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# CHAPTER IX

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PRODUCTION FUNCTION ANALYSIS

With a view to determine the simultaneous relationship between total farm return from crop and milk production (combined as well as separately) and various input variables, production function analysis was conducted. Only the Cobb-Douglas type of production function which gave the best fit was used in the present analysis on the basis of reasons discussed latter.

I. Combined farm business (crop + milk production), as a whole:

The general form of the production function equation for crop + milk production, as a whole, was :

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6} x_7^{b_7} x_8^{b_8}$$

Where :

Y	= Total value of gross farm return from crop + live-stock during the year,	}	All in rupees per hectare.
x <sub>1</sub>	= Expenditure on human labour in crop production	}	
x <sub>2</sub>	= Expenditure on bullock labour in crop production,	}	
x <sub>3</sub>	= Expenditure on seed,	}	
x <sub>4</sub>	= Expenditure on manures and fertilizers,	}	
x <sub>5</sub>	= Expenditure on irrigation,	}	
x <sub>6</sub>	= Expenditure on human labour in milk production)	}	
x <sub>7</sub>	= Expenditure on fodder,	}	
x <sub>8</sub>	= Expenditure on concentrates,	}	
a	= Constant,	}	

b<sub>1</sub>, b<sub>2</sub> ..... b<sub>8</sub> are regression coefficient of the respective variables. .

## II. Crop production only, as a whole :

(a) For crop production on sample farms taken as a whole, the production function equation took the form :

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5}$$

Where,

Y = The total gross value of farm crop output, )

x<sub>1</sub> = Expenditure on human labour in crop production, )

x<sub>2</sub> = Expenditure on bullock labour, )

x<sub>3</sub> = Expenditure on seed, )

x<sub>4</sub> = Expenditure on manures and fertilizers, )

x<sub>5</sub> = Expenditure on irrigation, )

a = Constant

b<sub>1</sub>, b<sub>2</sub> ... b<sub>5</sub> regression coefficient of respective variables.

All expressed in terms of rupees per hectare.

## (b) Production function for important individual crops :

The important individual crops dealt in the present study were maize, paddy (local and HYV), wheat (local and HYV) and sugarcane. The production functions were fitted on the same lines as in the case of crop production, as a whole, and the functional form and variables, taken into account remained unchanged.

## (c) Milk production, as a whole :

In case of milk production, as a whole, the functional equation form was :

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3}$$

Where,

Y = Total gross income from milk, )

x<sub>1</sub> = Expenditure on human labour, )

All expressed in terms of rupees per hectare.

- $x_2$  = Expenditure on fodder,  
 $x_3$  = Expenditure on concentrates.  
 $a$  = Constant,  
 $b_1, b_2$  and  $b_3$  are regression coefficient of respective variables.

The production function equations were fitted, using least square method of regression for which data were processed with the help of Electronic Computer I.B.M. 1620 available at the Institute of Agricultural Research Statistics, New Delhi. In choosing independent variables for inclusion in the functional equation, in those cases where two independent variables were highly correlated only one of them was retained with a view to eliminate the effect of multy-colinearity. Standard errors of the regression coefficient were examined and only those variables whose coefficient value was higher than its standard error, were choosen for the second and subsequent runs. Three types of production function equations, namely, Linear, Quadratic and Cobb-Douglas were tried. The Cobb-Douglas type of production function was finally preferred because of the higher  $R^2$  values generally obtained in this type of functional equation. The other two forms of functional equations, i.e. Linear and Quadratic, were eliminated from the findings. Most of the Agricultural Economists generally accept the Cobb-Douglas type of production function, partly because of the best fit it provides and also because of the computational ease with this form of algebraic equation and also the additional information regarding returns to scale, which it provides.

Coefficient of multiple determination :

An examination of  $R^2$  for production function equation of farm business, as a whole (crop +milk production combined), indicate

Table IX-1: Elasticity of production, coefficient of multiple determination and returns to scale on sample farms in Jaunpur district during 1973-74.

