction in dimensionality by parsimoniously explaining the entire covariance matrix. The essential purpose of factor analysis is to describe, if the covariance relationship among many variables in terms of a few underlying but unobservable random quantities called factors. Factor refers to a hypothetical, unobservable variable as in the phrase common factor. Factor analysis refers to all methods of data analysis, matrix factors, including component analysis and common factor analysis.

For the random variables $X_1, X_2, \ldots X_p$ the assumed factor analysis model is

$X_i = \mu_i + \lambda_{i1}Y_1 + \lambda_{i2}Y_2 + \ldots\ldots\ldots\ldots\ldots \lambda_{im}Y_m + Z_i$

Where, i = 1, 2 ….p

$Y_1, Y_2 \ldots\ldots\ldots Y_m$ are hypothetical unobserved random variable

$Z_1, Z_2 \ldots\ldots\ldots Z_p$ are p hypothetical unobserved random variable with Z_i specific to X_i

'λ_{ij}' (where ' i' goes from 1,2…….p and ' j'= 1,2 ……m) is the coefficient of Y_j in representing X_i .

The Y's are also called common factor and Z's are called specific factor or unique factor.

'm' is the number of common factor which is called complexity. Thus it seems that smaller the number of 'm' less complex the dimensionality of X_i

Co-efficient 'λ_{ij}' are called factor loading. So, 'λ_{ij}' is the loading of the original random variable X_i on the common factor Y_j

The whole thing is written in matrix form as follows

$X = \Phi + AY + Z$ ..... (A)

Assumptions: $E(Y) = 0, E(Z) = 0$

The specific factors had variance 'c_i^2' and co-variance zero. The variance of Z_i i.e. 'c_i^2' is called the specific variance i.e. V(Z) = C. The variance of Y is an identity matrix and this can be achieved by standardizing the common factor Y_i's. Thus from the relation (A) we have

$V(X) = V(AY) + V(Z)$

$\Sigma = AIA^{\wedge} + C$

$\Sigma = AA^{\wedge} + C$ ..... (B)

Σ = variance-covariance matrix of the original variable.

A = Factor loading matrix.

C = matrix of specific variance.

Then from relation (B) we get

Variance $(\sigma_i^2) = \lambda_{ij}^2 + c_i^2$

The 'λ_{ij}^2' i.e. the square of the loadings was described as the contribution of the standardization of the common factor Y_i to the variance of X_i.

$\lambda_{11}^2 + \lambda_{12}^2 + \lambda_{13}^2 + \ldots\ldots\ldots\ldots\ldots + \lambda_{1m}^2$ is called the communality of X^2.

Hence, the variance of X_i is expressed by communality and the specific variance.

RESULT AND DISCUSSION

Multivariate probit and tobit analysis

Multivariate probit and tobit regression were carried out to identify the factors determining adoption of modern varieties and results are presented in Table 1. For the plot level analysis (Probit model), the dependent variable is adoption (Yes/No) of modern varieties. The plot specific independent variables i.e., land type and soil types are specified as dummy variables. For the Tobit model, the dependent variable is the percentage area planted to modern variety in each household and the land type and soil type variables were represented in terms of percentage area under each category. In both the model, same factors were considered in a district. In Nagaon district, area of low lying and medium land (ha), area under clay soil (ha), area under loam sand soil (ha), area under sandy loam soil (ha), off farm and non farm income (Rs.), total farm holding (ha), dummy for credit used for production purpose, dummy for extension visit, number of years in schools by the household head, size of household and NPK use (kg/ha) were used for the analysis. In Golaghat district, all the factors except dummy for credit used for production purpose and instead of area under loamy sand soil (ha), area under clay loam soil (ha) were used. As no credit was used for production purpose in Golaghat district, the factor dummy for credit used for production purpose had not been used in the models fitted for the district. Also depending on the dominance different soil type were considered.

The Probit model estimates revealed that in Nagaon district co-efficient of per cent clay soil area (ha.), non-farm income (Rs.) and dummy for extension visit were positively significant. i.e., these factors had significant influence towards adoption of modern varieties in the district. While, in Golaghat district dummy for extension visit and NPK use (kg/ha) had shown significant influence towards adoption of modern varieties.

