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TECHNICAL EFFICIENCY OF WHEAT FARMING IN SINDH PROVINCE OF PAKISTAN

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ABSTRACT

This research study was conducted to compute technical efficiency of wheat production in Sindh Province of Pakistan through Cobb-Douglas frontier production function. Three wheat producing districts of Sindh namely Larkana, Hyderabad, and Badin were randomly selected from different agro-ecological zones of Sindh. Using multi-stage sampling method, 384 farmers were selected from the above districts and data were collected through interview schedule. Survey results revealed that on an overall basis, cost per acre was around (Rs.9000) and was distributed under different heads like tractor (Rs. 2,117), seed (Rs. 2,045), DAP (Rs. 2,858), Urea (Rs. 2,076), and pesticide (Rs.418). Per acre yield and revenue was computed as 33.5 mds of wheat grains and exactly the same yield of wheat chaff was recorded. The sale price of grain yield was Rs.921 per md, while Rs.150 per md for chaff. Total revenue generated from one acre was Rs.35,901. Quite a large variations in yield and corresponding revenue was observed across the District's under this survey. The highest yield and revenue were computed for Hyderabad where average yield was 51.6 mds/acre and lowest was found in Larkana (24.1 mds/acre). The benefit-cost ratio was 2.95, on an overall basis. Benefit-cost ratio for Hyderabad was 4.06 which was almost double of that in Badin (2.11). The average value of technical efficiency was 0.36% which ranged from 0.12% to 0.95%. Better performance of farms in Hyderabad was obvious while relatively similar distribution of farms by technical efficiency in Larkana and Badin was observed. In Hyderabad about 28% of farms under the survey had technical efficiency within the range of 50-60% against 2% in Larkana while none of the farms in Badin was observed within the above referred range.

Keywords: Production function, regression modeling, technical efficiency, wheat farming.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the major food crop of larger part of Pakistan's population and the most important cereal crop of Rabi season. Wheat self-sufficiency is a pre-requisite for the sustainable food security. The food availability can be secured through increasing productivity, especially of small farmers who are majority in Pakistan and putting emphasis on major wheat-growing districts (Mazhar *et al.,* 2007).

The term "production function" derived from mathematics and statistics, shows the relationship between the output variable or dependent variable (production of wheat) and independent variables viz. seed rate, fertilizer, pesticide, labor and other services. More specifically, production function refers to the relationship between the input factor services and output of products. Bahrwar *et al.* (2000) developed a regression model and explored the significant factors increasing wheat production in Northwest Frontier Province, Pakistan. The significant relationship between wheat production and five explanatory variables (credit, fertilizer, area, maximum price, tube-wells, and rainfall) was reported. Regression analysis was performed using multiple-linear, quadratic, and Cobb-Douglas functional forms.

Technical efficiency is one of the most important factors of farming business for efficient use of resources including land, labour and capital. Ismail (1998) used regression models on wheat production and economic efficiency of farms was estimated on the basis of the production function. Sharma *et al.* (2008) estimated technical efficiency using the frontier production function. Sarfraz and Bashir (2005) analyzed

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the technical efficiency of the wheat farms in the mixed farming system of the Punjab using stochastic frontier production function. The Cobb Douglas production function was found to be an adequate representation of the data, given the specification of the corresponding translog frontier model. Hussain *et al.* (2012) analyzed the technical efficiency in wheat production across major cropping zones of the Punjab (Pakistan) through Cobb-Douglas production frontier.

The present study was conducted with the main objective to develop production function on wheat and estimate technical efficiency of wheat farms in Sindh Province of Pakistan.

MATERIALS AND METHODS

Population and sample

A representative sample of districts was taken at the first stage since estimates of this study were planned to infer technical efficiency of wheat for Sindh Province of Pakistan, considering agro-ecological zones of Sindh, three districts namely Larkana, Hyderabad, and Badin were randomly selected; Larkana represented the upper, Hyderabad for middle, and Badin for lower Sindh province. Distribution of districts of Sindh province by agro-ecological zones has been presented here under.

