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Allocative and Technical Efficiency in Using Agricultural Inputs: A Case Study of Nepalese Farmers in Rupandehi District

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INTRODUCTION

Up to date knowledge on farmers attitudes and their reaction at various stages of progress is of crucial importance for planners in formulating relevant agricultural development policies and programmes. Allocative and technical efficiencies are two such aspects of farmers behaviours which often are sought to be known while a question is raised by policy makers regarding their attitudes and reactions. In connotation the allocative efficiency of farmers, necessarily means th rationality in using agricultural inputs, whereas the technical efficiency, means changing the level of production skill of farmers when the new inputs and production techniques are being introduced in the farming system. Both of these concepts and their empirical tests could be found as some of the leading matters for discussion in the literature of agricultural economics toward the latter half of the 1970s.

Schultz raised an important proposition regarding the allocative efficiency in a traditional or developing economy. He proposed a hypothesis that there were comparatively very few inefficiencies in allocating resources in such economies. Since then an overhelming number of testing of this hypothesis were carried out in various parts of developing world in the successive years. Some authors summarised some of these studies and argued that the appealing outcome was rather mixed. In other words, although the majority of studies were approved his hypothesis, number of evidences were forwarded by researchers to refute this hypothesis. Such controversy led the policy makers to retest his hypothesis before drawing any conclusion regarding the farmers rationality especially when the economy is in the process of changing from traditional into modern phase.

Policy implication of both of these efficiencies could be thought as very important. For, if farmers were rational in allocating resources, any government programme aimed at modernising agriculture could be highly successful. Similarly the level of technical efficiency would show the real stages of success of any such programme which in fact can also be used as a feed back for the further implementation of such activities.

NEPALESE CONTEXT

Nepalese agriculture is basically of traditional nature with about 95 percent of population engaged in agricultural sector. Bulk of the farming is done by using traditional bullock power in the rainfed fields.

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The process of transformation of traditional agriculture can be said to have been initiated since 1956 when the first development plan with highest priority given to agricultural development was introduced in the economy. Then onwards agricultural sector got highest priority in development plans. Simultaneously various agricultural development programmes like extension, supply of chemical fertilizers and pesticides, credits etc. were started to be launched upon. Such programmes affected to increase the total irrigated acreage of country from 6,228 hectare in 1956 to 338,672 hectare in 1985. Consumption of chemical fertilisers also went up with a speed from 54000 mt. in 1980/81 to 100121 mt. in 1984/85. In a similar way extension services, supply of agricultural tools and implements, etc. also increased to the tune of fertilisers. Moreover, in the mean time, various agricultural research activities showed a mushroom like growth in the economy.

With these progresses attempted in macro level the question may be raised that how far Nepalese farmers at micro level are also being-able in using inputs efficiently in their production system. Similarly a question may also be asked as to whether those farmers who have adopted more of these inputs are achieving higher level of technical efficiency than those using less of such inputs. Answers to these questions could be good guidelines for policy makers. The few studies so far carried out previously on this ground in the context of Nepal could be less relevant by now either because they were carried out before a decade or so or various changes in agriculture have occurred by this period or they suffer from insufficient coverage and sample size. Here an attempt is made to fulfill this gap and two hypotheses proposed to this effect are (a) Nepalese farmer are efficient in allocating/using agricultural inputs which they have at their disposal, (b) farmers using more of new variaties of inputs are technically efficient than those using less.

METHODOLOGY

Method of Analysis

The method of analysis used is based on production function approach which is rather a positive approach for analysis which is supposed to be suitable for this type of study. The Cobb-douglas production function has been selected for the analysis. This function is linear in logarithmic term which makes it easier for estimation. The Cobb-douglas production function is widely used in an input-output analysis like this since it fits well with economic data and is consistent with the general economic theories. One of the important critics which is often directed to this function is that it essentially implies the co-efficient of elasticity of substitution for inputs as one. Due to this very restrictive nature of this function, a constant elasticity function shortly named as CES function is often suggested over this. However within the manageable procedure of estimation, this function requires a presumption of perfect competition which then makes it impossible to test the allocative efficiency. Therefore, in various studies of similar type, despite the naivety of Cobb-douglas production function, no serious objection has been laid in using this function.