Table 1. Probit and Tobit models determining the adoption of modern variety

Variable	Probit model estimates		Tobit model estimates	
	Nagaon	Golaghat	Nagaon	Golaghat
INTERCEPT	0.409959*	0.59615**	37.03832	0.911995
PLAND1	0.117074	-0.019499	-0.117754	0.279932*
PLAND2	-0.021984	0.004324	-0.109015	0.424318**
PSOIL1	0.185735*	0.016726	0.008414	-0.178422

PSOIL4	-0.020405	-	0.019743	-
PSOIL5	-	-0.002734	-	-0.126273
PSOIL6	-0.098540	-0.032837	-0.020178	-0.143185
VALUE	0.000003*	-0.00000007	0.000096*	0.000182*
AREAFARM	0.024436	0.008397	-1.120306	-2.437054
DCREDPRO	0.062034	-	-5.543424	-
DEXTEN	0.327615**	0.088339*	17.876008*	17.006184*
EDYEARS	-0.005827	-0.000891	0.136342	-0.0259621
SIZEFAM	-0.019451	0.005476	2.052302*	2.306651*
NPK	0.004360	0.313906**	18.81940*	0.274823
R-square	0.33312	0.40964	0.286138	0.38491

Note: Those with * are statistically significant at 5% and ** are statistically significant at 1% level of significance

PLAND1=% area, low-lying land in ha.
PLAND2=% area, medium lying land in ha.
PSOIL1=% area, clay soil in ha.
PSOIL2=% area, sandy soil in ha.
PSOIL3=% area, loamy soil in ha.
PSOIL4=% area, loamy sand in ha.
PSOIL5=% area, clay loam in ha
PSOIL6=% area, sandy loam in ha
VALUE=off-farm and non-farm income in Rs.
AREAFARM=total farm holding in ha.
DCREDPRO=dummy for credit used for production purpose: 1=has credit; 0=otherwise
CV=Coefficient of variation of yield (t/ha)
DEXTEN=Dummy for extension visit: 1=visited; 0=otherwise
EDYEARS=Number of years in school attended by the household head
SIZEFAM=Size of household
NPK=NPK use in kg/ha.
D1ACCESS=Dummy for poor access to market: 1=poor access; 0=otherwise
D2ACCESS=Dummy for medium access to market: 1=medium access; 0=otherwise

The Tobit model estimates also revealed that dummy for extension visit off-farm and non-farm income and size of household had significant influence towards adoption of modern varieties in both the sample districts. Besides, NPK use (kg/ha) in Nagaon district and area under medium as well as low lying land (ha) in Golaghat district had shown significant influence towards adoption of modern varieties.

Factor analysis

Factor analysis has been carried out using the SPSS package version 7.5, taking some factors *viz.*, different land and soil types prevalent in the districts, extension visit, farm size, household size, credit use, off-farm and non-farm income (Rs.), education level of household head, NPK use etc. Outcome of the analysis are presented in Table 2 & 3.

Factor loading

The coefficients in the factor equations are called "factor loadings". They appear in each factor column in the Table, corresponding to each variable. The factor equations for Nagaon district are:

$F_1 = -0.1115X_1 + 0.0222X_2 + 0.0330X_3 + 0.0751X_4 - 0.0603X_5 + 0.2186X_6 - 0.2238X_7 + 0.2381X_8 - 0.2236X_9 + 0.0632\ X_{10} + 0.2491X_{11} + 0.0666X_{12} + 0.0597X_{13}$

$F_2 = -0.4469X_1 + 0.4799X_2 + 0.0771X_3 + 0.0504X_4 + 0.0667X_5 + 0.1406X_6 + 0.1715X_7 - 0.1217X_8 + 0.0250X_9 + 0.0437X_{10} - 0.0085X_{11} - 0.2025X_{12} - 0.1296X_{13}$

$F_3 = -0.0291X_1 + 0.0288X_2 + 0.0301X_3 + 0.1268X_4 + 0.0204X_5 + 0.1829X_6 + 0.2367X_7 - 0.2374X_8 - 0.0572X_9 + 0.3230X_{10} - 0.0337X_{11} + 0.3881X_{12} + 0.4144X_{13}$

$F_4 = 0.1232X_1 - 0.1224X_2 + 0.2220X_3 + 0.5396X_4 + 0.5821X_5 - 0.1038X_6 + 0.0927X_7 - 0.0770X_8 - 0.2269X_9 + 0.1631X_{10} + 0.0396X_{11} - 0.1221X_{12} + 0.0453X_{13}$

$F_5 = 0.1231X_1 - 0.1623X_2 + 0.8254X_3 + 0.2824X_4 - 0.1203X_5 + 0.1766X_6 - 0.0001X_7 + 0.0071X_8 + 0.0704X_9 + 0.2050X_{10} - 0.0449X_{11} - 0.1404X_{12} - 0.2166X_{13}$

The factor equations for Golaghat district are:

$F_1 = 0.2292X_1 + 0.2180X_2 + 0.1551X_3 + 0.1660X_4 + 0.1067X_5 + 0.1228X_6 + 0.0289X_7 - 0.1868X_8 - 0.2478X_9 + 0.2367X_{10} + 0.1461X_{11} + 0.1300X_{12}$

$F_2 = 0.0660X_1 + 0.0877X_2 + 0.0039X_3 + 0.0344X_4 + 0.1731X_5 + 0.3758X_6 - 0.4260X_7 - 0.06427X_8 + 0.1757X_9 - 0.2763X_{10} - 0.0089X_{11} + 0.1290X_{12}$

