TECHNICAL EFFICIENCY OF RICE PRODUCTION SINDH, (PAKISTAN): A STATISTICAL ANALYSIS

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ABSTRACT: *In this research study technical efficiency of rice crop production was estimated. According to agro-ecological zones, two districts were randomly selected from Sindh Province namely Larkana and Badin. Cobb-Douglas frontier production was applied using primary data. Production function is the most important medium of applied economic research especially in the field of agricultural economics. Survey results showed that the lower input cost per acre was cultivate of rice crop recorded for Larkana (Rs. 10,145) while comparatively higher costs were recorded for Badin District (Rs. 10,922). Study results revealed that on an overall basis, input costs under different heads were calculated to be Rs. 10,473. Most significant head of costs were recorded as DAP (Rs. 3,124), Urea (Rs. 2,667), tractor (Rs. 2, 498), seed (Rs. 2, 184) and a while average pesticide input costs was Rs. 688. Farmers of Badin spent Rs. 647 on pesticide while Rs.730 for Larkana. The mean yield of rice crop was about 51.6 mds. The higher yield (51.9 mds) was calculated in Badin district comparatively to Larkana district (50.7), no any higher variation in yield was calculated across districts under the survey. Likewise, the higher revenue was calculated for Larkana district (Rs. 42,596 per acre) followed by Badin (Rs. 42,039 per acre). Though relatively more average yield per acres was computed for Badin district, but sell price was found in Larkana district. Input-output ratio was 3.78 while benefit-cost ratio was 2.78. Almost the same technical efficiency of Larkna and Badin districts were observed.*

Keywords: Production function, Technical efficiency, Regression modeling, Rice crop

INTRODUCTION

Technical efficiency

The quantity of firm and exact technical efficiency is supported upon deviations of investigational output starting from the maximum tremendous production or resourceful production frontier. The optimum mixture of inputs to flourish a specified level of outputs (an input-direction) can be calculated through the technical efficiency or the maximum approving output that may perhaps known as a set of inputs (an output-direction). In their work [1], argued about the region-wise wheat yield technical efficiency through Cobb-Douglas production function in Pakistan. The main motivation behind this research was a food crisis issues the entire world in especially in Pakistan. They found out that decrease in technical ability as well as in managerial ability has been found in wheat growers in Pakistan.

Role of agriculture in national economy

Agriculture is the deepest and intimate to economic expansion and growth in Pakistan. Among them rice (***Oryza sativa L***.) is known as a major cornflakes crop of Sindh Province. Rotations of rice crop take place in the upper Sindh and can be grown in kharif season while. Authors in [1] insisted on increasing groceries invention that meet up the ever increasing demand from world inhabitants. They highlighted that rice has potential to fulfill the food requirements and to tackle food security issues in coming years. In this research work [2] authors have conducted experiments to study the rice varieties which are drought resistant. Since, rice grain is one of the major sources of diet all along the world.

The agriculture production function is a systematic way of studying the relationship between the output and different amounts of input variables. Production function is the most important medium of applied economic research especially in the field of agricultural economics. It is considered that production function is method of combining property of hidden and open sources. According to the manufacturers of supplies or else services or productivity, the production function is explained as the mathematical justification of the different technical necessities faced by means of the firm. It defines the maximum physical output levels obtainable from various levels of inputs [3]. In applied economics, the inference of production function has an extensive history which preliminary starting from 1800's. Researchers in their work [4] argued that the history cannot be believed an incompetent achievement, and also majority of econometric troubles hampered early judgments are at a standstill an issue today. The production function may be formulated as: output = *f* (quantity of input 1, quantity of input 2, ------, quantity of input *n*). On the basis of above theoretical and practical background this study was conducted having the chief purpose to produce a proper production function. The crop selected for the implementation of production function is rice and through this production function scientific efficiency of rice is estimated. The area selected for this study is Sindh, Pakistan.

