Do adoption of improved agricultural practises reduces production costs? empirical evidence from Bundelkhand region of Uttar Pradesh

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Abstract

The present study assessed the effect of improved agricultural technologies disseminated under the ambitious Farmer FIRST Programme (FFP) on production costs of major crops in Bundelkhand region of Uttar Pradesh. The findings show that the average real cost during the period 2017-18 to 2020-21 declined leading to increase in net return to cost ratio from farming. Technological interventions at farmer’s field resulted in gradual decline in share of seed, fertilizer and plant protection chemicals in cost of cultivation. The price elasticities of factors, estimated by fitting translog function, suggests that polices for controlling input price inflation, particularly wage rate, will be imperative in reducing cost of farming. The results on elasticity of technical substitution between labour and machinery highlights the need for devising suitable farm mechanization strategies which may be affordable too in small farm situation. The panel data estimate of negative cost elasticity of yield indicates that productivity growth plays vital role in absorbing increase in production cost.

Key words: Technological interventions, FFP, production cost, Bundelkhand

Introduction

Indian economy is growing with sound pace and so is the use of technology in the growing sectors of the country. Nonetheless, the share of agriculture in the country’s economy has gradually declined to less than 15% due to the high growth rates of the secondary and tertiary sectors, the importance of agriculture in India’s economic and social fabric goes well beyond this indicator. A major mass of the Indian population is still dependent and practicing agriculture as their primary source of income.

Indian agricultural policies have been in a continuous tryst with its farming infrastructure, improved agricultural practices and socio-economic upliftment of farming communities since
independence. Despite spectacular rise in agricultural production over the years, the farming communities in India continued to languish in poverty\(^1\). The economic unviability of crop production sector, particularly for small and marginal farmers, over the years is leading to agrarian crisis and can have a detrimental effect on the future of agriculture in the country\(^2\).

In India, agricultural development through improved technological interventions has been spread over time and regions. There is a galore of literature on capturing impact of improved agricultural technologies through various outcome indicators like production, productivity, cropping intensity, farm income, etc. However, assessment of impact on cost of farming assumes a significant importance, because rising production cost has become one of the underlying reasons of farm distress, particularly in largely cultivated rainfed areas. It is also important to ascertain the impact of promoted technologies on the change in level of input-use and its effect on cultivation cost. Such assessment is useful in devising suitable strategies for controlling the rising production cost in agriculture.

Srivastava et al (2017)\(^3\) using secondary data made an explicit attempt in analysing changes in production cost at national level; however field level evidence of changing cost after technological interventions has been poorly explored. Moreover, for a vast and agro-climatically diverse country like India, covering all the 500+ districts in a single study conceals the crucial regional dimensions for policy planning\(^4\).

The present study therefore, using the example of the Farmer FIRST (Farm, Innovations, Resources, Science and Technology) programme (FFP)\(^1\) aims to examines changes in real cost of crop cultivation of the beneficiaries. Under the FFP project, a broad set of technologies and cultivation practices (Table 1) like improved variety of crops, line sowing of

\(^1\) The Farmer FIRST Programme (FFP) was launched by Indian Council of Agricultural Research (ICAR), New Delhi in the year 2016 to promote farmer-participatory location-specific technology application for sustainable agriculture and livelihood security.
seed, optimum irrigation at critical stages, balanced use of fertilizers, use of biorationals were promoted among farmers making it an ideal context for an investigation of impact analysis of technologival interventions. The paper also investigates the effects of factor prices, factor substitution and technological interventions on production cost by estimating price elasticity of input use, elasticity of factor substitution and yield elasticity of cost in selected crops, respectively.

Material and methods

Study area and sampling

The analyses are based on primary survey data collected from Jhansi district of Bundelkhand region of Uttar Pradesh. Bundelkhand falls in semi-arid tropics and majority of the population in the region is dependent on crop/livestock-based activities and around one-third of the geographical area is covered by degraded forests, permanent pastures, fallows and wastelands. The prevalent undulating topography, hard rock geology, low soil fertility, scarce groundwater resources along with poor and erratic rainfall lead to frequent droughts and crop failure in the region.

The district Jhansi receives average annual rainfall of around 880 mm of which kharif season (June-September) has around 90% of the annual precipitation and the remaining 10% is distributed throughout the remaining eight months. The study used both purposive and random sampling approach for drawing sampled respondents. The first stage of the sampling approach involved purposively selecting five villages namely; Pali, Palinda, Datanagar, Dhimarpura and Parbai (hereafter called treated villages) as all the project activities were focussed within the physical boundary of these villages. The second stage involved randomly selecting farm households within the physical boundary of these villages. Household heads were stratified based on land size category in each village and then probability proportional to size method was used to draw sample households from each village. With the help of a well-
structured and pretested interview schedule, the data on production and cost of cultivation of four major crops of the study area namely wheat, groundnut, black gram and green gram were collected for the period 2017-18 to 2020-21.