$F_3 = 0.3575X_1 + 0.3611X_2 + 0.1082X_3 + 0.3184X_4 + 0.1143X_5 - 0.2210X_6 + 0.1683X_7 + 0.0819X_8 + 0.1973X_9 - 0.0803X_{10} - 0.0996X_{11} + 0.1293X_{12}$

$F_4 = 0.1898X_1 + 0.1178X_2 + 0.3333X_3 + 0.1145X_4 - 0.5403X_5 + 0.1134X_6 - 0.1455X_7 + 0.5424X_8 - 0.1322X_9 - 0.0787X_{10} + 0.2331X_{11} - 0.0061X_{12}$

$F_5 = -0.0092X_1 + 0.0105X_2 + 0.5627X_3 + 0.2151X_4 + 0.2753X_5 + 0.1031X_6 - 0.1383X_7 + 0.2871X_8 - 0.2017X_9 + 0.2151X_{10} + 0.4859X_{11} - 0.2575X_{12}$

The factor loading depicts the relative importance of each variable with respect to a particular factor. In all the five factor equations derived for Nagaon district, dummy for credit used for production purpose (X_3) dummy for extension visit (X_4) and per cent loamy sand area (ha) (X_{10}) appeared with positive loading indicating that they were the variables of importance in determining the adoption of modern varieties in the district. Likewise, in Golaghat district Coefficient of variation of yield (t/ha) (X_2), dummy for extension visit (X_3) and number of years in school attended by the household head (X_4) showed positive loading in all the five factor equations derived from the analysis indicating the importance the variables in determining the adoption of modern varieties in the district.

Table 2. Component Score Coefficient Matrix for Nagaon district

Factors	Factors					Communalities
	1	2	3	4	5	
AREAFARM (X_1)	-0.1115	-0.4469	-0.0291	0.1232	0.1231	0.7976
CVY (X_2)	0.0222	0.4799	0.0288	-0.1224	-0.1623	0.7732
DCREDPRO (X_3)	0.0330	0.0771	0.0301	0.2220	0.8254	0.8376
DEXTEN (X_4)	0.0751	0.0504	0.1268	0.5396	0.2824	0.6221
EDYEAR (X_5)	-0.0603	0.0667	0.0204	0.5821	-0.1203	0.5607
NPKUSE (X_6)	0.2186	0.1406	0.1829	-0.1038	0.1766	0.7289
PLAND1 (X_7)	-0.2238	0.1715	0.2367	0.0927	-0.0001	0.8111
PLAND2 (X_8)	0.2381	-0.1217	-0.2374	-0.0770	0.0071	0.8351
PSOIL1 (X_9)	-0.2236	0.0250	-0.0572	-0.2269	0.0704	0.6397
PSOIL4 (X_{10})	0.0632	0.0437	0.3230	0.1631	0.2050	0.4271
PSOIL6 (X_{11})	0.2491	-0.0085	-0.0337	0.0396	-0.0449	0.6890
SIZEFARM (X_{12})	0.0666	-0.2025	0.3881	-0.1221	-0.1404	0.6429
VALUE (X_{13})	0.0597	-0.1296	0.4144	0.0453	-0.2166	0.6283
Variance summarized (%)	25.4810	13.5588	12.9067	9.2526	7.9806	Average = 0.6918

Extraction Method: Principal Component Analysis

PLAND1 = % area, low-lying land in ha.

PLAND2 = % area, medium lying land in ha.

PSOIL1 = % area, clay soil in ha.

PSOIL4 = % area, loamy sand in ha.

PSOIL6 = % area, sandy loam in ha

VALUE = off-farm and non-farm income in Rs.

AREAFARM = total farm holding in ha.

DCREDPRO = dummy for credit used for production purpose: 1=has credit; 0=otherwise

CVY = Coefficient of variation of yield (t/ha)

DEXTEN = Dummy for extension visit: 1=visited; 0=otherwise

EDYEARS = Number of years in school attended by the household head

SIZEFAM = Size of household

Table 3. Component Score Coefficient Matrix for Golaghat district

Factors	Factors					Communalities
	1	2	3	4	5	
AREAFARM (X_1)	0.2292	0.0660	0.3575	0.1898	-0.0092	0.9087
CVY (X_2)	0.2180	0.0877	0.3611	0.1178	0.0105	0.8576
DEXTEN (X_3)	0.1551	0.0039	0.1082	0.3333	0.5627	0.7753
EDYEAR (X_4)	0.1660	0.0344	0.3184	0.1145	0.2151	0.6349
NPK (X_5)	0.1067	0.1731	0.1143	-0.5403	0.2753	0.7663
PLAND1 (X_6)	0.1228	0.3758	-0.2210	0.1134	0.1031	0.8954

