ESTIMATING AGRICULTURAL PRODUCTION FUNCTIONS FOR SOME FARM FAMILIES IN WESTERN NIGERIA

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I. PROBLEMS AND PURPOSE OF STUDY

OLIVER Lytleton [3, p. 1] stated that one of the most important problems facing agriculture in Africa was the generation of maximum output and the conservation of natural resources.

The principal features of Nigerian agriculture are its low level of technology and fragmentation of landholdings. The chief tools are hoes, cutlasses, axes, and knives. The introduction of heavy machinery and the rationalization of cultivation through consolidated farm holdings would increase output. But the institutional framework that prevents consolidation and enhances fragmentation makes this an unattainable ideal. The communal land tenure system with its low degree of internalization of externalities is responsible for fragmented landholdings and nullifies incentives for greater investments on land.

Yet, 60 per cent of the gross domestic output of Nigeria was earned in the agricultural sector and 80 per cent of the labor force was employed in this sector. Over 70 per cent of total Nigerian commodity exports and 95 per cent of total Nigerian food consumption was accounted for by this sector in the 1950s. The agricultural sector has been the predominant sector in the economy of Nigeria.

Between 1950 and 1957, real domestic food production was calculated by Pious Okigbo to have increased at an annual average rate of 2.1 per cent [6]. This is approximately equal to the estimated rate of population increase during that period. As development proceeds, it is expected that the proportion of the working population engaged in nonfood production would increase. To make this possible, the marketable "surplus" from agriculture must also rise. Since this sector predominates in the economy, economic growth could be constrained if changes are not made to increase productivity here.

As Gerald Helleiner [2, p. 10] had stated, though Nigeria is a "land surplus" economy, there exists a considerable potential "agricultural surplus" consisting not only of "unutilized" land, but also of unutilized labor which can be mobilized for increased agricultural output. Institutional farm arrangements may prevent the potential utilization of the excess supply of land so that the effective arrangement is that which is characterized by both an excess supply of labor and an excess supply of land.

In this paper an attempt will be made, using production functions estimated for Ibadan and Ife districts of Western Nigeria, to highlight the distortions in the agricultural sector of Nigeria. It shall be shown that a move to large-scale farm operations would be wealth maximizing from the standpoint of enhancing agricultural output. Also it will be shown that hitherto factor usage in the agricultural sector of Nigeria has been less than optimal, with an excess utilization of labor and fertilizers and an underutilization of capital and land. Thus, there is likely to be substantial output gains with factor reallocations here. The implicit assumption in this exercise is that the districts surveyed are a microcosm of the aggregate Nigerian farm sector.

II. METHODOLOGY AND DATA

For the purpose of collecting data for the production function analysis, two hundred farmers were interviewed in Ibadan and Ife districts of Western Nigeria in February 1973. A questionnaire was used for the interview.

The survey encompassed twenty-five villages in these two districts: Oduona-Kekere, Ajia, Akanran, Origbo, Apesin, Apomu, Ikire, Ejoku, Lalupon, Moniya, Erumu, Olodo, Olufon, Idioshe, Olukunle, Jago, Ashipa, Ipetumodu, Edun-Abon, Agbungbu, Ayokoka, Ajebandele, Ladin, Ashe, and Aye-Oba. These villages comprise the major communities on the main road axis of these districts and range in distance from six to sixty-nine miles from Ibadan, the largest native city in Black Africa.

The data collected from the two hundred farm families were the value of farm equipments, the acreage of land brought under cultivation, the number of family and hired labor, the value of fertilizers, and the value of output for the year 1972. The value magnitudes were estimated using prevailing market prices.

The data were stratified in several ways. Farmers with cultivated holdings less than five acres were classified as small-scale farmers,[1] those with cultivated holdings less than fifteen acres but greater or equal to five acres were classified as medium-scale farmers and those with cultivated holdings greater than fifteen acres were classified as large-scale farmers. For these groups, production functions were estimated. Other subgroups for which production functions were estimated were farmers utilizing fertilizers, farmers not using fertilizers, farmers with plots less than one mile apart, farmers with plots more than one mile apart, and all the farmers as a group. Also a division into less consolidated and more consolidated holdings was made. Farmers with largest single plots greater than five acres were considered to have achieved greater consolidation and farmers with largest single plots less or equal to five acres were considered to have achieved less consolidation, and classified accordingly.

