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PRODUCTIVITY AND FACTOR USE IN PEASANT AGRICULTURE: AN EMPIRICAL INVESTIGATION

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Introduction

Many attempts have been made in the past to estimate input-output relationships in peasant agriculture using various types of production functions [1], [3], [4], [5]. These estimates have been used to evaluate input productivity, production elasticity and returns to scale which are issues still debated intensely. Any function usually imposes certain restrictions on the input-output relationships and hence dictates the nature of the results. The Cobb-Douglas function, one of the most commonly used functions, for example, assumes unitary elasticity of substitution and partial and total production elasticities that do not vary over the range of the function. The aim of this paper is to use the transcendental logarithmic (translog) production function to formalize the relation between output and a given number in order to examine the relationship between input use and production in peasant agriculture.

I. Methodology

The translong production function is represented as follows:

$$(1) \quad \ln Y = \ln \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln X_i + {}^1/_2 \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ln X_i \ln X_j + E_i$$

where Y is output and the X_is are inputs, the Greek letters are parameters and $\beta_{ij} = \beta_{ji}$. In this model, the output elasticity with respect to X_{1i} is given by

$$(2) \quad \eta_i = \frac{\ln Y}{\ln X_i} = \alpha_i + \sum_{j=1}^{n} \beta_{ij} \ln X_j, \text{ the cooperating inputs.}$$

The singed measure of η_i at different values of X_j, indicate the nature and magnitude of the relationship between the output and a selected input.

The main advantage in using the translog function is that it does not impose prior constraints on returns to scale and factor substitution. It also

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does not require the additivity assumption unlike in many other functions [2]. The translong function differs from the Cobb-Douglas function by the addition of squared and cross product terms. These additional terms allow for a quite general specification of the production surface, which is important when examining the elasticity of substitution. If all coefficients of the interaction terms are not significantly different from zero, the function reduces to the Cobb-Douglas form.

II. The Data

The data required for this study were collected from two villages, one village from the Kandy district and the other from the Anuradhapura district. The Kandy and Anuradhapur districts represent the wet and the dry zones respectively. Both districts are major rice growing areas in Sri Lanka. Paddy farming is the main occupation of the households. A survey of selected farm households from the two villages was conducted using a structured questionnaire to obtain input-output data in relation to rice production. The date pertains to the years 1981/82 Maha (wet season) and 1982 Yala (dry season). The following variables were defined before the estimation of the functions.

Y = Value of gross output of paddy in rupees

X_1 = Total labour which includes family and hired labour used for all operations measured in man days. A woman and child day were converted to man day equivalents using scaling factors of 0.75 and 0.5.

X_2 = Operating cost representing all types of purchased inputs such as fertilizer, pesticides, herbicides etc. This, however, does not include machinery and buffalo hire cost.

X_3 = Land size which represents the actual cultivated area in acres.

X_4 = Buffalo cost. This includes the cost involved in hiring buffaloes for draught power.

X_5 = Machinery cost. This represents the costs involved in using machinery, mainly tractors. This variable is relevant only to the Anuradhapura sample.

III. Results and Analysis

The coefficients of the translog function estimated for the Kandy and Anuradhapura samples are given in Tables 1 and 2 respectively. The results show that at least one squared or cross product term is significant in each of the functions estimated. In the Kandy sample, two interaction terms are significant in Maha and one in Yala. In the Anuradhapura sample two and four such coefficients are significant for Maha and Yala respectively. On the basis of these results the translog function appears

preferable to the Cobb-Douglas function. The Cobb-Douglas functions were also estimated with the data to bring about comparisons where it was felt to be useful.

It is useful to study the estimated coefficients for labour, operating cost, land, buffalo cost and machinery cost in the two study areas. It is seen from Table 1, that the labour coefficients in the Kandy sample are negative but not significant in both seasons. The operating cost variable is also not significant for both seasons and negative for the Yala season. The shortage of water during Yala may constrain the potential for use of other inputs such as fertilizer and may result in a rapid decline in their productivity. The land input is significant for the Maha season but not for the

TABLE 1 ESTIMATES OF TRANSLOG PRODUCTION FUNCTIONS FOR RICE FARMS IN KANDY SAMPLE

Variable	Coefficient (Maha)	Coefficient (Yala)
Intercept	5.7188	15.1884
$\ln X_1$	0.0911	4.1777
	(0.4122)	(4.4891)
$\ln X_2$	0.3382	0.1590
	(0.3319)	(0.4956)
$\ln X_3$	1.5019*	3.9673
	(0.7876)	(3.0483)
$\ln X_4$	0.1158	0.3198
	(0.2354)	(0.4753)
$(\ln X_1)^2$	0.0016	0.6357
	(0.0289)	(0.5142)
$(\ln X_2)^2$	0.0014	0.0186
	(0.0042)	(0.0259)
$(\ln X_3)^2$	0.1413	0.1866
	(0.1077)	(0.2795)
$(\ln X_4)^2$	0.0277	0.0387
	(0.0286)	(0.0392)e
$\ln X_1 \ln X_2$	0.0466	0.0456
	(0.0534)	(0.1175)
$\ln X_1 \ln X_3$	0.0442	0.6353
	(0.1183)	(0.6885)
$\ln X_1 \ln X_4$	0.0356	0.2159*
	(0.0447)	(0.1025)
$\ln X_2 \ln X_3$	0.2525**	0.1124
	(0.1130)	(0.1239)
$\ln X_2 \ln X_4$	0.0193	0.0490
	(0.0446)	(0.0775)
$\ln w_3 \ln X_4$	0.1083*	0.0332
	(0.0655)	(0.1028)
R^2	0.8759	0.8576
Sample size	114.0	64.0