METHODOLOGY

Sample Size and Population

It was important to take sample size covering the man regions of Sindh province, therefore, corresponding size of samples were taken from different regions of the province depending on the ecological conditions. Furthermore, at random two districts were chosen namely district Badin and district Larkana. Since these two districts represent

Table 1. Selection of Districts from Agro -Regions Based on Ecological conditions

Region	District-wise representation of regions	Chosen Area
Region A:	District Dadu, District Kashmore, District Larkana, District Shahdadkot, District Jacobabad, District Shikarpur and Taluka Mehar and Talukha KN Shah	District Larkana
Region C:	Thatta, Karachi, Badin	District Badin

entirely different regions of Sindh province. Furthermore in the following table, districts of Sindh province are presented based on the division of ecological regions.

When it comes to the big population size, then Normally 256 sample size is taken at five percent confidence interval. Therefore, this sample size of taken for this particular research study [5]. Furthermore, it was observed that large number of people living in that area was associated with farming therefore, enumeration of farmers was not possible. Hence, the figure of number of farmers which was 256 was divided into two equal parts and 128 farmers were chosen covering each district.

Sampling unit and element

The method adopted to collect data from rice producers was based on in-person interviews. Furthermore, the questions asked from farmers were mainly related with their inputs and production of rice. Additionally, rice producers were a main sample unit. However, the sample element (known as main data collecting part) remained the farms where rice crops were cultivated.

It was important for data segregation to distribute farmers or rice producers into categories such as: lease farmers, tenants farmers, peasant proprietor farmers and landlord famers. The categories represent. Additionally, lease farmers as well as tenants' farmers represent the groups which acquire a piece of land on rent for some specified time ranging from a particular season to a particular calendar year. However, remaining two categories such as proprietor farmers and landlord farmers are owner of their land. Based on the sample frame and chief indicator, three main rice producers such as lease farmers, peasant proprietor and landlords were considered. However, the tenants' farmers could not be approached for data collection. Another chief reason for not considering tenants' farmers was lack of unavailability of proper data with them such as details of fertilizers, pesticides, quality of seeds and plowing etc.

Sampling method

Primary data associated with farmers was collected by employing sampling technique known as Multi-stage clustering. Multi-stage clustering sampling is known for its two main advantages upon two other

sampling techniques such as simple random and stratified, that it is not so expensive to execute and its flexibility in achieving sample size when it comes to unavailability of basic unit of sample frame. Additionally, this sampling requires to have details of cluster fundamentals [6]. Furthermore, during initial round, at random only one taluka of a particular district under study was chosen. Additionally out of range of Union Counsel's (UC's), only two UC's were chosen from every taluka. Moreover, 04 small villages and (16) sixteen famers from each village were chosen. Therefore, two sets of accumulatively, 128 farmers were chosen within eight small villages, two Union Counsels, one taluka and one district. Furthermore, it was considered to have proper arbitrariness of data overcome partiality and to have a proper simplification of overall result over provincial stage.

Statistical analysis

For data analysis SPSS version 17 was utilized. SPSS package is very well known for its usefulness and efficiently analysis of bulky data. Previously data was collected through the help of properly designed questionnaires. Apart from SPSS other computer tools such as Microsoft Excel was also utilized to approximate the farms with respect to their placement. Furthermore, other statistical methods were adopted such as calculation of frequency, standard deviation, percentage and mean were performed. It was very important to determine various stages of technical competences of farms, therefore, to achieve this objective linear regression modeling was utilized which is part of inferential statistics. In the following a production function Cobb-Douglas, which a linear regression model, is described briefly.

Cobb-Douglas production function

More than enough sign of the data is known as Cobb Douglas production function. In this research work [7] authors reported an innovative model which is foundation on Cobb-Douglas functions. By taking proper alteration steps any non-linear association can be transformed in linear one. The advantage of this transformation is to conduct any research contained within a particular structure of traditional linear regression model. Expression of Cobb-Douglas production function in stochastic form is outlined as:

$Y_i = \beta_1 X_{1i}^{\beta 2} X_{2i}^{\beta} \ldots\ldots\ldots\ldots e^{ui}$ Whereas, Y = output, X_1 = labour input, X_2 = 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: $\ln Y_i = \beta_1 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + u_i$. Parameters β_1, β_2 and β_3 are estimated through a linear regression approach to explore the association among production function and input feature in normal log.