**Empirical framework**

The changes in average cost and return from crop cultivation were examined by expressing them in real terms using Consumer Price Index for Agricultural Labour (CPI_AL). Transcendental logarithmic (translog) cost function was fitted to estimate the effect of price elasticity of factor demand and elasticity of technical substitution between factors (labour and machine) on cost of cultivation of the selected crops. The functional form of the function can be given as:

\[
\ln C = a_0 + \sum_{i=1}^{N} a_i \ln z_i + a_y \ln y + \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_{ij} \ln z_i \ln z_j + \sum_{i=1}^{N} a_{iy} \ln y + \frac{1}{2} a_{yy} \ln y \ln y
\]

The function takes \( z \) and \( y \) as its regressors and returns minimum cost \( (C) \). The total number of factors considered is indicated by \( N \), \( z \) is a vector of factor prices, \( y \) indicates level of production and the \( a \)'s are the parameters of the function.

The elasticities of substitution can be calculated by

\[
\sigma_{ii} = \frac{a_i + S_i^2 - S_i}{S_i^2}
\]

\[
\sigma_{ij} = \frac{a_{ij} + S_i S_j}{S_i S_j} \quad i \neq j
\]

The price elasticities can be calculated by

\[
\eta_{ij} = \sigma_{ij} S_j
\]

Seed, fertilizer, machinery, irrigation and labour were the inputs considered in empirical analysis. The model consisted of four share equations each for the factors except irrigation. The coefficient of ‘irrigation’ was estimated using homogeneity constraint in the model.\(^7\)
The effect of improved technological interventions gets manifested in crop yield. The relation between crop yield and production cost is indicative of the impact of the promoted technologies on cost of production. However, cost of production is also influenced by factor prices. Therefore, cost response model was constructed and yield elasticity of production cost for the selected crops by fitting log-linear panel cost functions for the period 2017-18 to 2020-21 was estimated. The model takes the functional form as

\[
\log(C_{pkit}) = \beta_0 + \beta_1 \log(P_{Seed})_{ikt} + \beta_2 \log(P_{Fertilizer})_{ikt} + \beta_3 \log(P_{Machinery})_{ikt} \\
+ \beta_4 \log(P_{Irrigation})_{ikt} + \beta_5 \log(P_{Labour})_{ikt} + \epsilon_{ikt}
\]

Where, \( C_{pkit} \) is production cost (Rs./q) of \( k^{th} \) crop of \( i^{th} \) farmer in \( t^{th} \) year. \( P_{Seed}, P_{Fertilizer}, P_{Machinery}, P_{Irrigation} \) and \( P_{Labour} \) represents unit prices of the factors, respectively. \( \beta_s \) are the time-invariant coefficient and \( \epsilon \) is random error term.

Hausman test \(^8,^9,^{10}\) inferred that the fixed effects model was more consistent than random effects model. In order to control the effects of unobserved cross-sectional variables and to capture year effects, the regression equation was estimated with two way fixed effects models, i.e. cross-section and period fixed effects specifications.

**Results and Discussion**

**Cost of cultivation and returns from farming**

Figure 1 depicts the changes in average cost of cultivation and returns from the selected crops in the study area over the period. The declining trend is real cost is encouraging and is indicative of rational use of inputs by the farmers in crop cultivation. Decrease in cost is further accompanied by increase in real returns that implies productivity gains by the farmers
in the treated villages. A slight dip in returns in the year 2019-20 was primarily attributed to untimely rains during maturity period of the *kharif* crops that caused substantial yield loss.

**Changes in factor share in Cost of Cultivation**

Figure 2 depicts changes in share of inputs in the average real cost over the period of time. Evidently, the share of labour dominated the total cost of cultivation in all the years, however a gradual shift from labour to machinery can be observed. The declining share of seed, fertilizer and plant protection is as per our expectation because ensuring use of improved varieties, line sowing and balance use of fertilizers by the farmers were among major agronomic interventions under the FFP in the treated villages. Adoption of biorational control measures for pests, diseases and weeds declined the share of plant protection chemicals by 3 per cent.

