FACTOR PRODUCTIVITY OF CROPS IN JHARKHAND FOR IRRIGATED AND UNIRRIGATED FARMS

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The sharp decelerating growth in the agriculture sector has been a major cause of concern and there is an urgent need to adequately address the issue of sustainability and technological change in the agriculture sector reforms. Use of new technology in agriculture and efficient use of agriculture inputs may increase the total factor productivity of crops.

Keywords : Agriculture, Marginal Value Productivity.

INTRODUCTION

Improved inputs allow the agricultural sector to move along the production surface. The use of modern inputs may also induce an upward shift in the production function to the extent that a technological change is embodied in them. Factor productivity (FP) measures the amount of increase in the total output which is accounted for by increases in the total inputs. It serves as an excellent indicator of the performance of any production system and sustainability of the growth process. It overcomes the limitations of partial input productivity measures as well as partial output productivity especially when the production of one activity affects the production of other activities. Factor productivity concept which implies an index of output per unit of total factor inputs, measures the shifts in output properly, holding all other inputs constant. Thus it measures the amount of increase in the total output that is not accounted for by increases in the total inputs. FP is influenced by changes in technology, institutional reforms, infrastructure development, human resource development and other factors. The crop-related technology changes are often embodied in the seed adoption by the farmer that can be divided into two components: the “quality” and the “quantity”. The former represents productivity improvement and cost reduction, while the latter is the extent of area on which the farmer adopts the technology. The “quality” reflects the research output that is determined by investment in research and is an exogenous variable in explaining TFP. The “quantity” of technology is linked to its adoption and is affected by the extension, literacy, infrastructural development, as well as the on-farm and the off-farm characteristics.

Several studies have highlighted that the factor productivity growth of important crop like rice and wheat in the Indo-Gangetic region is decelerating and the future production growth is input based in many regions of the country (Kumar et.al. 1998), Kumar and Rosegrant, (1994), Kumar and Mruthyunjaya, (1992). Besides, the widespread cultivation of paddy and agricultural intensification resulting from spread of irrigation are observed to have an adverse impact on the natural resources and ecology (Pingali et al. 1997)

OBJECTIVES OF THE STUDY

In the under developed countries and especially in India, it is not enough to only increase the use of inputs to raise agricultural output. The crux of the problem lies in the efficient utilization of resources and the attainment of least cost combinations of inputs. The purpose of this paper is to examine how

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efficiently agricultural inputs are being used by the farmers of the area under study. Besides this, one would be interested to know the specific contribution of a marginal unit of a particular independent variable to the dependent variable, when all other independent variables are held constant at their mean level. In case the specific contribution of a particular marginal unit is lower than its marginal cost, it would be advisable to reduce the use of this particular factor. On the other hand, if the marginal value product (MVP) is higher than marginal cost (MC), the use of this particular input could be increased in the production process. Finally, with the help of a Cobb-Douglas (CD) production function, it could be determined what type of laws of return is operating in the process of production in the farm sector by checking the values of coefficient of various inputs used.

METHODOLOGY

The present study analyses the efficient use of agricultural inputs by sample farmers irrigated (145) and unirrigated (63) of Jharkhand. For this Cobb-Douglas production function is employed for analysis.

The Model

On per farmer basis, to regress the output of all major farm products, the following variables were included and the following double-log (Cobb-Douglas) form of production function was used.

\[
\log Y = \log A + b_1 \log L + b_2 \log S + b_3 \log F + b_4 \log P + b_5 \log I + b_6 \log D + b_7 \log H + U
\]

Where \(Y\) = Total of the money values of all main products and by products. (Since it was not possible to aggregate the physical products, so gross outputs were calculated by converting both the main products and the by products of all major crops into single word value terms by multiplying yields of different crops with their respective market price.)

\(L\) = Land in acres \((X_1)\) / (The land input was measured as acres of land being operated per farm and it consisted of land owned by the cultivator and leased in minus leased out land.)