The estimated production functions are used to predict the output effect of factor transfers from small-scale to medium-scale holdings and from medium-

[1] The stratification was done on farmers rather than plots since each farmer had more than one plot, and output had been estimated on each farmer as the relevant economic unit. Two farmers with very large capital values (one a truck, the other a motorcycle) were removed from the groups since their inclusion could bias the results.

scale to large-scale holdings. This will be used to show the effect of a movement from small-scale to large-scale operations in terms of net increments in output. Also important conclusions were derived from the other classifications regarding factor disequilibria and optimal policy correctives.

To estimate a Cobb-Douglas production function, the equation used is:

$$Y = e^{\alpha} L^{\beta} A^{\delta} K^{\gamma} F^{\varepsilon},$$

for which

$$\log Y = \alpha + \beta \log L + \delta \log A + \gamma \log K + \varepsilon \log F,$$

where Y = income (total output in terms of money); L = labor months; A = total acres cultivated per farmer; K = value of equipments (in pounds); F = value of fertilizers (in pounds).

The results of the estimates and computations are shown in Table I.

TABLE

PRODUCTION FUNCTION FOR IBADAN

	Small Farmers	Medium Farmers	Large Farmers	Farmers with Fertilizers
Number of farmers	49	86	63	157
Production elasticities:				
Constant	4.5204*	4.3501*	3.6509*	4.1707*
Capital	0.2999*	0.0874	0.2584*	0.2258*
Land	0.0513	0.1947	0.2370*	0.1363*
Labor	0.1971	0.2795*	0.3516*	0.3048*
Fertilizers	0.0065	0.0042	0.00054	0.0193
Sum of elastic.	0.5548	0.5659	0.8475**	0.686
R-squared	0.2242	0.2706	0.4952	0.4648
Geometric means:				
Capital (in £)	1.66	2.8	4.36	3.38
Land (in acres)	2.35	7.92	26.2	10.2
Labor (in months)	16.3	26.1	34.9	29.6
Fertilizers (in £)	0.06	0.8	3.1	6.61
Income (in £)	189	314	426	340
Marginal products:†				
Capital (£ per £)	34.3	9.8	25.2	22.7
Labor (£ per month)	2.3	3.4	4.3	3.5
Land (£ per acre)	4.13	7.73	3.86	4.53
Opportunity costs:				
Capital (£ per £)	1.30	1.30	1.30	1.30
Labor (£ per month)	10	10	10	10
Land (£ per acre)	2	2	2	2
Marginal product/opp. cost ratios				
Labor	0.23	0.34	0.43	0.35
Land	2.07	3.87	1.93	2.27

Note: Nigerian £1 = U. S. $3.

* Significantly different from zero at 5 per cent confidence level.

** Not significantly different from unity at 5 per cent confidence level.

† Estimated at geometric mean input levels.

III. THE PRODUCTION FUNCTIONS

The estimated production function for small-scale farmers is:

	$\log Y = 4.5204$	$+\ 0.2999 \log K$	$+\ 0.05131 \log A$
standard error	(0.5237)	(0.1651)	(0.1471)
t-statistics	(8.6324)	(1.8166)	(0.3487)

	$+\ 0.197 \log L$	$+\ 0.0065 \log F.$	R-squared$=0.2242.$
standard error	(0.1922)	(0.0159)	
t-statistics	(1.0252)	(0.4041)	

Only the capital coefficient is significant at the 5 per cent level of confidence. The other coefficients are not significantly different from zero.

For the medium-scale farmers the production function is:

I

AND IFE DISTRICTS (1972)

