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Research Paper

Technical Efficiency of Wheat Production in Major Wheat Producing States of India: A Data Envelopment Analysis (DEA)

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ABSTRACT

This study was conducted to estimate the technical efficiency of wheat production in major wheat-producing states of India using secondary data for the period 2000-01 to 2016-17. The area of study comprised those states which covered more than 80 per cent of wheat production in India, i.e., Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, and Haryana. Data Envelopment Analysis (DEA) was used to estimate the state-specific technical efficiency in wheat production. The results showed that the technical efficiency in wheat production increased over time The correlation coefficient between mean technical efficiency and growth rate of yield was strongly positive and highly significant, revealing that the higher technical efficiency was directly reflected in higher yield from wheat cultivation.

HIGHLIGHTS

- The technical efficiency in wheat production was increased over time and the higher technical efficiency was directly reflected in higher yield from wheat cultivation.
- Higher change in technical efficiency over time was observed in Madhya Pradesh, followed by Uttar Pradesh, Haryana, Rajasthan and Punjab.

Keywords: Data Envelopment Analysis (DEA), technological development, technical efficiency, wheat yield

Wheat is one of the most popular cereal crops among vegetarians and non-vegetarians (Sahu *et al*. 2020). It is a good source of carbohydrates, energy and has no fat. It also contains vitamins and minerals, i.e., thiamine, niacin, iron, riboflavin, vitamin D, calcium, and fiber (Singh and Supriya, 2017). India is the second-largest producer of wheat globally, stands first in the wheat area with the share of 12.2 per cent and in terms of production, it occupies the second position next to China with an 11.5 per cent share (Food and Agriculture Organization, 2019). In India, wheat is grown all over the country, with an area of 29.3 million hectares, production of 103.5 million tonnes and the productivity of 3533 kg ha^{-1} during 2018-19 (Sahu, 2021).

The measurement of technical efficiency in agricultural production is an important issue for agricultural development. It gives useful information for making the relevant decision to use scarce resources and reformulating appropriate agricultural policies. Technical efficiency refers to the ability of the firm to produce the maximum output from its available resources. Measures of technical efficiency would indicate the potential gains in output if inefficiencies in production were eliminated.

Generally, relative efficiency is estimated using

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two common methods. These are the parametric or stochastic frontier analysis (SFA) and the non-parametric or data envelopment analysis (DEA). Stochastic frontier analysis has been used by many researchers like Goyal and Suhag (2003) for estimation of TE on wheat farms in northern India; Dhehibi *et al*. (2012) for estimation of TE of wheat production in Tunisia; and Asodiya *et al*. (2014) used for estimating resource use efficiency of wheat in south Gujarat. However, the DEA approach has recently been popularized in the estimation of efficiency in agriculture. Few of such studies are Murthy *et al.* (2009) employed DEA to study the TE and SE of tomato farmers in Karnataka, India; Ogunniyi and Oladejo (2011) used DEA methodology in the estimation of TE in Tomato production in Nigeria; Toma *et al.* (2015) employed DEA for the assessment of agriculture efficiency on areas with similar geographically patterns, Mukhtar *et al*. (2018) used DEA for technical efficiency of smallholder pearl millet farmers in Kano State, Nigeria. Pandey *et al.* (2020) used DEA to analyze farm efficiency of KVK adopted and non-adopted farmers in Janjgir district of Chhattisgarh.

The measurement of technical efficiency in agricultural production is an important issue for agricultural development. It gives useful information for making the relevant decision to use scarce resources and reformulating appropriate agricultural policies. Technical efficiency is the ability of the firm to produce the maximum output from its available resources. Measures of technical efficiency give an indication of the potential gains in output if inefficiencies in production were to be eliminated Therefore, the present study was undertaken with the following specific objective:

1. To analyze the technical efficiency of wheat production in major wheat-producing states of India.

METHODOLOGY

The study was based on secondary data collected from the Directorate of Economics & Statistics for the period 2000-01 to 2016-17 for the states of Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, and Haryana. Statistical tools like relative change, correlation coefficient, and growth in technical efficiency using Data Envelopment Analysis (DEA) were used to analyze the data.