Intercept in log	Human labour in crop product ion	Bullock labour in crop produc- tion	Seed	Mamures and fertili- zers	Irriga- tion	Human labour in milk produc- tion	Fodder	Concen- trates	R <sup>2</sup>	Returns to scale
<u>Crop + milk production combined:</u>										
0.72804	0.2604 <sup>**</sup> (0.0728)	-	0.16677 <sup>**</sup> (0.0509)	0.55595 <sup>**</sup> (0.1238)	0.53949 <sup>**</sup> (0.1265)	0.13452 <sup>**</sup> (0.0401)	-	0.41362 <sup>*</sup> (0.1546)	0.69057	Increasing
<u>Crop production, as a whole:</u>										
0.6007	0.2292 <sup>**</sup> (0.0712)	-	0.6296 <sup>**</sup> (0.1806)	0.4381 <sup>**</sup> (0.0973)	0.6474 <sup>**</sup> (0.1396)	-	-	-	0.9077	Increasing
<u>Milk production, as a whole:</u>										
0.3272	-	-	-	-	-	0.1987 <sup>*</sup> (0.0912)	0.2988 <sup>*</sup> (0.1134)	0.4987 <sup>**</sup> (.1241)	0.9878	Constant

\*\* Significant at 1.0 per cent level.

\* Significant at 5.0 per cent level.

Figures in brackets show the standard errors of respective values.

that variation in expenditure on human labour in crop production, seed, manures and fertilizers, irrigation, human labour in milk production and concentrates accounted for 69.057 per cent variability in the logarithm of gross farm income from crop + milk production, as a whole. As regards crop production only, as a whole, variations in expenditure on human labour, seed, manures and fertilizers and irrigation accounted for 90.77 per cent of the variability in gross income from crops on sample farms. In regard to milk production, as a whole only, variations in expenditure on human labour, fodder and concentrates accounted for 98.78 per cent of the variation in the farm income from milk production on sample farms.

#### Elasticity of production :

Table IX-1, depicts the elasticity of production along with test of significance and standard errors. The elasticities of production for all the input factors appearing in the production function equations are positive and highly significant. In regard to farm business, as a whole (crop + milk production taken together) the highest significant coefficients are found to be manures and fertilizers followed by irrigation, concentrates and human labour in milk production. In case of crop production only, positive and significant coefficients in descending order of values were those relating to irrigation, seed, manures and fertilizers and human labour. As regard to milk production only, positive and significant coefficients were concentrates, fodder and human labour.

#### Returns to scale :

Increasing returns to scale were noticed in case of farm business, as a whole (crop + milk production combined) as well as

for crop production alone. In case of milk production, constant returns to scale were indicated.

Marginal value products :

Table IX-2, shows the marginal value products of different input factors appearing in the production function equation fitted.

The marginal value products of input factors were estimated at their geometric mean levels by taking partial derivatives of returns with respect to the input concerned.

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} \dots \dots \dots x_n^{b_n}$$

The partial derivatives of return (Y) with respect to the input

$$x_1 \quad \frac{dy}{dx_1} = a b_1 x_1^{b_1-1} x_2^{b_2} \dots \dots \dots x_n^{b_n}$$

The marginal value product of  $x_1$  was then obtained by substituting the corresponding geometric values of  $x_1, x_2 \dots$  in the above equation.

The marginal value products of manures and fertilizers and irrigation were substantially high followed by seed in case of crop production, indicating thereby the possibility of raising income by more intensive use of these input factors. In case of milk production, the marginal value productivities of concentrates and fodder were sufficiently high. It shows the desirability of more intensive feeding of concentrates and fodder to milch animals to have higher returns. A comparison of marginal value products of input factors with their acquisition costs, indicated that the marginal value products of manures and fertilizers, irrigation and seed were significantly higher than their acquisition costs, in cas

Table IX-2: Comparison of marginal value products of input resources with their input costs on sample farms in Jaunpur district during 1973 - 74.

