Technical Efficiency in Organic and Conventional Wheat Farms: Evidence from a Primary Survey from Two Districts of Ganga River Basin, India

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Introduction

- Conventional farming (CF) is believed to be responsible for the degradation of soil, water, and environmental qualities.
- One of the ways to reduce its negative externalities is organic farming (OF), as it is believed to be beneficial to the environment (Aldanondo-Ochoa & Almansa-Sáez, 2009; Tuomisto et al., 2012).
- OF enables the agroecosystem to have rich biodiversity owing to the decomposition of crop residuals, use of bio-fertilizers, and lower use of nutrients (Hansen et al., 2001).
- With its potential benefits, government policies in India encourage OF.
- Comparing CF and OF systems' efficiency and their associated factors can help to understand the costs and benefits of switching to OF.
- This paper examines the technical efficiency of wheat farming under OF and CF systems and its determining factors in the Ganga Basin of India.

Literature Review

- Several studies find CF technically more efficient than OF (Charyulu & Biswas, 2010; Djokoto et al., 2017; Kargiannis et al., 2012; Kumbhakar et al., 2009; Larsen & Foster, 2005; Madau, 2007; Wibowo et al., 2019).
- While some studies show that OF has a higher TE than CF (Arandia & Aldanondo-Ochoa, 2008; Poudel et al., 2015; Raimondo et al., 2021; Songsrirote & Singhapreecha, 2007; Tzouvelekas et al., 2002).
- Lower levels of profit in OF are possible reasons for higher TE in OF, as it might have forced the farmer to use the inputs optimally (Tzouvelekas et al., 2002).
- A low level of SE in OF is found to be responsible for its low TE (Kargiannis et al., 2012). Wibowo et al. (2019) attribute the low TE of OF to the low crop yield. Restricted technology in OF is also a possible reason for low TE (Larsen & Foster, 2005).

Literature Review (contd.)

- Access to credit, household size, and farming experience positively impact the TE of OF (Poudel et al., 2015).
- The size of the farms, farmer's education, and capital were also found to positively affect the TE of OF (Tzouvelekas et al., 2002).
- Education, location, farm management, agricultural training, and management characteristics determine the TE in OF. In contrast, knowledge about agriculture, agricultural training, management characteristics, and location impact TE in CF (Songsrirote & Singhapreecha, 2007).
- In some studies, TE for wheat cultivation is found to be low (Al-Feel & AL-Basheer, 2012; Chebil et al., 2016; Croppenstedt, 2005).
- A panel data analysis to estimate the TE of wheat farms in Northern India finds that the average TE has been reducing through the years (Goyal & Suhag, 2003).

Literature Review (contd.)

- Some techniques like scheduling irrigation water, sowing, timely harvesting, and applying fertilizer improve TE (Chebil et al., 2016).
- Land preparation, timely irrigation, and using improved wheat seed varieties also improve the TE (Mirza et al., 2015).
- Existing literature focuses on the estimation of TE and its determinants. However, there is a research gap regarding comparing TE of OF and CF, particularly for wheat cultivation in the Ganga river basin.
- This study intends to fill this gap and contributes to the existing literature by estimating OTE, PTE, and SE for wheat cultivation under OF and CF systems and analyzing the determining factors for the same.

Data and Methodology

- To measure the TE and its determinants in wheat cultivation, a survey was conducted for primary data collection from July 2021 to August 2021.
- The study area included two districts, Haridwar (Uttarakhand) and Bulandshahr (Uttar Pradesh).
- Two blocks from each district were selected randomly for the survey. Then, five villages from each block were selected (20 villages).
- 30 farmers from each village were selected as the respondents, among which half were organic, and half were conventional.
- Since all farmers were not growing wheat in our sample households, the final sample size was reduced from 600 to 579 wheat farmers (294 organic farms and 285 conventional farms).

DEA Methodology (Contd.)

- DEA is applied to measure the TE in wheat under OF and CF systems.
- DEA can consider multiple outputs and inputs without assumptions in data distribution, making it an ideal choice for efficiency measurement.
- OTE, PTE, and SE under OF and CF systems are estimated using the following output and input variables:
- Output variable: The main output and its by-product
- Input Variables
  - Seeds
  - Human Labour
  - Machine Cost
  - Cost of Plant Nutrients
  - Value of FYM and Vermicompost
  - Plant Protection Cost
- Rupees per hectare is the unit used for all variables.