Two important considerations which are important in selecting variables for the Cobb-douglas production function are that: (a) variables should be correctly specified and (b) aggregation of variables should be correctly done. To simplify this problem, selection of a single and important activity is often suggested. Therefore, mainly due to this reason also the present analysis has been confined to paddy production in Rupandehi district irrespective of a multiculture has been the general practice in the area. Paddy being the main staple food crop in Nepal is the main product of Terai districts. Rupandehi district has been selected assuming to be a representative district of Terai on one side and farmers of various technological levels can be easily sampled from here on the other side.

With these considerations variables selected for the Cobb-douglas production function are expressed in the following equation:

$$LN\ Y = A + a \ln L + b \ln S + c \ln M + d \ln N + e \ln H + f \ln B + g \ln T + h \ln I \qquad (1)$$

Where:

Y = Production of paddy in quintal.

A = Intercept or shift variable.

L = Land in hectare.

S = Seed in Kilogram.

M = Manure in Kg.

N = Nutrient equivalent of chemical fertiliser in Kg.

H = Human labour days in standard working day of 8 hours.

B = Animal labour days in standard working day of 8 hours.

T = Machinary used in standard tractor hours.

I = Ratio of irrigated area to total operated land.

and a, b, c, d, e, f, g and h are the co-efficients of their related variables.

Testing of Allocative Efficiency

The condition set for allocative efficiency is that marginal value product of an input is equal to its market price. This is also a feature of perfect competition which then makes it possible to test the farmers rationality. Marginal product of input xi can be obtained by differentiating equation (1) as:

$$\frac{dy}{dxi} = Bi \quad \frac{Y}{xi} = MPi$$

Where MPi is marginal product of input i, Bi is the co-efficient of input i obtained from the estimation of Cobb-douglas production function. If price of input i is Pi and price of output Y is Py then the required condition is:

$$Py \cdot MPi = Pi$$

$$\text{or} \quad MPi = \frac{Pi}{Py}$$

$$\text{or} \quad MPi = Bi \cdot \frac{Y}{xi} = \frac{Pi}{Py}$$

$$\text{or} \quad Bi = \frac{Pi}{Py} \cdot \frac{xi}{y} \quad \text{.........................} \quad \text{(ii)}$$

If farmers are allocatively efficient then the observed value of Bi* should be equal to the estimated value of Bi^ obtained from the Cobb-douglas production function. Observed value of Bi* can be calculated from equation (ii) using the value of Pi and Py at their current market price and value of xi and y as the geometric mean value of input i and product y. Since market imperfection in the supply and price of input cannot be fully avoidable due to the constraints on expenditure, lagged responses etc., observed value of Bi* may not equal to estimated value of Bi^ even if farmers are rational in using inputs. For this reason a t-test is applied to see whether the estimated Bi* is significantly different from observed Bi* or not.

$$ti = \frac{Bi\hat{} - Bi^*}{SEi} \sim tn - i - 1$$

Where SEi is the standard error of estimated co-efficient Bi^, ti is the t value for the test of the allocative efficiency in using input i and n is the number of observation.

Test of Technical Efficiency

The intercept A of Cobb-douglas production function in equation (i) is a shift parameter i.e. a measure of technical efficiency. Therefore separate production functions have to be fitted for separate groups of farmers who correspond to different level of technology in use. The intercept of these functions can then be compared to see the difference in their technical levels. Since assured irrigation facility and use of improved varieties of seeds and chemical fertiliser are the major sources of technological advancement attempted in Rupandehi district, selection of groups of farmer relate to these factors. The five groups of farmers which represent the five different levels of technological advancement thus categorized and sampled are:

(a) Irrigated improved (II): Farmers using assured irrigation facility and improved variaties of seeds and chemical fertilizers.

(b) Non irrigated improved (NI): Farms not using assured irrigation facility but using improved varieties of seeds or chemical fertilizers.

(c) Non-irrigated local (NL): Farms neither using assured irrigation facility nor improved varieties of seeds and chemical fertilizers.

(d) Irrigated Farms (IF): Farms using assured irrigation facility irrespective of using improved varieties of seeds and chemical fertilizers.

(e) Non-irrigated Farms (NIF): Farms not using assured irrigation facility irrespective of using improved varieties of seeds and chemical fertilizers.