Technical efficiency

Point of technological competence of a specific entity normally known through the association among productivity obtained and through expected productivity measurements [8]. Furthermore, calculation of potent particular technological competence relies on deviation obtained through output of productivity or reliable productivity matrix. Moreover, optimized level of inputs is the main buildings blocks of efficient methods to attain a required medium of productivity. In another sense, vice versa of the situation

could also be considered from efficient output perspective which always required set of optimized level of inputs. Therefore, both these perspectives could be considered as input-oriented and/or out-oriented in terms of required efficiency.

RESULTS AND DISCUSSION

In order to simplify and efficiently communicate the results obtained, the whole dataset has been distributed in to the following sections.

a) Personal details of participants including information about demography
b) Production and cost of initial contribution
c) Productivity function
d) Technological competence of wheat farms

1. Personal Details of Participants (Information about demography)

Participants' Age & Experience Information

In the following, details of the participants are outlined. Specifically, participants' age and their farming experience have been considered. Furthermore, Table No: 02 contains details of the participants covering above said parameters. According to data obtained on average basis age of farmers in years was 38.4. Furthermore, on average farmers age in district Larkana was years 39.4. For district Badin on average farmers' age was 40.1 years. Similarly, on average for farmers experience relating with general farming was 19.5 years. This shows that normally farmers start farming at their earlier age which is around at the age of 20. These results indicate that the farmers start independent farming at the age around 20.2 years in Larkana and 21.2 years in Badin districts.

Participants position of Tenancy

In the following, summary of data relating with tenants is presented referring to Table No: 03. Furthermore, it was found out that in general nearly 71% participants were owners of their land or they were Landlords. However, nearly 26% of

participants were happen to be peasant proprietors. Furthermore, less then 2% participants were having lease of their lands. It was further found that detailed data of all districts had the largest portion of land as land owners. Furthermore, the highest fraction of owners of land was in Badin district having nearly 73% ownership. Additionally, in district Larkana ownership were nearly 69%. Furthermore, small fraction of landowners have lease of piece of land in district Badin was less than 1% and in district Larkana was nearly 2%.

Table 2. Age and experience of respondents.

Aspects	Larkana	Badin	Overall
Age (yaer)	39.4	40.1	38.4
Farming experience (Years)	20.2	21.3	19.2

Table 3. Participants position of Tenancy

Tenancy status	**Larkana**	**Badin**	**Overall**
Landlord (Owner)	89(69.5)*	94(73.4)*	183(71.4)*
Peasant Proprietor (Own cultivators)	36(28.1)*	33(25.8)*	69(26.9)*
Lease (Cultivating rented land)	03(2.3)*	1(0.8)*	04(1.56)*
Total	**128(100)***	**128(100)***	**256(100)***

Note: * the values in parenthesis indicate percentages

Educational profile of respondents

In the following, participants' profile related with education is presented, refer Table No: 04. Generally, it was found in the data that nearly 37% participants were uneducated and they never attended any school. Furthermore, table contains data related with education of participants in detail. As per the data participants who attended primary school were nearly 43%. Furthermore, participants who went to secondary school and intermediate college were respectively 12% and 4%. Participants who had educational background of up to graduation level were nearly 1%. Participants who had less than one percent fraction in the educational background were postgraduates and Madarsa went. Furthermore, it was found out that district Larkana had the highest fraction of educated participant as compare to other districts; the fraction was nearly 27% in comparison with uneducated farmers which were nearly 37% of all the participants. District Badin had highest fraction of uneducated participant farmers having nearly 46%.