A total sample size of 384 farmers is usually preferred at 5% level of confidence interval when population size is very large usually in hundreds of thousands (Wunsch, 1986). In view of available documentation and resources, number of farmers in the above selected three districts was quite large and could not be exactly enumerated. The proposed sample of 384 has been divided exactly equaly in three districts i.e. 128 farmers per district.

Table 1. Selection of Districts from Agro-Ecological Zones.

Zones	Districts	Selected District
Zone A:	Shikarpur, Jacobabad, Kashmore @ Kandh kot, Larkana, Kambar @ Shahdad Kot and Northern Talukas (Mehar and Khairpur Nathan Shah) of Dadu district	Larkana
Zone B:	Ghotki, Sukkur, Khairpur, Naushero Feroze, Sanghar, Hyderabad, Matiari, Tando Muhammad Khan, Tando Allah Yar, Mirpurkhas,Tharparkar and Umer Kot	Hyderabad
Zone C:	Thatta, Karachi, Badin	Badin

Sampling unit and element

Data were collected from wheat growers in three districts using personal interview method mostly on wheat inputs and produce. Hence, the sampling unit was wheat growers while sampling element (on which data were collected) was wheat farm. The wheat growers can be categorized landlords (owner of land), peasant proprietors (own cultivator's), tenants (shareholders), and lease farmers (who lease piece of land on fixed amount of rent for some specified period of time say one or two seasons/years). Considering indicators the data to be collected, landlords, peasant proprietors and lease farmers were included in the sampling frame while the tenants (cultivating land on share basis) were excluded since they do not have details of input costs incurred on various heads viz. ploughing, seed, fertilizer, pesticide etc.

Sampling method

Multistage cluster sampling was used to select farmers for the collection of primary data. Cluster sampling has two important advantages over simple random sampling and stratified sampling. Firstly, it is cheap to run and secondly it is suitable for selecting a sample when the sampling frame of entity fundamentals is not available. Cluster sampling only needs a list of essentials in the clusters sampled (Anderson *et al.,*

1993). In the first stage, one taluka from each district was randomly selected as per sampling plan. From each taluka, 2 union councils (UCs) were selected. From each UC, four villages were selected; and, from each village, 16 farmers were selected. Thus, from each district, 1 taluka, 2 UCs, 8 villages, 128 farmers were selected. In all, 384 farmers from 24 villages were selected for this study. Randomization at all the stages was applied to reduce the biases and ensure generalization of the results at provincial level.

Statistical analysis

Primary data collected with the help of questionnaire were analyzed using Statistical Package for Social Sciences. Besides, MS Excel was used for basic computations to estimate the distribution of farms by their level of efficiency. Descriptive statistics namely frequency, percentages, mean and standard deviations were computed and reported. Inferential statistics with special reference to linear regression modeling was applied to estimate the proportion of farms falling under different levels of technical efficiency. A brief on linear regression model (Cobb-Douglas production function) has been presented in the subsequent section.

Cobb-Douglas production function

With appropriate transformation, non-linear relationship can be converted into linear one so that research within the framework of the classical linear regression model can be undertaken. The Cobb-Douglas production function in its stochastic form can be expressed as:

$$Y_i = \beta_1 X_{2i}^{\beta 2} X_{3i}^{\beta 3} e^{ui} \qquad (1)$$

Whereas:

Y = output
X_2 = labour input
X_3 = capital input
u = stochastic disturbance term
e = base of natural logarithm

Log-transformation is used to get the Cob-Douglas model in linear function as:

$$\ln Y_i = \beta_1 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + u_i \qquad (2)$$

Parameters β_1, β_2 and β_3 are estimated through a linear regression approach to explore the relationship between production and input factors in natural log function.

Technical efficiency

The level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production (Greene, 1993). The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation).

