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Substitution Relationship of Resources in the Groundnut Farms

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Introduction: Profits from groundnut farm in India are not appreciable on account of the high cost of production. In the present study an attempt has been made to reduce the cost of production through reorganisation of resources by (i) input-output relationship of resources, (ii) yield iso-quants for different levels of output, (iii) the marginal rate of substitution of resources and (iv) least-cost combination of resources through iso-clines for different price ratios.

Materials and Methods: A production function of Cobb-Douglas model is fitted to the data collected during 1963-65 from 120 groundnut farmers in the Pollachi tract of Coimbatore region. Based on the estimated function, input-output relationships were derived; iso-quants for four levels of output were drawn; marginal rate of substitution of resources calculated for each level of output and iso-clines for different price ratios derived to arrive the least-cost combination of input factors.

Results: The production function fitted is (2)

$$Y = 20.75\, X_1^{\underset{(0\ 9363)}{0.25543^*}}\, X_2^{\underset{(0.1082)}{0.03588}}\, X_3^{\underset{(0.0938)}{0.10920}}\, X_4^{\underset{(0.0568)}{0.35817^{**}}}\, X_5^{\underset{(0.1002)}{0.24487^*}}$$

$R^2 = 0.92^{**}$

where, Y=output in rupees; X_1=land in acres; X_2=human labour in man [illegible]

Capital services (includes manures and fertilisers) in rupees. Figures in parenthesis indicate standard errors. Double and single asterisks indicate the significance at 1% and 5% level.

In this study, X_1, X_5 are found to be significant at 5% and X_4 at 1% level. Although the elasticity of land is statistically significant and shows an increasing trend of marginal productivity, the availability of land for increasing the size of farm is limited due to socio-economic conditions of the farmers. The marginal product of X_2 and X_3 show that any increase in human or bullock labour will result in loss and hence they are fixed at their respective mean levels. The inputs X_4 and X_5 alone are varied for different levels beyond their mean level (for the mean size of farm of 9.5 acres).

This shows the input-output relationships, from which one could know the optimum combination of these two inputs to attain the given output. The following equation was used to establish input-output relationship

$$Y = a\, X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5}$$

$$Y = C\, X_4^{b_4} X_5^{b_5}$$

$$\text{Where } C = a\, X_1^{b_1} X_2^{b_2} X_3^{b_3}$$

The notations are as usual.

The results are presented in Table 1.

TABLE 1. *Input-output relationship*

Input X_4	Output in Rupees				
1030	2459	2602	2725	2832	2928 (1.45)
930	2330	2509	2627	2731 (1.51)	2823
830	2276	2408	2523 (1.56)	2622	2711
730	2173	2300 (1.62)	2412	2503	2589
630*	2061 (1.69)	2180	2283	2373	2454
	383*	483	583	683	783.

Table 1. contains data indicating the nature of two-factor production function *viz.*, seed (X_4) and capital service (X_5). Increases in seed input (X_4) are measured from bottom to top along the Y axis, while capital services (X_5) are read from left to right of the X axis. Each box of the table includes the output which corresponds to the X_4 and X_5 inputs indicated on the axes. If we start from mean output Rs. 2061/- and add Rs. 100/- of each factor Rs. 2300/- worth of output is forthcoming when other resources were held constant at their mean level. When these two inputs are increased to Rs. 200/- each, total output becomes Rs. 2300/-. Diminishing marginal productivity is indicated for both resources taken together. Any diagonal movement towards the upper right-hand corner similarly results in diminishing productivity of the two factors.

A diagonal movement towards the lower right-hand corner of the table illustrates the factor-factor relationship. Output is more or less constant while input of X_4 is decreased and X_5 is increased or vice versa. Factor X_4 (Seed) serves in a limitational capacity, since some minimum quantity must be present if production is to take place. Factor X_4 and X_5 do not replace each other at a constant rate but at a diminishing rate (1). The analysis reveals the feasibilities of capital services and limitation of seed for substitution. Since the capital services (X_5) include manures and fertilizers, the input of X_5 may be increased to attain higher yield levels with limited reduction in the quantity of seeds used in groundnut production. The combination of seed and capital services to cause given output is explained further by iso-quant analysis.