\(S\) = Seeds in Rs. \((X_2)\)

\(F\) = NPK in Kg. \((X_3)\)

\(P\) = Pesticides in Rs. \((X_4)\)

\(I\) = Irrigation in pump hours \((X_5)\)

\(D\) = Draft power in a pair of bullocks a day (8 hours) in \((X_6)\)

\(H\) = Human labour in labour days (8 hours with one hour recess) in Rs. \((X_7)\) / (The labour input was recorded in terms of workdays of men, women and children employed for different farm operations during the agricultural year under study. Labour was measured in terms of adult man days. The child and woman labour was converted into man labour days by taking 1.5 woman days and 2.0 children days equivalent to one man day.)

\(U\) = Error term, & \(A, b_1, b_2, \ldots, b_7\) = constants,

All the variables taken are on per farm basis, for the production function and has been estimated accordingly. The variables that are not found in use in growing a particular crop have been omitted. For example, irrigation and pesticides in paddy and marua cultivation.

The ordinary least square method has been used to estimate the desired production functions.

Methodology To Compute MP, MVP and Marginal Benefit

The estimated production functions discussed above are in the double log form and hence regression coefficients represent elasticities. To compute MPP, say, of land, i.e., \(MPP_L\), the definition used is
The estimate of $b$ is available from regression coefficients, $Y$ (output) and $L$ do not have unique values and they vary from sample to sample and hence $MPP_L$ is variable. Therefore, the unique value of $MPP_L$ has been computed by using the mean values of $Y$ and $L$:

$$MPP_L = (b) \times (Y/L)$$

where

$Y = \text{Arithmetic mean of } Y$

$L = \text{Arithmetic mean of } L$

$$\partial Y/\partial L = \text{Partial derivative of output with respect to land (b)}^2.$$ 

The $MVP_L$ is computed as follows:

$$MVP_L = (MPP_L)(P_Y)$$

where

$P_y = \text{Price of output (Y)}$

Assuming perfect competition, the marginal cost of land ($MC_L$) is given by its price ($P_L$).

$$MC_L = P_L.$$ 

The marginal benefit of land ($MB_L$) is then given by

$$MB_L = MVP_L - MC_L.$$ 

Similarly the $MPP$, $MVP$, $MC$ and $MB$ of other factor of production (seeds, NPK, pesticides, irrigation, draft power and human labour) could be computed for all crops together.

In the estimation of production functions for all crops together, as $Y$ (output) is taken in money term, $MVP$ of a particular resource represents “the expected addition to the gross returns caused by an addition of one unit of that resource, while other inputs are held constant.” The marginal value productivity ($MVP$) has been calculated by multiplying the regression coefficient of the resource with the ratio of geometric mean of gross return to the geometric mean of the given resource. For example, the $MVP$ of seed has been calculated as follows;

$$MVP (S) = (b) Y (G.M) \div S (G.M)$$

Similarly, $MVP$ of other factors of production is computed for all crops together.

RESULTS AND ANALYSIS

To compute input elasticities of output, inputs’ relative contribution to the growth of farm output and inputs productivity, the production function of all crops taken together for different size groups of farms for farmers of sample irrigated and unirrigated farms has been estimated. The empirical results are discussed crop - wise and for all crops combined.

Production functions on per farm basis for all crops taken together for farmers of irrigated and unirrigated for each size group and at the aggregate level have been estimated.

Economic Efficiency of Resources

To evaluate how efficiently the farmers of the study areas are using the resources, the marginal value productivity of input factor was compared with its respective acquisition price. Then, the ratios of marginal value productivities of different factors to their acquisition prices were calculated. An optimum use of that was indicated if the ratio approached unity. The value of the ratio more than
unity meant that returns could be increased by using more of that resource, and value of MVP less than unity indicates more than optimum use of resource, which could be reduced to minimize losses. Table-1, presents the net regression coefficients for individual input categories along with their respective standard errors. The “t” values have also been calculated and tested for their significance.