N.B. One asterisk indicates the regressor to be significant at the 10% level and two indicate the regressor to be significant at the 5% level. Standard errors are in parentheses.

TABLE 2 ESTIMATES OF TRANSLOG PRODUCTION FUNCTIONS FOR RICE FARMS IN ANURADHAPURA SAMPLE

Variable	Coefficient (Maha)	Coefficient (Yala)
Intercept	8.0729	12.6094
$\ln X_1$	0.2866**	3.1149**
	(0.1274)	(0.8818)
$\ln X_2$	0.0669	0.2560
	(0.2072)	(1.7257)
$\ln X_3$	0.5760***	3.7167*
	(0.1695)	(2.1783)
$\ln X_4$	0.0004	0.1615
	(0.0082)	(0.0689)
$\ln X_5$	0.0114	0.1426***
	(0.0092)	(0.0505)
$(\ln X_1)^2$	0.0804*	0.0026
	(0.0465)	(0.0027)
$(\ln X_2)^2$	0.0317	0.2268
	(0.0278)	(0.1589)
$(\ln X_3)^2$	0.1129	0.3201
	(0.0827)	(0.2625)
$(\ln X_4)^2$	0.0017	0.0123**
	(0.0051)	(0.0057)
$(\ln X_5)^2$	0.0073	0.0050
	(0.0052)	(0.0052)
$\ln X_1 \ln X_2$	0.0776	0.5770
	(0.0617)	(0.1572)
$\ln X_1 \ln X_3$	0.0585	0.7006***
	(0.0414)	(0.2129)
$\ln X_1 \ln X_4$	0.0011	0.0048
	(0.0024)	(0.0040)
$\ln X_1 \ln X_5$	0.0062*	0.0182
	(0.0035)	(0.0102)
$\ln X_2 \ln X_3$	0.0192*	0.0397
	(0.0101)	(0.3462)
$\ln X_2 \ln X_4$	0.0012	0.0114
	(0.0013)	(0.0119)
$\ln X_2 \ln X_5$	0.0038	0.0001
	(0.0024)	(0.0023)
$\ln X_3 \ln X_4$	0.0022	0.0170
	(0.0068)	(0.0183)
$\ln X_3 \ln X_5$	0.0070	0.0183
	(0.0070)	(0.0200)
$\ln X_4 \ln X_5$	0.0004	0.0091***
	(0.0009)	(0.0021)
R^2	0.8977	0.9504
Sample size	116.0	66.0

N.B. Three asterisks indicate significance at the 1% level, two asterisks indicate significance at the 5% level and one asterisk indicates significance at the 10% level. The standard errors are given in parentheses.

Yala season.

In the Anuradhapura sample, the labour variable is negative and significant for both seasons. This is an unexpected result in view of the large size of the holdings in the Anuradhapura sample. The considerable amount of mechanisation in this sample may perhaps explain this observation. The land variable is significant in the sample for both Yala and Maha. For Yala, both the buffalo and machinery variables are also significant.

The coefficients of the traslog model indicate that the relationships are much more complex than is reflected by the simple models. It is also clear that there is no systematic relationship between the inputs and output. In cases where the relationship can be systematically explained the separate effect of one input alone is not always significant. But inputs significantly explain variation in productivity in association with other inputs. Thus the negative sign for labour for example observed while important, should not be taken to reflect the total relationship between productivity and labour.

The total relationship can be understood more clearly by examining output elasticities with respect to the different inputs used. Thus the elasticities were computed at minimum, average and maximum values of cooperating inputs from the sample of data using equation 2. Only those inputs with significant interactions were used in the computation of the elasticity. The signs of the elasticity measure depend on the signs of the estimated coefficients and the values of the cooperating inputs. An alaysis of these signs will show the role of the cooperating inputs in the overall relationship. The elasticities so computed for labour and land, which are the more important variables in peasant production are given in Table 3.