Tobit Regression

- The factors affecting the efficiency have been studied using the Tobit, a censored regression model that is appropriate for the data used in this study.

  Standard Tobit Model is given as:

$$y^* = x_i \beta + \varepsilon_i$$

where y is the dependent variable and i= 1,2,3,4,5,....N and ε_i is the error term

$$y = y^* \quad \text{if } y^* > 0$$

$$y = 0 \quad \text{if } y^* \leq 0$$

Here, the error term is assumed to be NID $(0, \sigma^2)$ and independent of the independent variables.

Description of Variables

Variables	Description	Hypothesized Sign
Farming practices	conventional=0, organic=1	+ve
Region	Haridwar = 0, Bulandshahr = 1	+ve
Gender	Female=0, male =1	+ve
Farming experience	In years	+ve
Education	Illiterate = 0, Primary = 1, Middle =2, Metric = 3, Inter = 4, Higher = 5	+ve
Farm size	In hectares	+ve
KCC	If a farmer has KCC (Yes = 1, No =0)	+ve
Smartphone	If a farmer has Smartphone (Yes = 1, No =0)	+ve
Membership	If a farmer is a member of any organization (Yes = 1, No =0)	+ve
Soil testing	If soil testing done (Yes = 1, No =0)	+ve
Dist. from the market	In km	-ve
Dist. from KVK	In km.	-ve

RESULTS & DISCUSSION

Summary Statistics for Inputs and Output Variables (Wheat)

Statistics	Seed	Lab	Machine	FER	PEST	IRR	VOP
Mean	4766	17676	7662	5110	355	5383	105501
Median	4615	17820	6200	4894	360	3500	106440
SD	688	1017	2924	1348	88	3981	13153
Min	3000	15255	3200	1515	150	0	78200
Max	6560	19935	14000	7641	758	17000	131892
Count	579	579	579	579	579	579	579

- The mean production value (VOP) under wheat cultivation is Rs. 105501 per ha, with a standard deviation of Rs. 13153.
- A high standard deviation (SD) for the VOP shows a variance in production value across all the farms.
- The input variables also have a high SD pointing towards the variation in seeds, labour, machine cost, fertilizer, pesticide, and irrigation across farms.
- The labour cost has the maximum share in the input cost, followed by machine cost, irrigation cost, fertilizers, seeds, and pesticides.

Average OTE, PTE, and SE in CF and OF

- Farms under CF have better OTE, PTE, and SE than their OF counterparts.
- An average farm under CF can be on the efficiency frontier by 10.2% input reduction, while for the OF, inputs must be reduced by 26.4%.
- The OTE is lower for OF because of low SE.
- As scale inefficiencies have a bigger role in the lower levels of OTE, it would help to devote more land to wheat cultivation and improve scale efficiency.

Efficiency Score	Wheat	
	OF	CF
OTE	0.736	0.898
PTE	0.901	0.956
SE	0.817	0.940

No. of Farms with 100% OTE, PTE, and SE Scores

- Under the CRS assumption, 28 CF units (9.8% of the total) operate at MPSS. In contrast, only three OF units (1% of the total) operate at MPSS,
- In the case of PTE and SE, a higher % of CF units are efficient. Practicing
- CF enables more farms to achieve SE and PTE; therefore, 100% OTE is achieved by more CF than OF.

Efficiency	Number of Farms with 100% efficiency scores		
	OF	CF	Total
OTE	3 (1.0)	28 (9.8)	31 (5.4)
PTE	16 (5.4)	59 (20.7)	75 (13)
SE	3 (1.0)	34 (11.9)	37 (6.4)
No. of Sample Farms	294	285	579

Efficiency Analysis by Farm Size

Land Holding	Efficiency	Wheat	
		OF	CF
Marginal(<1)	OTE	0.751	0.902
	PTE	0.905	0.956
	SE	0.828	0.943
Small (1-2)	OTE	0.733	0.891
	PTE	0.902	0.957
	SE	0.812	0.931
Medium (2-4)	OTE	0.713	0.894
	PTE	0.890	0.945
	SE	0.800	0.945
Large (>4)	OTE	0.709	0.836
	PTE	0.893	0.913
	SE	0.794	0.916

- The smaller farms under OF seem more efficient than the medium and large ones.
- On the other hand, PTE and SE scores do not behave in a similar way across farm sizes.
- PTE is more or less the same for various farm sizes.
- Small and marginal farms have a better OTE score than medium and large farms for CF.
- As the same pattern is seen in organic farms, it can be said that an inverse relationship is seen between farm size and overall technical efficiency.
- The lowest SE score under CF is on large farms.