RESULTS AND DISCUSSION

Results computed from primary data were divided into four sections:

1) Demographic profile of respondents
2) Input costs and revenue
3) Production function
4) Technical efficiency of wheat farms

Demographic profile of respondents

Age and experience of respondents

Table 2 reveals the average age and farming experience of the respondents. On an overall basis, the average age was 38.4 years which ranged from 35.7 years (Hyderabad) to 40.1 years (Badin). Likewise, the average farming experience was 19.5 years. These results indicate that the farmers start independent farming at the age around 20.2 years.

Table 2. Age and experience of respondents.

Aspects	Larkana	Hyderabad	Badin	Overall
Age(Years)	39.4	35.7	40.1	38.4
Farming Experience(Years)	20.2	17.2	21.2	19.5

Tenancy status of respondents

Table 3 displays summarized information about tenancy status of farmers. On an overall basis, 79.4% of the respondents were landlords (owners) while around one-fifth (19.0%) of the respondents were peasant proprietors and only 1.6% lease (cultivating rented lands). District-wise data reflected that there was highest proportion of landowners in district Hyderabad 95.3% against 69.5% in Larkana and 73.4% in Badin. Proportion of lease was very small and ranged from (0.8%) in Badin, 1.6% in Hyderabad, and to 2.3% in Larkana.

Table 3. Tenancy status of respondents.

Tenancy status	Larkana	Hyderabad	Badin	Overall
Landlord (Owner)	89(69.5)*	122(95.3)*	94(73.4)*	305(79.4)*
Peasant Proprietor (Own cultivators)	36(28.1)*	4(3.1)*	33(25.8)*	73(19.0)*
Lease (Cultivating rented land)	03(2.3)*	2(1.6)*	1(0.8)*	6(1.6)*
Total	28(100)*	128(100)*	128(100)*	384(100)*

Note: * the values in parenthesis indicate percentages.

Educational profile of respondents

Table 4 shows the educational profile of the respondents. On an overall basis, around (30%) of the respondents had no formal education. Distribution of respondents by level of education was recorded as primary (45.8%), secondary (14.9%), intermediate (6.3%), graduate (1.8%) and postgraduate (1.0%) while Madarsa education was less than 1%. Relatively better educational profile of the respondents from Hyderabad was found where only 15.6% farmers had no formal education against (29.9%), on an overall basis. On the contrary, Badin had very poor educational profile where 46.8% of the respondents had no formal education. Moreover, the proportion of respondents having graduate and postgraduate was less than 1.0% for each level of education.

Table 4. Educational profile of respondents.

Educational profile	Larkana	Hyderabad	Badin	Overall
No formal Education	35(27.3)*	20(15.6)*	60(46.8)*	115(29.9)*
Primary	60(46.8)*	64(50.0)*	52(40.6)*	176(45.8)*
Secondary	22(17.2)*	26(20.4)*	9(7.1)*	57(14.9)*

Intermediate	7(5.5)*	13(10.2)*	4(3.2)*	24(6.3)*
Graduate	3(2.3)*	3(2.3)*	1(0.8)*	7(1.8)*
Postgraduate	1(0.8)*	2(1.6)*	1(0.8)*	4(1.0)*
Madarsa	0(0)*	0(0.0)*	1(0.8)*	1(0.3)*
Total	128(100)*	128(100)*	128(100)*	384(100)*

Note: * the values in parenthesis indicate percentages

Input cost and revenue

Table 5 reveals input costs under various heads. Total cost, on an overall basis, was computed to be Rs. 9,095 per acre. Segregated data by districts revealed that relatively higher costs were recorded for Hyderabad (Rs. 10,945) while the lowest for Larkana (Rs. 7,871). Major heads of cost were tractor (Rs. 2,117), Seed (Rs. 2,045), DAP (Rs. 2858), Urea (Rs. 2,076), and Pesticide (Rs. 418). Except pesticides, comparatively more costs were recorded for Hyderabad in comparison of Larkana and Badin. Farmers of Larkana spent Rs. 473 on pesticide whereas Rs. 451 and Rs. 333 were computed for Hyderabad and Badin, respectively. Since costs on harvesting and threshing were paid in kind (part of harvested crop), therefore, the same have not been reported; neither in cost nor in revenue head. However, traditionally around 6-7% of the produce is charged on the account of harvesting and threshing.