Farmers without Fertilizers	Farmers Less than 1 Mile Apart	Farmers More than 1 Mile Apart	Farmers with More Consolidated Holdings	Farmers with Less Consolidated Holdings	All Farmers
41	62	136	96	102	198
4.5200*	4.4463*	4.2492*	4.213*	4.543*	4.2317*
0.1607	0.4600*	0.1432*	0.257*	0.138*	0.2051*
0.1942*	0.1979*	0.1421*	0.180	0.160*	0.1538*
0.1684	0.0892	0.3295	0.257*	0.210*	0.2939*
	−0.0079	−0.0004	0.003	0.003	0.0015
0.5234	0.7390	0.6136	0.698	0.511	0.6545
0.3149	0.5562	0.4579	0.5438	0.2774	0.4853
1.52	2.36	3.1	3.87	2.34	2.82
4.55	7.21	9.31	16.7	4.67	8.6
14.8	21.5	27.6	32.6	20.1	25.5
	0.21	1.15	2.02	0.26	0.66
208	249	338	389	253	307
22.0	48.5	15.6	25.7	15.0	22.3
2.36	1.03	4.02	3.07	2.65	3.5
8.87	6.84	5.16	4.19	8.66	5.5
1.30	1.30	1.30			
10	10	10	10	10	10
2					
0.236	0.103	0.402	0.307	0.265	0.35
4.43	3.42	2.58	2.09	4.33	2.8

$$\log Y = 4.3501 + 0.0874 \log K + 0.1947 \log A$$

standard error	(0.3523)	(0.0825)	(0.1247)
t-statistics	(12.3472)	(1.0593)	(1.5618)

$$+ 0.2795 \log L + 0.0042 \log F. \qquad R\text{-squared} = 0.2706.$$

standard error	(0.0988)	(0.0129)
t-statistics	(2.8286)	(0.3270)

Only the coefficient of labor is significantly different from zero at 5 per cent confidence level.

From the large-scale farmers the estimated production function is:

$$\log Y = 3.6509 + 0.2584 \log K + 0.2370 \log A$$

standard error	(0.4107)	(0.0807)	(0.0971)
t-statistics	(8.8892)	(3.2024)	(2.442)

$$+ 0.3516 \log L + 0.0005 \log F. \qquad R\text{-squared} = 0.4952.$$

standard error	(0.1028)	(0.0182)
t-statistics	(3.4195)	(0.0297)

The coefficients of labor, land, and capital are significantly different from zero at the 5 per cent level of confidence. As in the other two groups, the coefficient of fertilizers was not significantly different from zero.

To estimate the returns to scale, the sum of the coefficients is taken for each group. For the small-scale farmers, the coefficient sum is 0.5548 showing decreasing returns to scale. For the medium-scale farmers, the coefficient sum is 0.5659 also showing decreasing returns to scale. The coefficient sum for the large-scale farmers is 0.8475 which still indicates decreasing returns to scale.

Using a t-test,[2] the returns to scale were tested to see if they diverge significantly from unity. The t-value of the difference for small-scale farms is 2.27 which is significant at 5 per cent confidence level. For the medium-scale farmers the t-value is 3.17, which also is significant at 5 per cent confidence level. The large-scale farmers, however, do not diverge significantly from unity. The t-value is 1.217 which is statistically not significant at 5 per cent confidence level. Thus the hypothesis that there are constant returns to scale in large-scale holdings is held valid.

Also a t-test was applied to see if the returns to scale in the different groups are different from each other.[3]

[2] $$t = \frac{1 - \sum b_i}{\sqrt{\mathrm{var}\,(\sum b_i)}},$$
where b_i, $i=1, \cdots, n$, is the sum of the coefficient; $\sqrt{\mathrm{var}\,\sum b_i}$ = the standard error of the coefficient. The variance of the sum of the coefficients is the sum of the elements of the variance-covariance matrix printed out in the computer output except that of the constant term. See [1, pp. 116–17].

[3] $$t = \frac{\sum b_i^1 - \sum b_i^2}{\sqrt{\mathrm{var}\,(\sum b_i) + \mathrm{var}\,(\sum b_i^2)}},$$
where $\sum b_i^1$ = sum of the coefficients in group 1, and $\sum b_i^2$ = sum of the coefficients in

The test shows that there is no significant difference at the 5 per cent level between the returns to scale in the small-scale farms and the medium-scale holdings. The t-value is 0.458. The difference in the returns to scale between medium-scale and large-scale holdings is significant. The t-value estimated is 1.7 which is significant at 5 per cent confidence level. The output effects of factor transfers from small-scale to medium-scale and from medium-scale to large-scale holdings are investigated later.