Returns to Scale

- As most of the farms under OF and CF were found to be operating at IRS, they can improve OTE by increasing farm the size
- About 99% of the organic farms operate at IRS, which is higher than the percentage of CF at IRS (90%), implying that lower levels of efficiency in OF are because of small farm sizes.

Returns to Scale	OF	Non-OF	Total farms
IRS	291 (99.0)	231 (81.1)	522 (90.2)
DRS	0 (0)	26 (9.1)	26 (4.5)
CRS	3 (1.0)	28 (9.8)	31 (5.1)

Results of the Tobit Regression

Predictor (s)	OTE		PTE		SE	
	Coefficients	Std. Error	Coefficients	Std. Error	Coefficients	Std. Error
Farming practices	-0.1389*	0.0121	-0.0543*	0.0070	-0.1007*	0.010
Region	0.0511*	0.0098	0.0185*	0.0057	0.0394*	0.008
Gender	0.0080	0.0153	0.0104	0.0089	0.0014	0.0126
Experience	-0.0003	0.0003	-0.0002	0.0001	-0.0002	0.0003
Education						
Primary	-0.0032	0.0148	-0.0054	0.0085	-0.0003	0.0121
Middle	0.0109	0.1190	-0.0005	0.0069	0.0109	0.0098
Metric	0.0052	0.0122	-0.0054	0.0071	0.0097	0.0101
Inter	0.0123	0.0123	0.0001	0.0071	0.0123	0.0102
Higher	0.0010	0.0150	-0.0048	0.0087	0.0039	0.0124
Farm size	-0.0042	0.0037	-0.0035*	0.0021	-0.0013	0.0031
KCC	-0.0169**	0.0069	-0.0064	0.0039	-0.0135**	0.0057
Smart-phone	-0.0047	0.0079	-0.0011	0.0045	-0.0046	0.0065

Results of the Tobit Regression (Contd.)

Predictor (s)	OTE		PTE		SE	
	Coefficients	Std. Error	Coefficients	Std. Error	Coefficients	Std. Error
Dist. KVK	-0.0009*	0.0003	-0.0010*	0.0002	-0.0001	0.0003
Dist. market	-0.0014*	0.0004	-0.0016*	0.0003	0.0002	0.0003
Membership	-0.0118	0.0111	0.0014	0.0065	-0.0148	0.0092
Soil testing	-0.0098	0.0089	0.009***	0.005	-0.0185**	0.0073
Constant	0.9097*	0.0223	0.9772*	0.0131	0.9378*	0.0185
No. of farms	579		579		579	

Conclusion & Policy Implication

- CF has a higher level of OTE than OF. A higher percentage of conventional farms operate at the MPSS.
- The lower levels of OTE in OF are mainly due to lower SE, which can be attributed to the small farm sizes under it.
- Gender, farming experience, education, possession of a smartphone, and organization membership do not impact the efficiency scores.
- Practicing OF negatively impacts OTE, PTE, and SE.
- Farmers in Bulandshahr district (Uttar Pradesh) have relatively higher OTE, PTE, and SE than their counterparts in Haridwar district (Uttarakhand).
- Farm size affects managerial efficiency negatively.
- Holding a KCC also has a significant negative impact on OTE and SE scores.
- Farm distances from KVK and the market negatively impact the OTE and PTE but do not impact the SE.

Conclusion & Policy Implication (Contd..

- Lower SE calls for a policy intervention for the farm size. If farms are consolidated and the size of the farms is increased, OTE is likely to improve.
- As most farms operate at IRS, higher OTE can be achieved by increasing the farm sizes.
- Organic farmers would benefit more from group farming as their low SE scores cause low OTE scores.
- The field survey reveals that organic farmers have devoted only a part of their total land to OF and are still practicing CF on the remaining land. If government policies enable them to convert their whole land to OF and form organic clusters, it can improve technical efficiency in OF.
- Soil testing significantly impacts PTE, which implies that managerial efficiency can be improved by encouraging farmers to test their soil and use the recommended doses of plant nutrients to reduce costs and conserve resources.

Thank you