**Price elasticity and factor substitution**

Actual use of inputs also gets influenced by their respective prices. Such effects can be predicted from the price elasticity of inputs used in the crop cultivation. Table 2 presents the estimated price elasticities of inputs. Unsurprisingly, the average estimated price elasticities varied across the inputs used and the crops taken into consideration. The negative and less than one value of the estimated elasticities indicate that the demand of inputs was price inelastic. This implies that increase in prices of the factors would lead to less than proportionate decline in their use. Therefore, rising input prices will accentuate cost of cultivation of crops. In the present study, decline in the average cost of farming over the years clearly reflects substantial decrees in input use by the farmers and this reduction in factor use is mainly attributed to their rational use by the farmers. Price inelasticity of factors also indicates that polices for controlling input price inflation will be imperative in reducing cost of cultivation of crops.
It is important to note that, labour, which has highest share in the average cost of cultivation (Fig 2), exhibited the lowest price elasticity among all the inputs in all the crops. This result is in congruence with the findings of Srivastava et al. (2017)\(^3\) and suggests that labour use management in crop farming will dampen the production cost to a large extent. Similarly, crop production with rational use of seed will result in cost saving for the farmers. Therefore, agronomic practices like use of recommended seed rate and line sowing should be strategically promoted among the farmers for economizing production at macro scale. The price elasticity values for machinery indicate that cost reducing effect of machine would be lowest among all the inputs.

Factor substitution between technically feasible inputs like labour and machinery is another well acknowledged way of cost control. For example, if relative prices of labour (wage rate) in comparison to machine increases, farmer will prefer use of machine for various farm operations. In our analysis, the elasticity of technical substitution between labour and machinery was though positive but less than unity (Table 3) indicating that the two factors are inelastic substitutes of each other. In other words, it is technically not feasible to replace all labour operations of farms with machine. The inelastic substitution between labour and machine along with inelastic demand for labour appropriately explains why the share of labour in cost of cultivation has increased over the years in the study area.

Inelastic substitution between the two factors signifies lack of efficient labour-saving farm machinery as well as its suitability and accessibility among the farmers. Therefore, efforts are warranted for developing suitable farm efficient machinery. Easing credit availability and promoting institutional innovations like custom hiring centres would be imperative in improving economic access of machinery in farm operations.

**Effect of technological interventions on cost of farming**
Impact analysis of technological interventions on cost of cultivation was based on the assumption that adoption of improved promoted technologies by the farmers gets manifested in the yield of the crops. The econometric analysis supports the postulated inverse relationship between yield and outcome variable i.e. production cost. The negative cost elasticity of yield indicates that yield enhancement through technological interventions offers an opportunity to absorb the rising cost of production of crops. The less than unity value of yield coefficients shows that increase in yield resulted in less than the proportionate decrease (0.33 to 0.71 %) in production cost. The yield effect on reducing cost was highest in the case of wheat but quite weak in the case of black gram.

Conclusions

Accentuating cost of production in Indian agriculture is one among major sources of agrarian distress. Ensuring respectable income in farm sector needs adequate attention in devising and promoting cost saving strategies at farmer’s field. The findings from the present study indicate that sensitizing farmers for rational use of inputs and adopting improved agricultural practises can have encouraging effect on production cost of crops. Further, human labour management in farm operations would be more imperative for substantial reduction in the crop budget of the farmers. Therefore, efficient and appropriate farm mechanization needs to be promoted. One of the possible ways forward in this direction is institutional innovation in providing farm mechanization to farmers based on custom hiring and Uberization models that make farm machinery and equipment available as a service to farmers of all farm categories at the doorstep at affordable cost on a ‘pay per use’ basis. Further, as the possibility of a perfect substitution between labour and machine in Indian context is hardly possible, therefore efforts for bolstering crop productivity would be crucial to counter the rise in cost of production. The estimated negative cost elasticity of yield in the present study strongly supports this argument. Therefore, efforts towards accelerate seed replacement rate,
revitalising the seed chain with focus on replacing varieties older than ten years by new ones and incentivise public sector and facilitate private sector to raise quality seed production to generate adequate supply will be crucial in accentuating crop output in unit time and space. Additionally farmers must be encouraged to follow recommended agronomic practises and to better calibrate the balance as well as level across different input uses.

The kind of rigorous econometric analyses used in this study is crucial for understanding the actual field-level impacts of various sets of improved agriculture technologies and practices on production cost and net returns from farming. The evidence from Bundelkhand region, with its typical agro-ecological conditions, can offer important lessons for the promotion of improved technological interventions for reducing production cost in semi-arid regions around the world which face similar challenges like Bundelkhand.