Table 4. Educational profile of respondents

Educational profile	**Larkana**	**Badin**	**Overall**
Noformal Education	35(27.3)*	60(46.8)*	95(37.1)*
Primary	60(46.8)*	52(40.6)*	112(43.75)*
Secondary	22(17.2)*	9(7.1)*	31(12.10)*
Intermediate	7(5.5)*	4(3.2)*	11(4.29)*
Graduate	3(2.3)*	1(0.8)*	4(1.56)*
Postgraduate	1(0.8)*	1(0.8)*	2(0.78)*
Madarsa	0(0)*	1(0.8)*	1(0.3)*
Total	128**(100)***	128**(100)***	256**(100)***

Note: * the values in parenthesis indicate percentages

Table-5: Input costs

Head of Cost		Larkana	Badin	Overall
Tractor	Hrs/acre	3.74	3.36	3.58
	Rate(Hrs/acre)	614	810	698
	Cost (Rs./acre)	2,296	2,721	2,498
Seed	kg/acre	55	49	52
	Rate(kg/acre)	39	46	42
	Cost (Rs./acre)	2,145	2,254	2,184
DAP	Bags/acre	0.99	1.03	1.0
	Rate(Rs./Bag)	3,025	3,222	3,124
	Cost (Rs./acre)	2,995	3,319	3,124
Urea	Bags/acre	3.04	2.98	3.01
	Rate(Rs./bag)	891	882	886
	Cost (Rs./acre)	2,709	2,628	2,667
Pesticide	kg/acre	730	647	688
Total cost (Rs./acre)		10,145	10,922	10,473

Input costs and revenue

The results of input costs of different heads were recorded and indicated in Table-5. Whereas, the district-wise separated data of input costs were recorded in Larkana (Rs. 10,145) lowest and higher (Rs. 10,922) was in Badin district in per acre. While, on overall basis, it is calculated to be (Rs. 10,473). Major head of costs were tractors plow (Rs. 2,498 per acre), seed (Rs. 2,184 per acre), DAP (Rs. 3,124 per acre), Urea (Rs. 2,667 per acre), and pesticide (Rs. 688 per acre). Relatively, maximum costs were calculated for Badin district in comparisons of Larkana apart from pesticides. The farmers of Larkana used-up (Rs. 730 per acre) on pesticide spray while more (Rs. 647 per acre) in Badin district respectively. In view of the fact that costs on harvesting and threshing were paid in kind (part of harvested crop), therefore, these were not described in above heads; neither in cost nor in revenue head. Nevertheless, usually about 7-8 percent production of harvesting and threshing charges was explained. Before planting any crop land preparation is pre-requisite for better production. Here cultivation means no. of cultivations is applied on land. Further, seed is essential input for crops yield. Appropriate seed use is very crucial to determine the production of crop. While, adequate application of fertilizers and enhances the yield so it is vital element in determining crop yield. Also, Pesticides play important role to kill the pests and have significant effect on yield.

Physical productivity of rice crop

When the yield can be finding in physical weight is identified as physical productivity. The results of rice crop are given in 1950 to 68.

the shape of physical productivity and revenue in Table 6. The mean results of yield of rice crop were about (51.6 maunds) and farm size about (5.9 acres) was calculated on overall basis. Moderately a smaller amount of deviation was calculated across the districts under the survey. In comparison somewhat better yield (51.9 mds per acres) was found in Badin district as compare to Larkana (50.7 mds per acre). Like the physical productivity, the highest revenue was calculated for Larkana district (Rs. 42, 596 per acre) followed by Badin (Rs. 42,039 per acre). Though more yields in maunds per acres were received for Badin district, but more sell out price was found in Larkana district. Therefore, in comparison for net income Larkana district remained higher than Badin district. These conclusions are also in line with [1] insisted on increasing food production to convene the ever increasing demand for the world inhabitants. They highlighted that rice has potential to fulfill the food requirements and to tackle food security issues in coming years. They further concluded that the improved rice breed development could be the best solution to the problem. These investigations are also in line with [9] studied to develop a model that take into consideration the sunshine hours and mean temperature in relationship with tiller production. Also some related ideas of [3] presented their work to analyze investment inputs in agriculture research within India. They achieved this study on the basis of time series analysis to obtain productivity gain. They took data for 18 years from

Table 6: Physical productivity and revenue from rice crop.