TABLE 3 OUTPUT ELASTICITIES

	Translog Function			Cobb-Douglas Function
	with minimum values of cooperating inputs	with average values of cooperating inputs	with maximum values of cooperating inputs	
Y wrt X_1[a]	0.0911	0.0911	0.0911	0.1069
Y wrt X_1[b]	4.525	4.95	5.407	0.0474
Y wrt X_1[c]	0.2607	0.2596	0.2356	0.0368
Y wrt X_1[d]	0.4953	0.3535	0.074	0.0122
Y wrt X_3[a]	1.2459	0.945	0.641	0.4746
Y wrt w_3[b]	3.96	3.96	3.96	3.96
Y wrt X_3[c]	1.5162	0.2137	1.0375	0.8864
Y wrt X_3[d]	0.6671	0.6912	0.7219	0.9465

a. Kandy Maha
b. Kandy Yala
c. Anuradhapura Maha
d. Anuradhapura Yala

The elasticities obtained from the Cobb-Douglas function are also given in Table 3. The table shows that the elasticity for labour in the Maha season in the Kandy sample is negative and constant since there was no significant cooperating input. For Yala, the elasticity declines with increase in the cooperating input buffalo variable.

For the Anuradhapura sample also the elasticity of labour for Maha is negative but increases with increase in the cooperating input, machinery. Since machinery is not a perfect substitute for labour as more machinery is substituted, the productivity of labour could increase. For Yala, the elasticity of labour increases with increase in the cooperating inputs, operating cost and land. The operating cost was positive and land negative in this relationship. The net effect here depends on the individual effects acting in conjunction with one another. Effectively the influence of operating cost dominates the negative effect of land and thus the elasticity becomes positive at higher levels of land.

The Kandy sample shows that the elasticity with respect to land increases with increase in the values of cooperating inputs, operating cost and buffalo cost in this case. The negative effect of operating cost is swamped by the positive effect of buffalo power and thus ensures an increase in the elasticity for land. The elasticity of land for the Yala season remains positive but unchanged since there is no significant cooperating input associated with it.

The Anuradhapura Yala results show that the elasticity of output with respect to land diminishes as the value of cooperating inputs (labour in this case) increases finally reaching a negative value. This implies that the gross output per cultivated hectare increases at a diminising rate with average size of holding when more and more units of cooperating inputs are used. At maximum value of cooperating inputs, larger average size of holdings produce lesser output per cultivated hectare. Thus as more and more labour is used the negative effect of labour swamps the positive effect of land.

For Anuradhapura Maha, the output elasticities with respect to land increases with increase in the values of the cooperating inputs which is operating cost with a positive sign. The increase in operating cost increases the productivity of land and the difference in this and the previous case stems from differences in water availability which is the major difference between the two seasons. In the absence of water the operating cost variable cannot play a significant role since the productivity depends on the availability of water. These results also show that the oft repeated inverse relation between productivity and land size is not universally true[4].

Further analysis of elasticities of output with respect to other factors such as operating cost, machinery and buffalo use, gave some insightful results. In the Kandy sample, the elasticity of the operating cost variable remained constant for the Yala season. For Maha, it declines with increase

in the cooperating input land. For the buffalo variable, the elasticity was negative for all values of the cooperating input land both for the Yala and Maha seasons.

In the Anuradhapura sample, the elasticity of output with respect to operating cost for both Yala and Maha increased with increase in the cooperating inputs land and labour respectively. The output elasticity with respect to machinery showed a similar trend in both seasons in the Anurahapura sample. The elasticity tended to increase with increase in the cooperating input labour for the Maha season. This also suggests that labour and machinery are not perfect substitutes for each other. For the Yala season, however, the elasticity tended to decrease with increase in the cooperating input buffalo use. This fact indicates that buffalo power substitutes for machinery with ease.

IV. Concluding Remarks

In general, this study indicates that labour productivity is not high in both samples and the potential to use labour for productivity gains does not exist. The land variable indicated higher elasticities implying that land is a most productive resource in peasant agriculture. The study also shows that inputs such as fertilizer (operating cost) can still be used in the Anuradhapura sample as is evidenced by an increasing elasticity at higher levels of land and labour. For the Kandy sample, however, the opportunity to enhance productivity through such means as application of fertilizer (operating cost) is not available. The scope for substitution of buffalo for machinery is also evident in the study. Both land and operating cost are scarce in peasant agriculture and this also suggests that development of acceptable technical innovations in peasant agriculture should proceed along lines where it tends to use more of the available inputs such as labour and less of land and fertilizer.

REFERENCES

[1] Abeysekera, W.A.T., "Production Efficiency in Paddy Farming," *Sri Lanka Journal of Agrarian Studies*, Vol. 1, No. 1 (1980): 12–19.

[2] Berndt, E. and L. Christensen, "The Translog Function and the Substitution of Equipment, Structures and Labour in U.S. Manufacturing," *Journal of Econometrics*, Vol. 1 (1973): 81–113.

[3] Herath, H.M.G., "Production Efficiency, Returns to Scale and Farm Size in Rice Production: Evidence from Sri Lanka," *Agricultural Administration*, Vol. 12(1983): 141–153.

[4] Rao, V. and T. Chotigeat, "The Inverse Relationship between Size of Land Holdings and Agricultural Productivity," *American Journal of Agricultural Economics*, Vol. 63, No. 3 (1981): 571–574.

[5] Wyzan, M.L., "Empirical Analysis of Soviet Agricultural Production and

Policy," *American Journal of Agricultural Economics*, Vol. 63, No. 3 (1981) 475–483.