**Statistical Significance of the Coefficients**

The results of Cobb - Douglas production function and related statistics show that the coefficients of all the variables turn out to be significant at 5 percent level of significance for farmers of irrigated villages. The coefficients are positive and are highest for land (0.409), followed by seeds (0.175), pesticides and human labour (0.050) pesticides and insecticides (0.050) while it is negative for fertilizers (-0.012), irrigation (-0.055) and bullock labour (-0.198). The value of $R^2$ i.e. coefficient of determination (0.272) indicates that the independent variables that are seeds, fertilizers, pesticides and insecticides, irrigation, draft power and human labour, explained about 27 percent of the variability in gross output.

In case of farmers of unirrigated villages, all the coefficients are significant, though, at different levels of significance. The coefficient (0.161) of land turns out to be significant only at 5 percent level of significance. The coefficient of seeds (-0.243) is negative and significant at 5 percent level of significance. The use of fertilizer too has a negative coefficient to the extent of (-0.202) and it is significant at 5 percent level of significance. The coefficient of irrigation also has a negative value (-0.039). However, draft power and human labour have positive coefficients to the extent of $R^2$ = 0.225; $\bi$ = 4.134; $N$ = 63.

**Table 1, Regression Coefficients under Irrigated and Unirrigated Farms.**

<table>
<thead>
<tr>
<th>Particular</th>
<th>Irrigated Farms</th>
<th></th>
<th>Unirrigated Farms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\bi$</td>
<td>S.E.</td>
<td>$t$</td>
<td>$\bi$</td>
</tr>
<tr>
<td>X1</td>
<td>0.409</td>
<td>0.137713</td>
<td>3.69*</td>
<td>0.161</td>
</tr>
<tr>
<td>X2</td>
<td>0.175</td>
<td>0.05706</td>
<td>3.07*</td>
<td>-0.243</td>
</tr>
<tr>
<td>X3</td>
<td>-0.012</td>
<td>0.108103</td>
<td>0.11**</td>
<td>-0.202</td>
</tr>
<tr>
<td>X4</td>
<td>0.050</td>
<td>0.037436</td>
<td>1.34*</td>
<td>0.128</td>
</tr>
<tr>
<td>X5</td>
<td>-0.055</td>
<td>0.079924</td>
<td>0.69*</td>
<td>-0.039</td>
</tr>
<tr>
<td>X6</td>
<td>-0.1968</td>
<td>0.148842</td>
<td>1.33**</td>
<td>0.432</td>
</tr>
<tr>
<td>X7</td>
<td>0.361</td>
<td>0.152693</td>
<td>0.327*</td>
<td>0.257</td>
</tr>
<tr>
<td>$\bi$</td>
<td>0.730</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$N$ = 145 ;  $R^2$ = 0.272; $\bi$ = 3.724 ;

where

- $\bi$ = Constant in the equation
- $R^2$ = Coefficient of multiple determination
- S.E = Standard Error
- * Significant at 5 percent level of significance
- ** Significant at 10 percent level of significance.
(-0.432) and (0.357) respectively and they are statistically significant at five percent level of significance. The value of $R^2$ (0.225) indicates that independent variables account for about 22 percent of variations in the gross output.

For both types of farms, irrigated and unirrigated, the entire individual regression coefficient computed from the Cobb-Douglas production function is less than one or unity, which indicated the operation of diminishing returns in the agricultural sector of the areas under study. It shows that if one particular input was increased by 100 percent, holding other inputs constant, output would increase but less than 100 percent. For example, if farmers of irrigated villages increase the use of seeds by Re. 1, the output would increase by around 17 paise. The same level of decrease in the use of seed in unirrigated villages increases the output by about 24 paise, as the coefficient is negative. Similarly, coefficients of fertilizers (-0.012) in irrigated villages and (-0.202) in unirrigated villages shows that farmers of both types of villages should reduce the use of this input in order to reduce the level of loss. Comparing the coefficients of bullock labour for farmers of irrigated and unirrigated villages, it is evident that it is negative (0.198) in the former case which indicates that the farmers of these villages have used more than the required amount of bullock labour on their fields. However, the coefficient of bullocks' labour for farmers of unirrigated villages is positive to the extent of (0.532) which indicates that the use of this particular factor in these villages could be increased and by doing so, farmers could increase their level of incomes. One possible explanation for the coefficient of draft power being negative in irrigated villages could be that farmers of these villages might have incurred more expenses by hiring tractors for this operation.