Table 6 reveals physical productivity and revenue from grain wheat. On an overall basis, farm size was computed around 7 acres. The average yield of wheat grain was about 1360 Kgs per acre. Quite a large variation in yield was computed across districts under the survey. The highest yield (51 mds/acre) was recorded in Hyderabad district in comparison of Larkana (24 mds/acre) and Badin (25 mds/acre) districts. Like physical productivity, the highest revenue was computed for Hyderabad district (Rs. 55,348/acre) followed by Badin (Rs. 26,443/acre) and Larkana (Rs. 25,909/acre).

Table 5. Input costs.

Head of Cost		Larkana	Hyderabad	Badin	Overall
Tractor	Hrs/acre	2.34	3.68	2.49	2.90
	Rate(Hrs/acre)	611	789	811	730
	Cost (Rs./acre)	1,427	2,906	2,017	2,117
Seed	kg/acre	49.9	54.3	49.5	51.2
	Rate(kg/acre)	40.86	41.44	37.29	39.94
	Cost (Rs./acre)	2,039	2,250	1,846	2,045
DAP	Bags/acre	0.86	1.01	0.93	0.93
	Rate(Rs./Bag)	3,064	3,072	3,082	3,073
	Cost (Rs./acre)	2,635	3,103	2,866	2,858
Urea	Bags/acre	1.98	2.99	2.01	2.33
	Rate(Rs./bag)	893	899	880	890
	Cost (Rs./acre)	1,770	2,687	1,771	2,076
Pesticide	kg/acre	473	451	333	418
Total cost (Rs./acre)		7,871	10,945	8,500	9,095

Table 6. Physical productivity and revenue from grain wheat.

Head	Larkana	Hyderabad	Badin	Overall
Wheat cultivated area (acres)	4.3	8.7	7.6	6.9
Yield of grain (mds/acre)	24.1	51.6	24.8	33.5
Price of grain (Rs. /md)	926	922	915	921
Revenue (Rs./acre)	22,297	47,603	22,718	30,873
Yield of chaff (mds/acre)	24.1	51.6	24.8	33.5

Price (Rs. /md)	150	150	150	150
Income from Chaff (Rs./acre)	3,612	7,745	3,725	5,028
Total Income (Rs./acre)	25,909	55,348	26,443	35,901
Total cost (Rs./acre)	7,871	10,945	8,500	9,095
Net Income (Rs./acre)	18,038	44,403	17,943	26,806

Figure 1 unveils the average input-out put and benefit-cost ratios of wheat farms. On an overall basis, input-output ratio was 3.95 which ranged from 3.11 (computed for Badin) to 5.06 (estimated value for Hyderabad) white estimated input-output ratio for Larkana was 3.29. Like input-out put ratio, the highest benefit - cost ratio was computed for Hyderabad at the rate of 4.06 and lowest for Badin (2.11) while for Larkana, benefit-cost ratio was 2.29 against the overall ratio of 2.95.