References


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Table 1: Technological interventions under the farmer FIRST programme

<table>
<thead>
<tr>
<th>SI no.</th>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crop varieties</td>
<td>Wheat (RAJ-4179), Blackgram (Shekhar-2), Greengram (PDM-139 (Samrat)) and Groundnut (GG-2)</td>
</tr>
<tr>
<td>2</td>
<td>Cultivation practices</td>
<td>Summer ploughing, FYM application, soil test based micronutrient application (ZnSO₄ at 20-25 kg ha⁻¹), line sowing, seed rate, Irrigation on critical crop stages, integrated weed management practices</td>
</tr>
<tr>
<td>3.</td>
<td>Farm machinery</td>
<td>Seed drill, groundnut decorticator, power operated thresher cum grader.</td>
</tr>
<tr>
<td>4.</td>
<td>Plant protection measures</td>
<td>Seed treatment with fungicides and biofertilizers, use of biorational</td>
</tr>
</tbody>
</table>
Table 2: Price elasticity of inputs used in crop production

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Black Gram</th>
<th>Green Gram</th>
<th>Ground Nut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>-0.23</td>
<td>-0.18</td>
<td>-0.19</td>
<td>-0.21</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>-0.36</td>
<td>-0.35</td>
<td>-0.31</td>
<td>-0.33</td>
</tr>
<tr>
<td>Machinery</td>
<td>-0.47</td>
<td>-0.41</td>
<td>-0.44</td>
<td>-0.69</td>
</tr>
<tr>
<td>Irrigation</td>
<td>-0.39</td>
<td>-0.27</td>
<td>-0.33</td>
<td>-0.09</td>
</tr>
<tr>
<td>labour</td>
<td>-0.21</td>
<td>-0.19</td>
<td>-0.17</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

Source: Author’s estimate based on field data
Table 3: Elasticity of substitution between labour and machine use in the selected crops

<table>
<thead>
<tr>
<th>Crops</th>
<th>Wheat</th>
<th>Black Gram</th>
<th>Green Gram</th>
<th>Ground Nut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elasticity of substitution</td>
<td>0.67</td>
<td>0.53</td>
<td>0.56</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Source: Author’s estimate based on field data
Table 4: Regression estimates of log-linear cost function for different crops

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Black Gram</th>
<th>Green Gram</th>
<th>Ground Nut</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(Yield)</td>
<td>-0.712*</td>
<td>-0.336*</td>
<td>-0.424*</td>
<td>-0.632*</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.032)</td>
<td>(0.026)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>log(Seed prices)</td>
<td>0.113**</td>
<td>0.256**</td>
<td>0.224*</td>
<td>0.327*</td>
</tr>
<tr>
<td></td>
<td>(0.051)</td>
<td>(0.123)</td>
<td>(0.013)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>log(Fertiliser prices)</td>
<td>0.256*</td>
<td>0.033</td>
<td>0.029</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.152)</td>
<td>(0.031)</td>
<td>(0.037)</td>
</tr>
<tr>
<td>log(Labour wages)</td>
<td>0.121*</td>
<td>0.241*</td>
<td>0.483**</td>
<td>0.386*</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.003)</td>
<td>(0.235)</td>
<td>(0.080)</td>
</tr>
<tr>
<td>log(Machine prices)</td>
<td>0.102*</td>
<td>0.111**</td>
<td>0.149</td>
<td>0.172*</td>
</tr>
<tr>
<td></td>
<td>0.171</td>
<td>(0.049)</td>
<td>(0.081)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>log (Irrigation rate)</td>
<td>0.131</td>
<td>0.012</td>
<td>0.007</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>0.037</td>
<td>(0.023)</td>
<td>(0.011)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>Intercept</td>
<td>6.325*</td>
<td>5.441*</td>
<td>3.233*</td>
<td>4.671*</td>
</tr>
<tr>
<td></td>
<td>(0.334)</td>
<td>(0.423)</td>
<td>(0.782)</td>
<td>(0.782)</td>
</tr>
<tr>
<td>Cross section: Chai square</td>
<td>127.89*</td>
<td>134.77*</td>
<td>129.41*</td>
<td>127.41*</td>
</tr>
<tr>
<td>Observations</td>
<td>516</td>
<td>346</td>
<td>424</td>
<td>364</td>
</tr>
</tbody>
</table>

Source: Author’s estimate based on field data
Figures in parentheses shows standard error
*Significant at 1%, **significant at 5%
Figure 1: Changes in average cost of cultivation and returns at constant price

Figure 2: Changing share of inputs in cost of cultivation of major crops in the study area
Figure 1: Changes in average cost of cultivation and returns at constant price

Source: Author’s estimate based on field data
Figure 2: Changing share of inputs in cost of cultivation of major crops in the study area

*Others include farm yard manure, depreciation, interest on working capital and miscellaneous expenses on other inputs