PLAND2	(X_7)	0.0289	-0.4260	0.1683	-0.1455	-0.1383	0.9169
PSOIL1	(X_8)	-0.1868	-0.0642	0.0819	0.5424	0.2871	0.7848
PSOIL5	(X_9)	-0.2478	0.1757	0.1973	-0.1322	-0.2017	0.8199
PSOIL6	(X_{10})	0.2367	-0.2763	-0.0803	-0.0787	0.2151	0.8196
SIZEFARM	(X_{11})	0.1461	-0.0089	-0.0996	0.2331	0.4859	0.8034
VALUE	(X_{12})	0.1300	0.1290	0.1293	-0.0061	-0.2575	0.8135
Variance summarized (%)		22.5530	16.8689	15.4247	9.5529	8.8619	Average = 0.8164

Extraction Method: Principal Component Analysis

PLAND1 = % area, low-lying land in ha.

PLAND2 = % area, medium lying land in ha.

PSOIL1 = % area, clay soil in ha.

PSOIL5 = % area, clay loam in ha

PSOIL6 = % area, sandy loam in ha

VALUE = off-farm and non-farm income in Rs.

AREAFARM = total farm holding in ha.

CVY = Coefficient of variation of yield (t/ha)

DEXTEN = Dummy for extension visit: 1=visited; 0=otherwise

EDYEARS = Number of years in school attended by the household head

SIZEFAM = Size of household

NPK = NPK use in kg/ha.

Variance summarized

Factor analysis employs the criterion of maximum reduction of variance – variance found in the initial set of variables. Each factor contributes to the reduction of variance. After the analysis it was found that in Nagaon district the five factors (1 to 5) accounted for 25.48, 13.56, 12.91, 9.25 and 7.98 per cent of variance respectively; altogether explained more than 69 per cent of variance. While in Golaghat district, the five factors contributed 22.55, 16.87, 15.42, 9.55 and 8.86 per cent variance, respectively. The five factors together explained more than 81 per cent of the variances.

Communality

In an ideal solution the factors derived would explain 100 per cent of the variance in each of the original variables. "Communality" measures the percentage of the variance in the original variable that is captured by the combination of factors in the solution. Thus, communality is computed separately for each of the original variables. In each variable, communality might be thought of as showing the extent to which it is revealed by the system of factors. It was observed that in Nagaon district the average communality was more than 69 per cent, ranged from 42.71 per cent to 83.76 per cent. While, in Golaghat district the average communality was 81.64 per cent, which ranged from 63.49 per cent to 91.69 per cent. Thus, the five factors seem to capture the underlying dimensions involved in the variables considered in both the districts.

Summary

The Probit model revealed that in Nagaon district co-efficient of per cent clay soil area (ha.), non-farm income (Rs.) and dummy for extension visit were positively significant. i.e., these factors had significant influence towards adoption of modern varieties in the district. While, in Golaghat district dummy for extension visit and NPK use (kg/ha) had shown significant influence towards adoption of modern varieties. The Tobit model estimates also revealed that dummy for extension visit and size of household had significant influence towards adoption of modern varieties in both the sample districts. Besides, NPK use (kg/ha) in Nagaon district and area under medium as well as low lying land (ha) and off farm and non-farm income (Rs.) in Golaghat district had shown significant influence towards adoption of modern varieties. While, co-efficient for off-farm and non-farm income (Rs.) was found to be negatively significant in Nagaon district.

From factor analysis it was observed that the amongst the factors considered for Nagaon district, dummy for credit used for production purpose, dummy for extension visit and per cent loamy sand area (ha) were the variables of importance in determining the adoption of modern varieties in the district. Likewise, in Golaghat district Coefficient of Variation of yield (t/ha), dummy for extension visit and number of years in school attended by the household head emerged out to be the important variables in determining the adoption of modern varieties in the district.

REFERENCES

Akudugu, M.A.; Guo, E. and Dadzie, S.K. (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What

Factors Influence their Decisions? *Journal of Biol., Agri. and Healthcare*. **2(3):** online journal www.iiste.org.

Bhowmick, B.C. and Borthakur, N. (2002), Report on the project Socio-economics dynamics of changes in rice production system in Assam (RRPS-2).

Greene, W. H. (2008). Econometric Analysis, 6th Edition, Upper Saddle River, New Jersey, Prentice-Hall, New York University.

Sharma, B.L. and Sharma, R.C. (2004). Income and employment increasing possibilities at various levels of technology in Agro-climatic Zone II-A of Rajathan. *Agricultural Situation in India* **61(1):** 13-28

Sharma, H.O.; Soni, S.N. and Khare, P. (2006). Determinants of adoption of soybean production technology by the cultivators at different regions of India. *Agricultural Situation in India* **62(10):** 671-5