The values of intercepts of these five model cannot be directly compared since the number of variables and sample sizes in these models may differ. To see the statistical significance of the difference between two such intercepts, the following t- statistics has been calculated and tested.

$$t = \frac{X1 - X2}{\sqrt{\frac{1}{n1} + \frac{1}{n2}}\sqrt{\frac{(n1-1)\ Di^{\wedge}2 + (n2 - 1)\ D2^{\wedge}2}{n1 + n2 - 2}}} \sim tn1 + n2 - 2$$

Where Xi = intercept of ith group, ni = numbers of observation in ith group, Di = Standard error of the intercept of ith group.

Data

Farm level data were collected during autumn 1985. In order to obtain best sample for all the different levels of technology, 5 wards from the 5 panchayats of Rupandehi district were selected. Altogether 200 sample size was planned with an attempt to have at least 50 observations for each level of technology. However, 40 observations were found not suitable for analysis either because of incomplete information in the observation or because of the non-correspondence with any of the groups. Therefore, altogether 160 observations were used for analysis.

RESULTS

Results on the estimation of the Cobb-douglas production function for the whole set of sampled observation and for various groups of farmers relating to different technical levels are presented in Table 1. Statistical qualities of estimates are found reasonably satisfactory. Value of R 2 in all of these models are fairly high and also the high values of F statistics together with these approve a fair goodness of fit of models.

Estimation from equation 2 have been used in testing allocative efficiency. The untransformed intercept term in this equation is negative (or less than unity if transformed) and insignificant at 5 percent level of significance. This over and above suggests that the function passes through origin. Thus if all the input levels are at zero, there would not be production at all. This is reasonable in the present case, since land has also been introduced as a variable. Except for bullock labour estimates for all other variables in this equation are significantly greater than zero at ten percent or lesser than this level of significance.

Equation 2 to 6 are the 5 models which give the estimates for 5 sub-groups of farm household growing paddy. As can be noticed on observation that, all the five equations have been essentially estimated using same set of variables to make it easier for comparison of shift variable with each other. However, there is a great variation in the magnitude and, to some extent, in the sign of these variables in these different equations. This shows a hetrogeneous effect of these variables to the level of production at different conditions or technological stages of growing paddy in Rupandehi district. Among some remarkable differences one is that co-efficient of bullock labour in equation 3 and 6 are with negative signs showing too much application of this input at these stages of production technology. Similar to these cases some other variables e.g. nutrients, human labour and machinery hours all have a negative effect on the level of production in equation 5. Probably lack of assured irrigation facility but high rate of application a good rainfall may in fact has deteriorated the level of production. Also in equation 6 are manure and bullock labour with negative signs. Apart from these qualitative influences of these variables a presence of higher multicollinirity may have effected to result in this way since number of observations in this group is lowest at 40. Despite these deficiencies, however, shift variables are comparable in these models without serious objections, which in fact is the only desired requirement for the present analysis.

Results on the testing of hypotheses are summarised in Table 2 and 3. For testing allocative efficiency geometric mean values of all related variables were obtained in the same unit as they appeared in the estimation of production function. Although the data are cross sectional, some variations in the price of variables among the observations were noticed. Therefore, weighted average price was obtained by weight being the number of observation in the respective price group. Rented value of land was taken to be the price of land, the amount which otherwise would have been obtained by the holder if leased out for paddy production. Amount of kind transaction in this regard was valued at the current market price of product. Weighted price of nutrients was also achieved by using the weight as the nutrient equivalent amount of chemical fertilizer which itself was aggregated through weighting it by the amount for corresponding observation.

Table 2

Observed mean value and price of variables and test of significance of difference of observed co-efficients with the estimated co-efficient

Variable	Mean value	Mean price	Observed Bi*	Estimated Bi	t-value	Significance at 1%	5%	Remarks
Production	16.61	294.0	-	-	-	-		Dependent vari.
Area	0.72	4427	0.6496	0.45	1.757	NS	NS	
Seed	61.39	3.30	0.4149	0.135	1.323	NS	NS	
Manure	485.0	12.50	0.01242	0.063	1.346	NS	NS	
Nutrient	18.298	11.15	0.04179	0.035	0.414	NS	NS	
Bullock	37.48	20.0	0.1535	0.051	2.712	S	S	
Human lab	103.19	16.0	0.3387	0.366	0.254	NS	NS	
Tractor	3.57	120	0.08775	0.146	1.613	NS	NS	