The production function for farmers who use fertilizers is:

	$\log Y=$ 4.1707	+ 0.2258 $\log K$	+ 0.1363 $\log A$	
standard error	(0.2046)	(0.0607)	(0.0433)	
t-statistics	(20.3813)	(3.7221)	(3.1461)	
	+ 0.3048 $\log L$	+ 0.0193 $\log F$.		R-squared=0.4648.
standard error	(0.0748)	(0.0387)		
t-statistics	(4.0733)	(0.49709)		

The coefficient of labor, land, and capital are significantly different from zero at 5 per cent confidence level. Only the coefficient of fertilizers was not significantly different from zero at this level of confidence. The coefficient sum is 0.686 and shows decreasing returns to scale. This deviated significantly from unity at 5 per cent confidence level with a t-value of 5.14.

The production function of farmers not utilizing fertilizers is:

	$\log Y=$ 4.5200	+ 0.1607 $\log K$	+ 0.1942 $\log A$	+ 0.1648 $\log L$.
standard error	(0.4886)	(0.1553)	(0.0711)	(0.1961)
t-statistics	(9.2514)	(1.0349)	(2.7329)	(0.8589)
	R-squared=0.3149.			

Only the coefficient of the land input is significantly different from zero at the 5 per cent level of confidence. The other inputs with positive t-value do not differ significantly from zero at the 5 per cent level. The coefficient sum is 0.5234 which is significantly different from unity at the 5 per cent level of confidence (t-value = 2.69).

On testing the difference in the returns to scale between the farms without fertilizers and farms with fertilizers, the t-value attained is 0.8695 which is not significantly different from zero at the 5 per cent level of confidence. Thus the hypothesis that fertilizers contributed nothing to the output receives a further boost.[4]

The production function for farmers with plots less than one mile apart is:

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group 2, and the denominator is an estimate of the standard error of the difference. See [1, p. 117].

[4] A plausible explanation for the difference found in the two production functions (farmers utilizing fertilizers and farmers not) is that farmers using fertilizers may be more educated than those not, since they understood the necessity to use this additional input. They are thus more competent farmers and the fertilizer input stands as a proxy for this greater acquired or inate capacity, we shall not call managerial ability on the part of farmers who use it.

	$\log Y=$ 4.4463	+ 0.4600 $\log K$	+ 0.1979 $\log A$
standard error	(0.3501)	(0.1170)	(0.0630)
t-statistics	(12.6732)	(3.9308)	(3.1424)

	+ 0.0892 $\log L$	− 0.0079 $\log F$.	R-squared=0.5562.
standard error	(0.1318)	(0.0127)	
t-statistics	(0.6769)	(0.6278)	

The coefficients of capital and land are significantly different from zero at 5 per cent confidence level. The coefficients of labor and fertilizers are not significantly different from zero at 5 per cent confidence level. The coefficient sum is 0.7390 and shows decreasing returns to scale since it differs significantly from unity. The t-value is 2.5 which is significant at the 5 per cent level of confidence.

For farmers with plots more than one mile apart, the production function is:

	$\log Y=$ 4.2492	+ 0.1432 $\log K$	+ 0.1421 $\log A$
standard error	(0.2341)	(0.0618)	(0.0431)
t-statistics	(18.1486)	(2.3156)	(3.2987)

	+ 0.3295 $\log L$	− 0.004 $\log F$.	R-squared=0.4579.
standard error	(0.0788)	(0.0108)	
t-statistics	(4.1789)	(−0.0373)	

The coefficients of labor, land, and capital are significant at 5 per cent confidence level. Only the coefficient of fertilizers show no significant difference from zero. The coefficient sum is 0.6136 and when a t-test was applied to test the degree of homogenity attained, the t-value was 5.6, which is significant at 5 per cent confidence level.

On testing the difference between the returns to scale in the two groups above, the t-value attained was 1.024. This is not significant at 5 per cent confidence level.

The difference in the production functions must be due to the fact that farmers with plots more than one mile apart had the opportunity for expansion. They utilized more land and capital than farmers with plots less than one mile apart in face of a high marginal product for these factors (see Table I). They were thus able to achieve a better input mix than the other group of farmers.

For the more consolidated farmers the production function is:

	$\log Y=$ 4.213	+ 0.257 $\log K$	+ 0.18 $\log A$
standard error	(0.2486)	(0.0569)	(0.0530)
t-statistics	(16.9430)	(4.5189)	(3.3879)

	+ 0.257 $\log L$	+ 0.003 $\log F$.	R-squared=0.5438.
standard error	(0.0675)	(0.0128)	
t-statistics	(3.7981)	(0.2975)	

The coefficients of capital, labor, and land were all significantly different from zero at 5 per cent confidence level. The coefficient of fertilizers was not significant at the 5 per cent level of confidence.