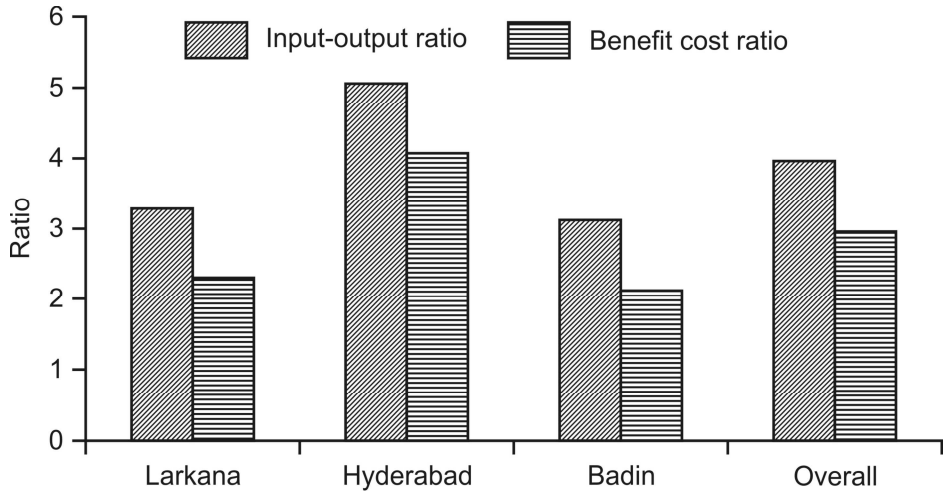

Figure 1. Benefit cost ratio of wheat farms.

Production function

Estimates of the Cobb Douglas production function have been presented in Table 8. Relatively higher values of t-statistic were recorded to be highly significant at 1%, level of significance. The following production function was proposed for wheat farms:

Ln (Revenue) = 3.56 + 0.08 ln (Area) + 0.10 ln (tractor) +0.03 ln (Seed) + 0.05 ln (DAP) + 0.58 (Urea) + 0.19 (pesticide) - 0.42 (D_1) -0.35(D_2)

The estimates of the model revealed that one percent increase in the area, revenue from wheat production increased at the rate of 0.08%. The coefficient for the tractor was 0.10%, depicting that one percent increase in the cost on tractor for leveling and ploughing, the corresponding change in revenue was 0.10%. Likewise, with additional increment of one percent in cost incurred on DAP, Urea and pesticide costs, brought changes in wheat revenue at the rate of 0.05, 0.58, and 0.19%, respectively. In comparison of Hyderabad, relatively low revenue was computed from Larkana and Badin at the rate of 42% and 35%, respectively from reference line of the model i.e. Hyderabad. Among the input factors, tractor was significant at 0.05% while urea and pesticides were highly significant at 0.01, level of significance. Seed and DAP were non significant. For seed, it may be inferred that majority of farmers apply recommended dose of seed, hence, further investment in seed did not increase revenue. The reason behind DAP could be exorbitant prices recorded during last five years. Hence, investment in DAP did not increase the revenue at some significant level.

Table 7. Coefficients of Cobb Douglas production function.

	Un-standardized Coefficients		Standardized Coefficients	t-value	Sig.	95% confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	3.56	0.38	-	9.38	0.00	2.81	4.31
Ln_Area	0.08	0.05	0.07	1.74	0.08	-0.01	0.18
Ln_Tractor	0.10	0.04	0.09	2.26	0.02	0.01	0.18
Ln_Seed	0.03	0.04	0.02	0.61	0.54	-0.06	0.11
Ln_DAP	0.05	0.05	0.04	1.12	0.27	-0.04	0.14
Ln_Urea	0.58	0.07	0.51	8.21	0.00	0.44	0.72
Ln_Pesticide	0.19	0.04	0.15	5.36	0.00	0.12	0.26
D1 (Dummy for Larkana)	-0.42	0.04	-0.23	-9.59	0.00	-0.51	-0.33
D2 (Dummy for Badin)	-0.35	0.04	-0.18	-9.43	0.00	-0.42	-0.28

R^2 = 0.907 F-ratio = 925.7

Technical efficiency of wheat farms.

Table 8 presents descriptive statistics of technical efficiency of wheat farms. On an overall basis, the average value of technical efficiency was (0.36%) which ranged from (0.12%) to (0.95%). The highest technical efficiency was computed for Hyderabad (0.45%) followed by Larkana (0.32%) and Badin (0.31%). Technical efficiency of Hyderabad ranged from (17%) to (81%) while ranges of Larkana and Badin were recorded to be (13-59%) and (12-95%), respectively.

Table 8. Descriptive statistics of technical efficiency of wheat farms.