Relative change: This explains comparative change among wheat production components, while absolute change does not explain these changes.

a) Relative change (%) = $\frac{\text{Current year–Base year}}{\text{Base Year}} \times 100$

Where, Base year was 2000-01 & Current year was 2016-17

b) Simple growth rate (%) = $\frac{b}{\bar{y}} \times 100$

where, b = regression coefficient

$\bar{y}$ = mean of Y

c) Correlation coefficient

$$r = \frac{\Sigma\left(X - \bar{X}\right)\left(Y - \bar{Y}\right)}{\sqrt{\Sigma\left(X - \bar{X}\right)^2 \Sigma\left(Y - \bar{Y}\right)^2}}$$

Where r = Correlation coefficient

X = Values of the x-variable

$\overline{X}$ = Mean of the x-variable

Y = Values of the y-variable

$\overline{Y}$ = Mean of the y-variable

Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) was the method used in the present study to analyze technical efficiency with the help of R software (Dakpo *et. al.* 2018). This was a non-parametric approach for the measurement of efficiency and does not assume production function as stochastic frontier analysis creates. DEA consists of preparing an efficient frontier in order to compare the inputs and outputs of the DMUs. In the terminology of DEA, a farm is a decision-making unit (DMU). Farrell (1957) reported that a firm's efficiency had three components: technical, allocative and economic. Technical efficiency (TE) is defined as ability of a firm to produce a given level of output with a minimum quantity of inputs or the minimum amounts of inputs to produce a given output level under certain technology (Coelli *et al.* 1998; Toma *et al.* 2015; Mahmudah *et al.* 2018).

$$TE_n = \min_{\lambda,\theta_n} \theta_n$$

$$s.t.$$

$$\sum_i^I \lambda_i X_{ij} - \theta_n X_{nj} \leq 0$$

$$\sum_i^I \lambda_i Y_{ik} - Y_{nk} \geq 0$$

$$\sum_i^I \lambda_i = 1$$

$$\lambda_i \geq 1$$

Where,

Subscript *i*, *j* and *k* are used for i^{th} states, j^{th} input and k^{th} output. The symbol *X* denotes input while Y denotes output. λ_i is the non-negative weight associated with i^{th} states. When it set equal to one, then variable return to scale (VRS) prevails, and when this constraint is omitted, then constant returns to scale (CRS) prevails. Similar method used by Pandey *et al.* (2020).

*[**Note**: The base year's technical efficiency is considered 100, so that the clear-cut comparison of the increase in TE can be made.]*

RESULTS AND DISCUSSION

Change and growth of technical efficiency in wheat production

The data presented in Table 1 showed that technical efficiency increased from the base year to the current year during the study period for all the wheat-producing states under study. The highest increase in efficiency was recorded for Madhya Pradesh, which was increased from 100.00 to 125.56 per cent, followed by Uttar Pradesh from 100.00 to 122.01 per cent, Haryana from 100.00 to 114.37 per cent, Rajasthan from 100.00 to 112.49 per cent and least for Punjab from 100.00 to 106.73 per cent. A similar pattern was noticed in the relative change of efficiency. The highest change was recorded for Madhya Pradesh with 25.56 per cent and the lowest in Punjab with 6.73 per cent. On the other hand, the overall growth rate of TE was highest for Uttar Pradesh (0.52%) followed by Punjab (0.42%),

Table 1: Technical efficiency of wheat production in major wheat growing states of India

Particulars	Haryana	Madhya Pradesh	Punjab	Rajasthan	Uttar Pradesh
Base Year	100.00	100.00	100.00	100.00	100.00
Current Year	114.37	125.56	106.73	112.49	122.01
Relative Change (%)	14.37	25.56	06.73	12.49	22.01
Growth Rate (%)	0.36	0.20	0.42	-0.06	0.52