It is pertinent to note that chemical fertilizers, pesticides and insecticides, considered to be harmful for human beings, are being used more than two required amount by the farmers of both irrigated and unirrigated villages and hence, their uses are to be discouraged to the desired level.

The coefficient of human labour (0.361) is higher in case of farmers of irrigated villages than that of unirrigated villages (0.257) which indicates that the potentiality of increasing labour employment is higher in new farm technology than that in traditional farm technology.

**Geometric Means and Marginal Value Productivities of Farm Resources**

Geometric means (GM) of gross output and factor inputs have been calculated to know the average use of inputs and the resultant output per farm. The marginal value productivities have also been calculated based on production elasticities obtained from Cobb-Douglas production function for various inputs. Table - 2 gives the data concerning geometric means and marginal value productivities of various inputs used by the farmers in the farm sector.

It may be seen from Table. 2 that geometric means of all the farm inputs for farmers of irrigated villages are higher than that of farmers of unirrigated villages. It shows that the introduction of new farm technology has increased the use of farm inputs substantially. The geometric mean of gross output per farm is considerably higher (25700.00) in irrigated villages than those of unirrigated villages (7845.79). Similarly marginal value productivities of land, seeds, pesticides and human labour are higher in case of farms of irrigated villages. The marginal contribution of land in case of farms of irrigated villages is (Rs. 12776.96) whereas it is only (Rs. 2510.00) per farmer in unirrigated villages. The marginal return of seeds is (Rs. 2.78) for farmers of irrigated villages while for unirrigated farmers it is (Rs. 0.22) only. The marginal value productivity of labour for farmers of irrigated villages is (Rs. 13.13) whereas it is (Rs. 6.46) only for farmers of unirrigated villages. On the contrary, MVP$_S$ of fertilizers, irrigation and draft power are found to be negative in irrigated villages. However, in unirrigated villages MVP$_S$ are calculated to be positive for all the factor inputs used by the farmers.
in farm operations. Thus, farmers of irrigated villages should reduce the expenses incurred by them on the use of fertilizers, irrigation and draft power in order to increase their profitability from farm business. It can be observed from the table that MVP of human labour is almost double (Rs. 13.13) for farmers of irrigated villages than that of farmers of unirrigated villages (6.46). This means that the farmers of irrigated villages could increase their income by (Rs. 13.13) by investing Re. 1 in hiring farm labourers, while their counterparts in unirrigated villages could enhance their income by (Rs. 6.46) by investing the same amount in this particular farm input. Thus, the new farm technology has much larger potential of increasing the productivity of rural labour force engaged in the agricultural sector.

**Efficiency of Farm Inputs**

As explained in the methodology section, the economic efficiency of farmers as users of resources is measured by comparing MVP\textsubscript{S} with their acquisition costs. The ratio of MVP\textsubscript{S} to their factor cost are given in Table - 3.

From Table - 3, it can be observed that the ratios of MVP\textsubscript{S} of land to its factor costs are 2.49 for farmers of irrigated villages and 1.60 for farmers of unirrigated villages. This shows that land as a farm input could be further used remuneratively by the farmers of both irrigated and unirrigated villages until the ratio becomes equal to unity. Similarly, farmers of irrigated villages could use more of seeds on their farms as the ratio of MVP to the acquisition price of seeds is 2.78. On the contrary, farmers of unirrigated villages should reduce the expenses made on the purchase and use of seeds as in their cases MVP is negative to the extent of (Rs. -4.35). The farmers of unirrigated villages are required to cut expenses on the use of fertilizers because in their cases MVP is calculated to be negative to the extent of (Rs. -0.10). On the other hand, farmers of unirrigated villages could increase the use of fertilizers and by spending Re.1; they could increase their income by (Rs. 3.44). As regards draft power, farmers of irrigated villages are to reduce its use on their fields because for them it is negative (Rs. -9.05) whereas farmers of unirrigated villages could gain up to (Rs. 1.82) by making an extra expenditure of Re. 1 on this factor input. The negative ratio concerning bullock labour in irrigated villages indicates that these farms had made much more than optimum use of this