Human labour in crop production	Bullock labour	Seed	Manures & fertilizers	Irrigation	Human labour in milk production	Fodder	Concentrates
<u>Crop + milk production combined.</u>							
0.95 (0.77)	-	2.38 <sup>*</sup> (0.89)	6.13 <sup>**</sup> (2.02)	4.98 <sup>**</sup> (1.57)	0.47 (0.38)	-	2.17 <sup>**</sup> (0.73)
<u>Crop production only</u>							
0.83 (0.54)	-	3.06 <sup>**</sup> (1.01)	5.89 <sup>**</sup> (1.61)	4.37 <sup>**</sup> (1.18)	-	-	-
<u>Milk production only.</u>							
-	-	-	-	-	0.56 (0.48)	1.74 <sup>**</sup> (0.72)	3.41 <sup>**</sup> (1.13)

\*\* Significant at 1.0 per cent level.      \* Significant at 5.0 per cent level.

Note: Factor cost for all the input is Rs. 1.07 for Re. 1.00 investment.

Figures in parentheses denote standard errors of respective marginal value products.

of crop production. In regard to milk production, the marginal value products of concentrates and fodder were significantly higher than their acquisition costs.

Individual crop enterprises :

Similar production function analysis was carried out with important crop enterprises, i.e. maize, paddy (local and high yielding), wheat (local and high yielding) and sugarcane. The details of such analysis are presented in table IX-3.

Coefficient of multiple determination ( $R^2$ ):

The  $R^2$  values, in general, were very high in practically all the crops. In case of maize 95.66 per cent variation in the output values was due to human labour, manures and fertilizers and irrigation. As regard paddy local, 89.05 per cent variation in the output was due to human labour, seed and manures and fertilizers. In case of paddy high yielding, human labour, seed and manures and fertilizers and irrigation accounted for 92.79 per cent variation in the output. Human labour, seed and manures and fertilizers accounted for 83.67 per cent variation in the output of wheat local. As to high yielding variety of wheat, the input factors, namely, human labour, seed, manures and fertilizers and irrigation explained 85.26 per cent variation in the output value of this crop. As regard to sugarcane, human labour, manures and fertilizers and irrigation accounted for 96.57 per cent variation in the value of total output.

Elasticity of production :

The elasticities of production for all the input factors in case of all the crops were positive and significant. The highest elasticity of production was observed in case of manures and

Table IX-3: Elasticity of production and coefficient of multiple determination for important crop equations on sample farms in Jaunpur district during 1973-74.

Crop	Intercept in Log	Human labour	Bullock labour	Cost of seed	Manures & fertilizers	Irrigation	Coefficient of multiple determination $R^2$	Returns to scale
Maize	0.64349	0.4281 <sup>*</sup> (0.2341)	-	-	0.4878 <sup>***</sup> (0.1305)	0.3385 <sup>**</sup> (0.1246)	0.9566	Increasing
Paddy local	5.226	0.6828 <sup>*</sup> (0.3512)	-	0.3378 <sup>**</sup> (0.1102)	0.2131 <sup>***</sup> (0.0632)	-	0.8905	Increasing
Paddy HYV	1.0053	0.1067 <sup>*</sup> (0.0411)	-	0.3157 <sup>**</sup> (0.0913)	0.4543 <sup>***</sup> (0.1145)	0.4239 <sup>**</sup> (0.1233)	0.9279	Increasing
Wheat local	0.63338	0.3315 <sup>*</sup> (0.1634)	-	0.2339 <sup>*</sup> (0.1124)	0.1689 <sup>*x</sup> (0.530)	-	0.8367	Decreasing
Wheat HYV	0.11807	0.3444 <sup>*</sup> (0.1723)	-	0.3114 <sup>**</sup> (0.1032)	0.5327 <sup>**</sup> (0.1624)	0.3042 <sup>**</sup> (0.1003)	0.8526	Increasing
Sugarcane	0.9052	0.6767 <sup>*</sup> (0.3124)	-	-	0.7293 <sup>***x</sup> (0.1444)	0.2813 <sup>**</sup> (0.0873)	0.9657	Increasing

\*\*\* Significant at 10.0 per cent level. \*\* Significant at 5.0 per cent level

\* Significant at 10.0 per cent level.