Iso-quants: An iso-quant or iso-product line is the locus of all combinations of two factors of production capable of producing a given amount of a product. An iso-product map relating the use of two factors of production to output, is ordinarily based on the assumption that other factors of production are held constant. In the present study, the factors X_1, X_2 and X_3 are held constant at their mean levels and the iso-value products are calculated for X_4 and X_5 using the following equation derived from the production function.

$$X_5=\left[\frac{Y}{C.X_4^{\,b_4}}\right]^{1/b_5} \quad ; \quad X_4=\left[\frac{Y}{C.X_5^{\,b_5}}\right]^{1/b_4}$$

Four iso-value product lines are drawn for four given output levels

TABLE 2 (a) *Requirements of X_5 for X_4*

X_4	Rs. 2061 level X_5 required	Rs. 2100 level X_5	Rs. 2200	Rs. 2300
630	383	413	500	599
655	362	391	472	566
680	313	370	447	536
705	325	351	421	509
730	309	334	403	495
735	294	317	384	460
780	280	303	368	439
805	268	289	349	419
830	256	276	334	400

TABLE 2 (b) *Requirements of X_4 for X_5.*

X_5	X_4 required	X_4	X_4	X_4
383	629	663	755	855
408	603	635	723	819
433	579	609	694	786
458	557	586	668	756
483	538	566	645	730
508	519	546	622	705
533	502	529	603	683
558	487	513	584	661
583	471	498	567	642

Table 2 (a) shows the requirements of X_5 for different levels of X_4 to produce given amount of output. Conversely, requirements of X_4 for different levels of X_5 to cause the given level of output presented in Table 2 (b).

As output level increases, requirement of X_5 for X_4 also increases, but the rate at which one substitute for another is indicated by the marginal rate of substitution.

Marginal rate of substitution: The term marginal rate of substitution is applied to factor-factor relationship and it refers to the amount by which one resource is decreased as input of another resource is increased by one unit. The marginal rate of substitution of X_5 for X_4 is calculated by using the following equation.

$$\frac{\Delta X_5}{\;} = \frac{X_5}{\;} \times \frac{b_4}{\;}$$

TABLE 3. *Marginal rate of substitution of X_5 for X_4*

Rs. 2061	Rs. 2100	Rs. 2200	Rs. 2300
0.89	0.96	1.16	1.39
0.77	0.87	1.05	1.26
0.73	0.79	0.96	1.15
0.67	0.73	0.88	1.05
0.62	0.67	0.81	0.99
0.57	0.61	0.71	0.89
0.52	0.56	0.69	0.82
0.48	0.52	0.63	0.76
0.45	0.48	0.58	0.70

The table shows that the marginal rate of substitution is continually diminishing, since more and more units of X_4 is required to replace X_5, as X_5 is reduced, so that the fraction $\frac{X_5}{X_4}$ becomes smaller and smaller. This is called the principle of diminishing marginal rate of technical substitution of X_5 for X_4. The marginal rate of technical substitution of X_5 for X_4 can be measured at any point on the iso-value product curve by the slope at that point. The different marginal rate of substitution worked out for the four levels of output is considered in the study.

To attain the output level of Rs. 2061, an increase of Rs. 25 in X_4 (from its mean level) replaces Rs. 21.10 of X_5 (from its mean level) (Table 2(a)). A further increment of Rs. 25 in X_4 replaces only Rs. 19.40 worth of X_5 to attain the same level of output. Thus, the substitution ratio is found to be diminishing in all the successive combinations of the two input factors. This analysis reveals that there is scope for replacing one factor with another but there is a limit to the process, beyond which substitution may be difficult.

Iso-clines or Iso-cost lines: There are several possible combinations of factors which can be used to produce a particular level of output when the units of inputs are continuous. In order to define precisely the optimum economic combination of inputs, it is necessary to apply the iso-cost line concept. The iso-cost line shows the quantity of either factor and the combination of both factors which can be purchased for a given cost.