For the less consolidated farmers, the production function is:

$$
\begin{array}{llll}
 & \log Y= 4.543 & +\ 0.138 \log K & +\ 0.160 \log A \\
\text{standard error} & (0.3311) & (0.0834) & (0.0731) \\
\text{-statistics} & (13.7215) & (1.6597) & (2.1950) \\
 & +\ 0.210 \log L & +\ 0.003 \log F. & R\text{-squared}=0.2774. \\
\text{standard error} & (0.1179) & (0.0111) & \\
t\text{-statistics} & (1.7783) & (0.2293) &
\end{array}
$$

The coefficients of capital, land, and labor were all significantly different from zero at 5 per cent confidence level. As before, only the coefficient of fertilizers was not significantly different from zero at the 5 per cent level of confidence.

The sum of elasticities in both the less consolidated as well as the more consolidated holdings shows decreasing returns to scale. Applying the t-test to the difference from unity, the t-value for the less consolidated holdings is 4.85 which is significant at the 5 per cent level of confidence. For the more consolidated holdings, the t-value is 4.1 which is also significant at 5 per cent confidence level. The two sums of elasticities when tested for significant difference had a t-value of 1.56 which is not significant at 5 per cent confidence level.[5]

The production function for all farm holdings is:

$$
\begin{array}{llll}
 & \log Y= 4.2317 & +\ 0.2031 \log K & +\ 0.1538 \log A \\
\text{standard error} & (0.1938) & (0.0538) & (0.0364) \\
t\text{-statistics} & (21.8363) & (3.8115) & (4.2235) \\
 & +\ 0.2939 \log L & +\ 0.0015 \log F. & R\text{-squared}=0.4853. \\
\text{standard error} & (0.0667) & (0.0082) & \\
t\text{-statistics} & (4.4066) & (0.1869) &
\end{array}
$$

The coefficients of labor, land, and capital are significantly different from zero at 1 per cent confidence level. Fertilizer input is seen as contributing nothing to output as its coefficient is not significantly different from zero.

The sum of coefficients is 0.6545 which is significantly different from unity at 5 per cent confidence level (t-value is 8.03) showing decreasing returns to scale.

All the above production functions show decreasing returns to scale with the exception of the large-scale holdings. Seven out of the ten equations estimated can be considered reliable on the basis that at least two of the factor coefficients are significantly different from zero at the 5 per cent confidence level. The bad equations are those for small- and medium-scale farmers, and farmers without fertilizers. In the large-scale operations, the hypothesis that constant returns to scale prevail is acceptable. This, however, does not show that least-cost combinations have been attained in the large-scale holdings. In order to estimate efficient factor combinations and thus compare the relative efficiency of factor usage in the different categories stratified, an examination of the marginal product-opportunity cost ratios will be made. This is done below.

[5] When farmers with their largest plot equal to five acres each were included in the more consolidated group, the difference in the returns to scale is significant at the 5 per cent level of confidence.

IV. THE MARGINAL PRODUCT-OPPORTUNITY COST RATIOS AND LABOR SURPLUS

Maximum efficiency in the use of resources occurs when the revenue from using one additional unit of input equals the social cost of that additional unit of input, that is, when the marginal product-opportunity cost ratio is equal to unity. If the ratio is less than one, it indicates that too much of the particular factor is being utilized. If the ratio is greater than one, it means that too little of the resource is being used. Efficiency would dictate the purchase and use of more of that particular factor.

The estimate of the opportunity cost of labor was derived from averages of daily wages for unskilled labor.[6] This average of 10 shillings per day would amount to a lower limit of £10 (pounds sterling) per month (this is equivalent to $30 per labor per month). For the purpose of calculating the opportunity cost of labor, the lower limit of £10 per month was used.

In like manner we could estimate the opportunity cost of land. Since no data for the relevant period (1972) is present, an estimate based on earlier works will be made. C. W. Rowling reported "stranger rents" on land in Ijebu Province of 5 shillings to 10 shillings an acre per year. These estimates were for the 1940s [7, pp.35–36]. Also in the *Report on Land Tenure in Ondo Province*, rents on land of 20 shillings per acre per year (£1 per acre per year) were recorded. This was for 1952 [4, p. 53]. For 1972, the year in which the sample of the farmers for this production analysis was conducted, we estimate that the social opportunity cost of agricultural land should be approximately £2 per acre per year as an upper limit.