Figures in brackets show standard errors.

fertilizers for sugarcane while the lowest elasticity of production was noticed for human labour in paddy high yielding. The production elasticities for human labour varied from 0.1067 in paddy high yielding to 0.6826 in case of paddy local. The elasticity of production for seed was highest in paddy high yielding, being 0.3378 and lowest in wheat high yielding, being 0.2339. The production elasticity of manures and fertilizers varied from 0.1689 to 0.7293 in wheat local and sugarcane, respectively. Similarly, the production elasticity of irrigation was highest in case of paddy high yielding, being 0.4239 and lowest, being 0.2813, in case of sugarcane.

#### Returns to scale :

Increasing returns to scale were observed in case of maize, paddy (local and high yielding), wheat high yielding and sugarcane. Wheat local showed decreasing returns to scale.

#### Marginal value products :

Table IX-4, shows the marginal value products of various input factors for different crops. The marginal value products were worked out at their geometric mean levels and were compared with their factor costs.

The analysis of marginal value products reveals that the marginal value products of manures and fertilizers were high in practically all the crops. It was <sup>the</sup> highest in case of wheat high yielding, being 6.78 and <sup>the</sup> lowest in case of paddy local, being 3.23. Similarly, the marginal value products of irrigation were outstandingly high in several crops. It was <sup>the</sup> highest in case of wheat high yielding, being 7.92 and <sup>the</sup> lowest in case of maize, being 3.30.

Table IX-4: Marginal value products of input factors in rupees.

Crop	Human labour	Bullock labour	Seed	Manures and fertilizers	Irrigation
Maize	1.93 (1.0222)	-	-	3.52 <sup>**</sup> (0.5934)	3.30 <sup>**</sup> (0.8123)
Paddy local	2.04 (1.0638)	-	2.83 <sup>*</sup> (0.8102)	3.27 <sup>**</sup> (0.5823)	-
Paddy HYV	1.04 (0.5926)	-	3.96 <sup>**</sup> (0.0123)	5.82 (1.3890)	4.69 <sup>**</sup> (0.7342)
Wheat local	2.07 <sup>*</sup> (0.8321)	-	2.42 <sup>*</sup> (0.3765)	5.83 <sup>**</sup> (1.6589)	-
Wheat HYV	1.87 (0.9621)	-	3.45 <sup>**</sup> (0.5293)	6.78 <sup>**</sup> (1.8495)	7.92 <sup>**</sup> (1.4967)
Sugarcane	3.21 <sup>**</sup> (0.5164)	-	-	6.23 <sup>**</sup> (1.4762)	4.13 <sup>**</sup> (1.0495)

Factor cost for all the inputs is Rs. 1.07 for Re. 1.00 investment.

Figures in parentheses denote standard errors of respective marginal value products.

\*\* Significantly different from the acquisition cost at 1.0 per cent level.

\* Significantly different from the acquisition cost at 5.0 per cent level.

The marginal value products of human labour was observed to be high in sugarcane, being 3.21 followed by wheat local (2.07), paddy (2.04), maize (1.93), wheat high yielding (1.87) and paddy high yielding (1.04). The marginal value products of seed was highest in paddy high yielding, being 3.96 followed by wheat high yielding (3.45), paddy local (2.83) and wheat local (2.42).

The present analysis of marginal value products relative to factor cost clearly reveals that under a situation of general scarcity of working funds, it pays relatively much more for every rupee invested in high yielding varieties of paddy (fertilizer, irrigation and seed), in wheat high yielding (irrigation followed by manures and fertilizers and seed) and in sugarcane manures and fertilizers followed by irrigation.

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