The iso-cost line or iso-cline is a line connecting all points of equal slopes or substitution rates on a family of iso-quants. In otherwords, it connects all factor combinations which have the same substitution rates for

In this study, the iso-cline is a straight line connecting all points of equal slopes on a family of iso-quants Rs. 2061/-, Rs. 2100/-, Rs. 2200/- and Rs. 2300/-. The iso-clines are not only linear but also pass through the origin. They are also called as scale lines, indicating a fixed proportion of the two inputs used at different levels.

The least-cost combinations of two inputs at different factor prices for four levels of output have been predicted by using the following equation.

$$X_4 = \frac{b_4}{b_5} \cdot \frac{P_5}{P_4} \cdot X_5; \qquad X_5 = \frac{b_5}{b_4} \cdot \frac{P_4}{P_5} \cdot X_4$$

The notations are as usual. P_4 and P_5 are the price per unit of X_4 an(X_5 respectively. The result is presented in Table 4.

TABLE 4. *Least-cost combination of factors*

Price	Price of inputs per unit	Different levels of output			
		Rs. 2061	Rs. 2100	Rs. 2200	Rs. 2300
P_1	X_5 – Rs. 1.00	410	421	455	490
	X_4 – Rs. 1.00	600	620	670	730
		(0.68)	(0.68)	(0.68)	(0.67
P_2	X_5 – Rs. 1.00	470	481	522	560
	X_4 – Rs. 1.25	545	561	610	660
		(0.86)	(0.86)	(0.86)	(0.85
P_3	X_5 – Rs. 1.00	520	535	580	—
	X_4 – Rs. 1.50	508	525	565	
		(1.02)	(1.02)	(1.02)	
P_4	X_5 – Rs. 1.25	360	370	400	430
	X_4 – Rs. 1.00	658	680	732	789
		(0.55)	(0.54)	0.55)	(0.54)

Table 4 shows that the unit price (P_1) of X_4 and X_5 is rupee one each the least-cost combination of these two resources is Rs. 600/- and Rs. 410/- to produce a output of Rs. 2061 level. As the price of X_4 increases, the requirement of it decreases, which is substituted by more units of X_5. The same interpretation holds good for other output levels also. From this analysis, mt' um combination of factors to produce given out level at different

Conclusion: This study was undertaken in Pollachi tract of Coimbatore region to establish substitutional relationship of resources used in groundnut farms. The first step in estimation of substitution rates involved the derivation of the production function viz., Cobb-Douglas model. The production function indicated the scope for increasing the land size, seed and capital services. Investigation of the farmers showed that the size of farm is limited by the socio-economic conditions of the cultivators. Seeds constitute 36.5% of the total cost of production per acre while the investment on manures and fertilisers (capital services) accounted for 9.8% of the total cost of production. Hence an attempt has been made to find out least-cost combinations of these two resources to attain different levels of output, *viz.*, Rs. 2061, Rs. 2100, Rs. 2200 and Rs. 2300/-. The input-output relationship of these two resources shows that the manures and fertilisers may be increased with limited reduction in the seed input so as to produce the given level of output. Eighteen possible combinations of seed and capital services are worked out to attain the four given levels of output. The marginal rate of substitution indicate a diminshing rate of substitution between manures and fertilisers and seed input. One rupee worth of seed substitutes for Re. 0.89 rupee worth of manures and fertilisers. Conversely, Re. 0 89 of X_5 is required to substitute one rupee worth of X_4. The iso-clines indicate the least-cost and highest profit combination of seed and capital services to attain higher yield levels for a given price of these inputs.

From the enquiry, it is known that one pound of seed costs Rs. 1.25 and one unit of capital services (*i. e.*, manures and fertilisers) costs Re. 1-00. The least-cost combination of seed and capital services at the aforesaid price to pruduce Rs. 2061/- worth of output (from a 9.5 acre rainfed farm) is Rs. 545/- and Rs. 470/- respectively. Least-cost combinations of these two resources are computed four different price levels of the input factors (P_1, P_2, P_3 and P_4) to arrive at optimum combination of these resources to attain given levels of output.

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