Districts	Minimum	Maximum	Average	SD
Larkana	0.13	0.59	0.32	0.07
Hyderabad	0.17	0.81	0.45	0.09
Badin	0.12	0.95	0.31	0.09
Overall	0.12	0.95	0.36	0.11

Figure 2 shows distribution (%) of farms by technical efficiency. On X-axis, levels of technical efficiency and on Y-axis, proportion (%) of farms have been shown. Better performance of farms in Hyderabad is much evident from the figure while relatively similar distribution of farms in Larkana and Badin has been observed. In Hyderabad about (28%) of farms under the survey had technical efficiency within the range of (50-60%) against (2%) in Larkana while none of farms in Badin was observed within the above referred range. In comparison of Hyderabad, less technical efficiency in Larkana and Badin could be threefold; firstly educational status of farmers is much better, secondly more educational and research institutions of agriculture, and thirdly Larkana and Badin are essentially belong to rice-wheat zone while Hyderabad belongs to cotton-wheat zone.

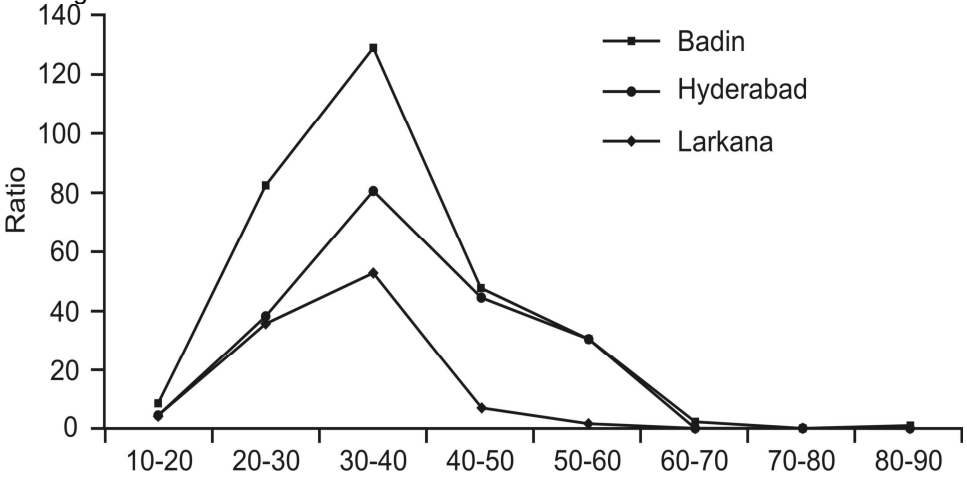

Figure 2. Technical efficiency of wheat farmers.

CONCLUSION

Quite a large variation in yield and corresponding revenue was observed across the district under this survey. The highest yield and revenue was computed for Hyderabad where average yield was 51.6 mds/acre and lowest in Larkana 24.1 mds/acre. The benefit-cost ratio was (2.95), on an overall basis. Benefit-cost ratio for Hyderabad was 4.06, which was almost double of that in Badin (2.11). Estimates of the production function revealed that tractor was significant at 0.05 while urea and pesticides were highly significant at 0.01, level of significance. Seed and DAP were non significant. For seed, it may be inferred that majority of farmers apply recommended dose of seed, hence, further investment in seed did not increase revenue. The reason behind DAP could be exorbitant prices recorded during last five years. Hence, investment in DAP did not increase the revenue at some significant level.

The average value of technical efficiency was (0.36%) which ranged from (0.12%) to (0.95%). Better performance of farms in Hyderabad was obvious while relatively similar distribution of farms in Larkana and Badin was observed. In Hyderabad about (28%) of farms under the survey had technical efficiency within the range of (50-60%) against (2%) in Larkana while none of farms in Badin was observed within the above referred range. Although wheat is grown in all the agro-ecological zones of Sindh Province of Pakistan; however, significant variations across these areas in input costs, revenues, production and distribtuion of farms by technical efficiency were observed. It was, therefore, concluded that with increasing awarness among the farmers regarding advanced technology, production of this important crop can be increased to face the future challenges of food insecurity inwake of increasing population and climate change scenario.

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