Head	Larkana	Badin	Overall
Rice cultivated area (acres)	4.3	7.6	5.9
Yield of grain (mds*/acre)	50.7	51.9	51.6
Price of grain (Rs. /md)	840	810	825
Revenue (Rs./acre)	42,596	42,039	42,570
Total cost (Rs./acre)	10,970	11,535	11,250
Net Income (Rs./acre)	31,626	30,504	31,320

md* = 40 kg

Benefit cost ratio rice

Figure 1 reveals the mean input-out and benefit-cost ratios of rice farms. It was found through the results of input-output ratio 3.78 on overall basis, which ranged from 3.64 (calculated for Badin) to 3.88 was (observed value for Larkana). While, through the results of input-output ratio, the maximum benefit-cost ratio was calculated for Larkana district (2.88) and minimum for Badin

(2.64) although for Larkana, benefit-cost ratio was 2.88 beside the overall ratio of 2.78. The results show there is not much more difference between both of them. Those above lines reflects with conclusions of [4] he argued and found in their results that technical inefficiency associations were formulated to be a linear function of dissimilar and accurate factors.

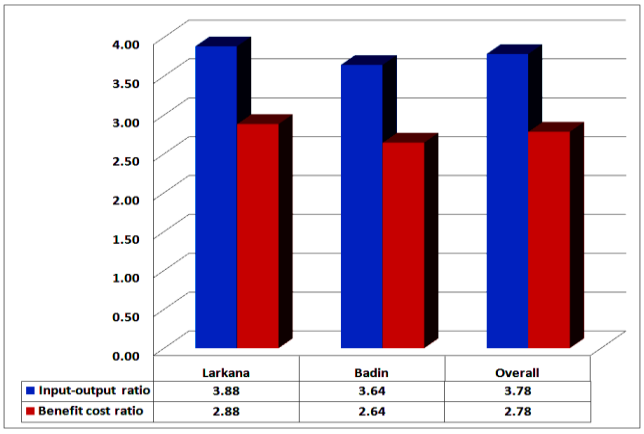

Figure 1. Benefit cost ratio of rice farms

Production function and technical efficiency of rice crop

The results of Cobb-Douglas rice production function is reported in Table -7, whereas moderately higher values of t-statistics were found to be extremely significant at the 0.01 level of significance. The suitable model for rice farms of production function was suggested as: *Ln (Revenue) = 3.52 + 0.25 ln (Area) + 0.09 ln (tractor) +0.32 ln (Seed) + 0.05 ln (DAP) + 0.30 (Urea) + 0.13 (pesticide) -0.04(D).* This indicates that one percent increase in the rice production. The calculated t-value for this coefficient is 1.97; this indicates that the coefficient is statistically significant at less than 5 percent level of significance. The coefficient for the tractor plow was 0.09, depicting that one percent increase in the cost on tractor for leveling and plowing, the corresponding change in revenue was 0.09 percent. The calculated t-value for this coefficient is 1.97; this indicates that the coefficient is statistically significant at less than 5 percent level of significance. The coefficient for the seed was 0.32, showed that one percent increase in the variable will increase the rice production by 0.32 percent. The calculated t-value for this coefficient is 5.47 means greater than one. This indicates that the coefficient is statistically significant at less than 5 percent level of significance. The suggested model indicated that one percent increase in the account of area, while revenue taken from rice production increased at the rate of 0.25 percent. Similarly, the

more increase of one percent in cost were recorded in the account of fertilizer (DAP & Urea) and pesticides, it brought some changes in rice revenue at the rate of 0.05, 0.30, and 0.13 percent, accordingly. Comparatively less revenue was calculated from Badin as comparative to Larkana at the rate of 04 percent, according to the proposed model. For example, amongst the various input factors, seed was significant at 0.05 even as tractor plow and DAP fertilizer were non-significant found. Further, it was found regarding Urea which was significant at the rate of 0.05, it possibly will be incidental that mainstream of farmers be appropriate and suggested dose of urea, hence. The matter of very expensive prices of DAP fertilizer calculated throughout last five years. Consequently, investment in DAP could not increase the revenue at a few significant level. Multiple linear regressions (MLR) modeling is found to be a sophisticated and very rich technique and is comprehensively utilized for scientific agricultural research. A linear relationship between response and explanatory variable is a major highlight of this method. These findings are also in line with [7] which argued a new model is based on Cobb-Douglas functions. Moreover, an overview of some additional parameters such as measurements and also structural are very essential for the development of model and also for the introduction of robust partial least square path modeling for the Cobb-Douglass production functions.