As shown in Table I, the marginal product to opportunity cost ratios for labor are all less than one. The highest ratio attained is 0.43 for the large-scale farmers showing the relative efficiency of large-scale operations with regards to the utilization of labor.[7] If a higher limit of £15 (pounds sterling) is used as the relevant opportunity cost of labor, the figures would all diverge further from unity. Thus, evidence attests to the over-utilization of labor in the agricultural sector.

The marginal products of capital are all very high. Farmers use very little capital in this sector. Almost all the farmers used hoes, cutlasses, and knives, as they are not differentiated in the use of capital. None used motor driven equipment for cultivation; though one farmer owned a motorcycle and another a car. Thus the high marginal products of capital is a result of the very small amounts of capital used by farmers in this relatively labor-intensive agricultural sector. It is not necessary, therefore, to compare the marginal product-opportunity cost ratios for capital over the different groups. We assume that capital is equally inefficiently applied over the different categories.

The marginal product-opportunity cost ratios for land are all greater than

[6] See [5]. There is an implicit assumption that these wages are the social opportunity costs of labor.

[7] The reader is reminded that the equations estimated for the small-scale and medium-scale operations are not very good. Thus the above conclusions are subject to this limitation.

unity, but not that much greater. This shows the relative scarcity of land in the agricultural sector. The ratio closest to one was 1.93 for the large-scale farmers, showing their relative efficiency in the utilization of land. Thus (subject to the limitations of the equation estimated as shown in footnote 7 above), large-scale operations are more efficient in the use of the dominant factors, land and labor, than either medium- or small-scale operations.

Farmers with plots less than one mile apart are less efficient than farmers with plots more than one mile apart in both the use of land and labor. The marginal product-opportunity cost ratios for these factors are closer to unity in plots more than one mile apart. The equations estimated for these two groups are fairly good. The farmers with plots more than one mile apart used more land than the other group, thus lowering further the marginal product of land closer to its social opportunity cost, and raising the marginal product of labor closer to its social opportunity cost.

Farmers who use fertilizers are more efficient in the use of labor and land than farmers not using fertilizers. This also is subject to the limitation of the bad equation estimated for farmers not using fertilizers. The marginal product-opportunity cost ratios of land and labor for farmers utilizing fertilizers are closer to unity than those for farmers not using fertilizers (see explanation in footnote 4).

Farmers with more consolidated holdings are more efficient in the use of labor and land than farmers with less consolidated holdings. The ratio for labor is closer to unity in the more consolidated holdings than in the less consolidated ones. The ratio for land diverges further from unity in the less consolidated group (4.33) than in the more consolidated group (2.09). The equations estimated for the two groups are both good.

Thus, the more consolidated holdings are closer to the attainment of an optimal allocation of the dominant factors, labor and land in the agricultural sector. A movement to consolidated units from erstwhile fragmented units would lead to a more efficient allocation of factors in the agricultural sector. Thus, a desirable objective of land reform in Nigeria should be the consolidation of erstwhile fragmented units to larger units.

V. PREDICTION OF THE IMPACT OF FACTOR TRANSFERS ON OUTPUT

In this section, the effect on output of factor transfers from medium-scale to large-scale operations will be accessed. With the results we will attempt to decide on the type of operations that would augment increases in output regarding the agricultural sector.[8]

The changes in output with 10 per cent factor transfer from medium- to large-

[8] We would expect the same result with factor transfers from small-scale to large-scale operations as with factor transfers from medium-scale to large-scale operations since there is no difference in the returns to scale between medium- and small-scale operations. The reader should bear in mind that the equations estimated for small- and medium-scale operations are not very good, so these factor transfer results are subject to these limitations.