Source: *Author's calculation based on data from DES, 2016-17.*

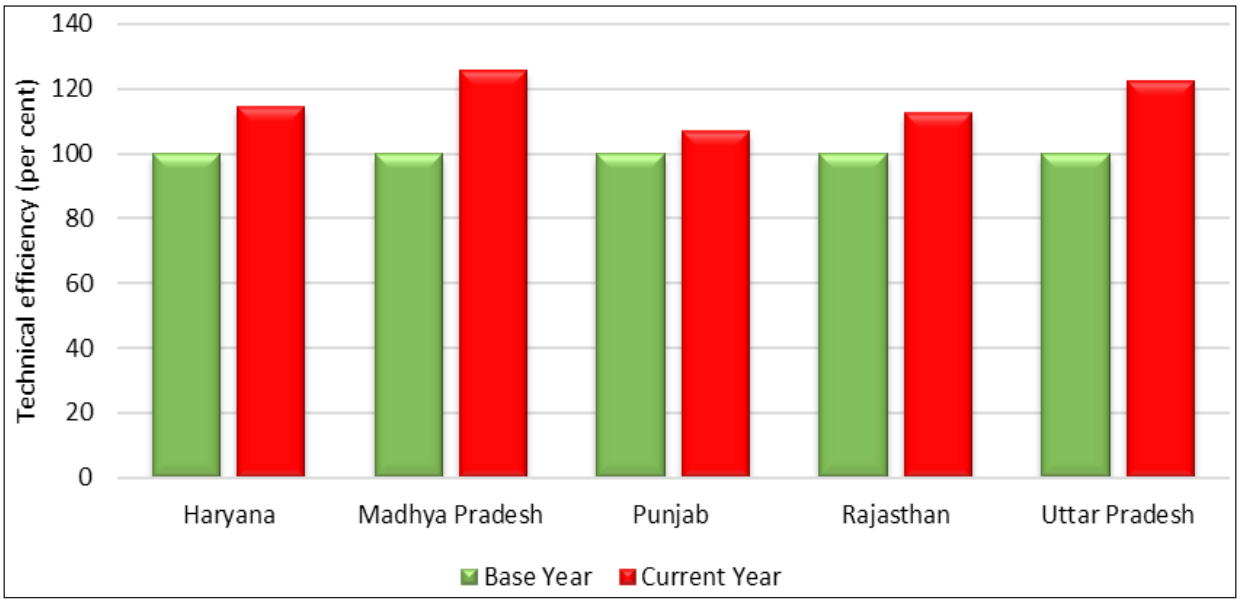

Fig. 1: Technical efficiency of wheat production across major wheat-producing states of India

Table 2: Association between average technical efficiency and growth in yield of the wheat crop for major wheat-producing states of India

States	Average Technical Efficiency (ATE)	Growth Rate of Yield (GRY)	Correlation between ATE & GRY
Haryana	100.54	00.87*	
Madhya Pradesh	104.08	04.48**	
Punjab	100.22	00.64	0.98**
Rajasthan	101.96	01.59**	
Uttar Pradesh	100.72	00.66	

** *Significant at 1% level, * Significant at 5 % level*

Source: *Author's calculation based upon data from DES, 2016-17.*

Haryana (0.36%), Madhya Pradesh (0.20%) and least with a negative growth rate in Rajasthan (-0.06%).

The above result revealed that the technical efficiency in wheat production increased over time. It may be due to some factors i.e. especially increase in irrigation facility, regular electricity supply, it was evident from the study of Sahu *et al.* (2021) and Singh (2012) followed by the development of improved varieties suited to different agro-climatic conditions and agronomic practices by Ramdas *et al*. (2012); Mishra *et al.* (2014); and Nahatkar and Rajan, (2015). The highest increase in technical efficiency for the state of Madhya Pradesh (Fig. 1) indicated that the rate of conversion of input into output in wheat production was higher in this state as compared to other states under study.

Associationship between average technical efficiency and growth in wheat yield

After generating estimates on technical efficiency in wheat production for different states, the association between average technical efficiency and growth in yield of the wheat crop was worked out using correlation analysis and data on same were presented in Table 2.

Mean technical efficiency was positive and more than 100 in all the major wheat-growing states. It was highest in Madhya Pradesh, followed by Rajasthan, Uttar Pradesh, Haryana and least in Punjab. The productivity level of Madhya Pradesh and Rajasthan has posted a highly significant growth rate of 4.48 and 1.59 per cent, respectively, as compared to other wheat-producing states. It showed that TE was having a strong association with yield levels of wheat, and this was further tested using correlation analysis. The correlation coefficient between mean technical efficiency and growth rate of yield was strongly positive, i.e., 0.98, and highly significant, revealing that the higher technical efficiency was directly reflected in higher yield from wheat cultivation.

The high degree of associationship between average technical efficiency and growth rate of yield of wheat for major wheat-producing states revealed that increased technical efficiency not only increase efficient use of resources but also led to an increase in the productivity of wheat. The mean technical efficiency was lower for Punjab and Uttar Pradesh with corresponding non-significant growth in productivity, revealing that over time the higher use of inputs did not result in higher productivity which might be due to the fact that in these states, the productivity of wheat was already reached to plateau and thus only some breakthrough in wheat varieties could increase the yield further.

CONCLUSION

The highest increase in technical efficiency of wheat for Madhya Pradesh led to conclude that over the period of time, conversion of input into output was higher on account of technological development followed by required on-farm services. The higher association between average technical efficiency and growth rate of yield in wheat led to conclude that an increase in technical efficiency not only increase the efficient use of resources but also led to an increase in the productivity of wheat.

Looking at overall results of the technical efficiency of wheat production in major wheat-producing states; the efficiency of wheat production was

highest for Madhya Pradesh; therefore, it would be recommended that one state-level institute on wheat research may be opened in Madhya Pradesh for carrying out the region-specific research and development for value-added products of wheat for price stabilization and enhancing the share of wheat producers in wheat value chain especially for durum wheat and trait-specific wheat varieties like pasta making wheat varieties, high zinc and iron content varieties, low gluten content varieties etc.

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