<table>
<thead>
<tr>
<th>Variables</th>
<th>Irrigated Farms</th>
<th>Unirrigated Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G.M.</td>
<td>MVP\textsubscript{S}</td>
</tr>
<tr>
<td>12 3 4 5</td>
<td>25700.00 - 7845.79</td>
<td>2.63 12776.96 1.61 2510.00</td>
</tr>
<tr>
<td>Land (acres)</td>
<td>47.4 -0.78</td>
<td>81.28 16.27 3.89 8.13</td>
</tr>
<tr>
<td>Irrigation (Pump hours)</td>
<td>17.38 -3.33</td>
<td>11.75 -8.87 7.59 53.70</td>
</tr>
<tr>
<td>Pesticides (Rs.)</td>
<td>100.00 13.13</td>
<td>69.18 6.46</td>
</tr>
<tr>
<td>Human Labour (L. Days)</td>
<td>100.00 13.13</td>
<td>69.18 6.46</td>
</tr>
</tbody>
</table>
factor in their farms. There could be a plausible explanation of the negative contribution or excess use of bullock power by the farmers of irrigated villages. Mechanization has changed the mode of preparation and sowing operations. In order to save time between two crops, the farmers often prefer to use tractors for these operations. The greater use of bullock labour on some of the farms may be responsible for the negative elasticity of bullock labour.

Table 4, Regression Coefficient of Factor Inputs in C - D Production Function and Returns to Scale

<table>
<thead>
<tr>
<th>Type of Farms</th>
<th>Sum of regression Coefficient</th>
<th>Returns to scale by “t”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irrigated Farms</td>
<td>0.830</td>
<td>Diminishing</td>
</tr>
<tr>
<td>Unirrigated Farms</td>
<td>0.594</td>
<td>Diminishing</td>
</tr>
</tbody>
</table>

Return to Scale

The regression coefficients of different factor inputs determined in the production of Cobb - Douglas type structure could also be used to estimate the returns to scale. The scale increase remain constant or decreasing accordingly as the sum of the regression coefficients is greater than one, equal to or less than unity respectively. Table 4 gives the sum of regression coefficients of major factor inputs used by the farmers of irrigated and unirrigated villages of the study areas.

The sum of the regression coefficient was tested for their deviation from unity. The “t” test indicated diminishing returns to scale for farmers of irrigated and unirrigated villages.

CONCLUSIONS

On the basis of the above study, we may conclude that new farm technology has remarkably enhanced the productivities of most of the factor inputs used by farmers who have adopted it. The enhancement in the productivity of labour is more noticeable in irrigated villages where farmers have adopted new farm practices. However, the negative marginal value productivity of fertilizer in irrigated villages shows that a heavy reliance on this input for raising farm output has driven the farmers to use it even beyond the desired level and this is definitely not beneficial from the economic point of view. The undue reliance on fertilizers to increase farm productivity is unlikely to achieve its objective.
In case of farmers of unirrigated villages, there is much scope to increase the use of almost all factor inputs to raise the level of farm productivity as all the inputs’ coefficient are found to be positive. Hence, farmers of unirrigated villages could also raise their incomes by making more intensive use of their farm resources.

In the post green revolution era, a greater investment on research and development is necessary in agriculture. The promotion of HYV seeds, fertilizers, irrigation technology had a high pay off and provided rapid strides in the progress of food production. However, in recent years we have been confronted with diminishing returns to technological change because a large number of districts have been facing stagnation in agriculture growth. If the sustainability issue of the crop sector is not properly addressed it may adversely affect the economic growth and household food security. So, it is necessary that agricultural inputs are efficiently used by the farmers of Jharkhand to get a better remunerative price for their output.

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