TABLE II
FACTOR TRANSFERS BETWEEN MEDIUM- AND LARGE-SCALE OPERATIONS

Factors	Medium Farms Reduced 10%	Large Farms Plus 10% Medium Farms	Medium Farms Reduced 20%	Large Farms Plus 20% Medium Farms
Capital	2.52	4.64	2.24	4.92
Land	7.128	26.992	6.336	27.784
Labor	23.49	37.51	20.88	40.12
Fertilizers	0.72	3.18	0.64	3.26

Note: The data are geometric means of the farm operations.

scale operations are as shown below:

$$\log Y_{\text{medium}} = 4.3501 + 0.0874 \log 2.52 + 0.1947 \log 7.128 + 0.2795 \log 23.49 + 0.0042 \log 0.72.$$

$\log Y_{\text{medium}} = 5.6944$, therefore, $Y_{\text{medium}} = 298$.

$$\log Y_{\text{large}} = 3.6509 + 0.2584 \log 4.64 + 0.2370 \log 26.992 + 0.3516 \log 37.51 + 0.00054 \log 3.18.$$

$\log Y_{\text{large}} = 6.1036$, therefore, $Y_{\text{large}} = 448$.

Medium-scale operations have lost output of 17 units (i.e., 315–298) while large-scale operations have gained output equal to 22 units (i.e., 448–426). Therefore, there is a net gain in output to the economy of 5 units.

For a 20 per cent factor transfer between medium-scale and large-scale operations, the relevant magnitudes are:

$$\log Y_{\text{medium}} = 4.3501 + 0.0874 \log 2.24 + 0.1947 \log 6.336 + 0.2795 \log 20.88 + 0.0042 \log 0.64.$$

$\log Y_{\text{medium}} = 5.6279$, therefore, $Y = 279$.

$$\log Y_{\text{large}} = 3.6509 + 0.2584 \log 4.92 + 0.237 \log 27.784 + 0.3516 \log 40.12 + 0.00054 \log 3.26.$$

$\log Y_{\text{large}} = 6.1548$, therefore, $Y = 471$.

Thus the medium-scale operations lost output by an amount of 36 units (i.e., 315–279) while large-scale operations gained an output of 45 units (i.e., 471–426). Therefore, there is a net gain to the economy of 9 units.

In each case, with a 10 per cent and 20 per cent factor transfer between medium- and large-scale operations, there is a gain in output to the economy. The change from small-scale to medium-scale operations is not likely to affect net output given the fact that the sums of elasticities are about the same in both. Thus the type of factor redistributions that is likely to increase output should be large-scale transfers or a quantum jump from small-scale to large-scale operations. Further, large-scale operations have been found to be more efficient in the use of labor and land, which as shown earlier, are the dominant factors of production in the agricultural sector. Therefore, a movement to large-scale operations would also lead to a better allocation of factors in the agricultural sector.

CONCLUSIONS

Ten production functions were estimated. The functions which had more than two significant variables and as such were felt to be fairly good are the ones for (1) large-scale farmers; (2) farmers who utilized fertilizers; (3) farmers with plots less than one mile apart; (4) farmers with plots more than one mile apart; (5) all farmers as a group; (6) farmers with relatively more consolidated holdings; and (7) farmers with less consolidated holdings.

Thus, although the large-scale operations seem to be more efficient in the use of labor and land than either the small-scale and medium-scale operations, and the factor transfers from medium- to large-scale operations were shown to produce net increments in output, we should accept this result with caution. The equations for small- and medium-scale operations were not very good as shown above.

Farmers with more consolidated holdings were more efficient in the use of labor and land than farmers with less consolidated holdings. The equations estimated for both groups are good and as such comparable. Thus, it was shown that a movement towards consolidated holdings would help the attainment of more efficient input mix and hence increased output in the agricultural sector.

As seen in the production function studies, the emphasis placed on fertilizers in governmental input subsidy schemes could be reaching suboptimal limits. The elasticities of fertilizer input in all our regression categories are not significantly different from zero. Since the marginal products of capital are very high in these subgroupings, the government in their subsidy schemes should look for ways to provide more capital as substitute for labor and fertilizers. Better hoes could be experimented with like hoes that reduce the amount of motive power applied to them for traction. Also, the introduction of mules and ploughs could be experimented with, as these would save human labor and substitute more efficient animal power towards cultivation. The introduction of motor driven equipment should be made in highly consolidated holdings. Thus evidence abounds to substantiate the presumption that agricultural productivity would be doubly enhanced with the consolidation of erstwhile fragmented units, and the incorporation of capital equipments into cultivation.

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