Table 3

Test of significance of difference in the intercept of production function among different sub-groups of farm-households

Sub-groups of farm household for comparison	Estimated intercept	t- value for Chow	Significance at 5% level
1. (a) All Irrigated (b) All Non-irrigated	2.462 0.144	10.9924	Yes
2. (a) Irrigated Improved (b) Non-irrigated Improved	2.896 1.914	5.5996	Yes
3. (a) Irrigated Improved (b) Non-irrigated Local	2.896 0.051	23.0116	Yes
4. (a) Non-irrigated Improved (b) Non-irrigated Local	1.914 0.051	11.8120	Yes

Note: (1) S = Significant
NS = Not Significant

(2) The tabulated critical value of t-statistics with degree of freedom 151 at 1 percent level is 2.576 and 5 percent level in 1.96.

Table 1
Results on the estimation of the Cobb-douglas production function

Statistics Model	All Farms	All irrigated	All non-irrigated	Non-irrigate local	Non-irrigate impro.	Irrigated impro.	Remark
1	2	3	4	5	6	7	8
Intercept	-0.073 (0.12)	2.462 (3.97)	0.144 (.16)	.051 (.03)	1.914 (1.8)	2.896 (3.38)	
Area	0.450 (3.96)	.707 (6.13)	.500 (3.27)	.477 (2.08)	.817 (4.26)	.743 (4.75)	
Seed	0.135 (1.91)	.023 (0.23)	.163 (1.62)	.108 (0.64)	.178 (1.63)	0.14 1.17	
Manure	0.866 (1.66)	.01 (0.15)	0.103 (1.92)	.096 (1.05)	-.076 (1.63)	-.029 (0.57)	
Nutrients	0.035 (2.14)	0.004 (0.37)	0.024 (0.99)	.059 (1.55)	.016 (0.7)	.0001 (0.1)	
Bullock labour	0.051 (3.35)	0.005 (0.26)	-0.046 (0.71)	0.012 (0.10)	0.142 (2.13)	-0.028 (1.36)	
Human labour	0.366 (3.35)	.157 (1.87)	.374 (2.35)	.368 (1.41)	-0.105 (0.59)	0.01 (0.07)	
Tractor	0.146 (4.04)	0.115 (1.26)	0.12 (2.01)	0.156 (1.75)	-0.004 (0.06)	0.115 (1.74)	
Irrigation	0.802 (9.4)	-	-	-	-	-	
R2	0.9149	0.953	0.8786	0.8230	0.9624	0.9816	
F statistics	213.15	175.72	102.08	31.96	168.56	281.99	
DW-Stasistics	1.93	2.20	1.79	1.83	2.36	2.30	
N	160.00	60.00	100.00	49.00	49.00	40.00	

Note: Figures in the parenthesis are t-ratios.

Except for bullock labour, the difference between the observed value of the co-efficient and the estimated value of the co-efficient for all the variables are not significantly greater than zero. This leads to accept the first hypothesis that the paddy growers in Rupandehi district are efficient in allocating their resources rationally. Similarly, as given in Table 3, the Chow-test signifies that the intercepts of the production functions between the two sub-group of farmers in all the five cases are significantly different from each other. This suggests to accept hypothesis 2 as well.

CONCLUSION

With few exceptions, testing of above hypotheses have approved that farmers in Rupandehi district are not only efficient in using agricultural inputs which they have at their disposal but also that those who have got a chance to use chemical fertilizers, new varieties of seeds and irrigation facilities are technically advanced than others. In technical terms, new inputs have caused an upward shift in the production function of farms with an efficient use of those inputs. This certainly is a very important and encouraging result for the policy prescription. Policy makers with these results are suggested to concentrate themselves much more toward supplying agricultural inputs in a regular and more efficient way than before. However there should also be an attempt to increase the financial abilities of farmers for buying such inputs.

The fact that present level and state of supplying modern inputs from central level to farm level has not yet shown an expected result to the expected magnitude and this needs now to be carefully examined. In this regard the present channel of supplying such inputs to farm level should be reviewed and constraints both at intermediate and at destined level should be carefully identified. Side by side of this, it is also important that farm level constraints to absorb these inputs should also be suppressed more effectively. Only then the desired level of supplying agricultural inputs to farmers can be achieved. However, only further studies on these aspects can provide some detailed insight to elicit the actual problems and forward more detailed recommendations.

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