District-wise technical efficiency of rice farmers

Efficiency can be measured in conditions of the most favorable grouping of inputs to reach a presented level of output (an input-orientation). The technical efficiency of rice farms in percentage is presented in Figure 9. Whereas, the level of technical efficiency is given on X-axis and proportion in (percent) of farms is given in Y-axis.

The rice farms of Larkana district remained much better than Badin district through the results of Figure 2. With reference to figure (10 percent) of rice farms under the survey had a technical efficiency in Larkana district within the range of (65-69 percent) next to as regards (6 percent) in Badin. Comparatively, a lesser amount of technical efficiency was found in Badin district as compare to Larkana. According to the investigations that few better elements were found in Larkana district. First, the status of education of farmers is much better, secondly more educational and research institutions of agriculture, more the climate of much better than Badin and irrigation water system. While there is no any facility of installation of tube-wells in Badin district due to brackish water in water table

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Table 7: Coefficients of Cobb Douglas model on Rice production function.

	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
	B	Std. Error	Beta		
(Constant)	3.52	0.54		6.49	0.00
Ln_Area	0.25	0.04	0.26	5.73	0.00
Ln_Tractor	0.09	0.04	0.10	1.97	0.04
Ln_Seed	0.32	0.06	0.18	5.47	0.00
Ln_Dap	0.05	0.04	0.05	1.15	0.25
Ln_Urea	0.30	0.08	0.31	3.51	0.00
Ln_Pestcide	0.13	0.07	0.12	1.84	0.06
(Dummy for Districts)	-0.04	0.03	-0.03	-1.40	0.16

$R^2 = 0.929$

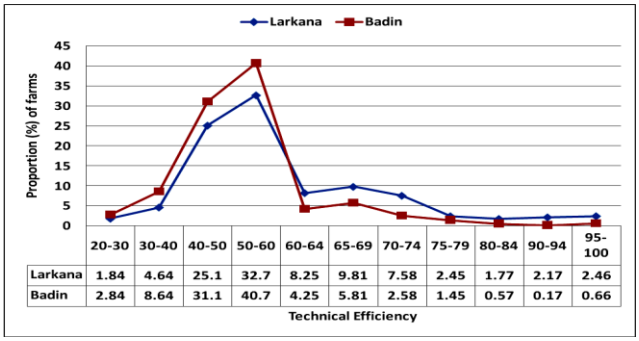

Figure 2: District-wise technical efficiency of rice farmers

CONCLUSION

Demographic profile of the respondents revealed that the average age was 38.4 years; (71.4%) of the respondents were landlords (owners) while around one quarter (26.9%) of the respondents were peasant proprietors and only (1.56%) as lease (cultivating rented lands); around 37.1% of the respondents had no formal education. For rice crop, input costs under different heads were calculated to be Rs. 10,473/acre. Most significant head of cost was recorded for DAP (Rs. 3,124) followed by urea (Rs. 2,667), tractor (Rs. 2, 498), seed (Rs. 2, 184) and pesticides (Rs. 688). The average yield of rice crop was about 51.6 md/acre and revenue generated was recorded as Rs.31, 320/acre with average price of Rs. 825/ maund. Input-output ratio was 3.78 while benefit-cost ratio was 2.78. Almost the same technical efficiency of Larkna and Badin districts were observed. Estimates of the production function revealed that tractor was significant at (0.05) while urea and seed were highly significant at (0.01), level of significance. DAP was non significant. 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 (10 percent) of rice farms under the survey had a technical efficiency in Larkana district within the range of (65-69 percent) next to as regards (6 percent) in Badin. Comparatively, a lesser amount of technical efficiency was found in Badin district as compare to Larkana. It was, therefore, concluded that with increasing awareness 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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