Research Article

An Assessment of Technical Efficiency of Tomato Farms in District Lasbela, Balochistan

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Abstract | This study was conducted in district Lasbela, Balochistan. Its objective was to investigate the technical efficiency of tomato farms in the district and its determinants. A well-structured questionnaire was used to collect data from one hundred tomato growers. Multi-stage random sampling technique was used for selection of the farmers. The Cobb-Douglas production function was used to estimate the technical efficiency and performance of the farmers. The study results disclosed that all explanatory variables have a positive impact on the farmers' technical efficiency apart from pesticides. Additionally, the average technical performance of the farmer was 85% which shows that on average a farmer can spur the tomato production by 15 % by using the existing resources. Moreover, the inefficiency model results showed that farmer experiences were negatively linked with technical inefficiency. It seems that the experience will affect more and more on the contemporary cultivation of tomatoes. The study recommends that the government should launch both formal and informal training programs for the farmers to enhance the productivity.

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1. Introduction

Pakistan is an emerging economy where the agriculture sector represents nearly 43 percent of the workforce (Manzoor et al., 2015). Moreover, practically 60 percent of the country population is living in the countryside, and the livelihood of these rural people is linked directly or indirectly to the agriculture sector (Khan et al., 2018). All this evidently indicates the significance of the agricultural sector for Pakistan's economy. Moreover, agriculture contributes 22 percent to Gross Domestic Product (GDP) of Pakistan. (GoP, 2018).

Pakistan possesses all the resources that are vital for a well-established agriculture sector i.e. fertile land, an improved irrigation system, vibrant climatic conditions, and workforce (Mari and Lohano, 2007). But unfortunately, the performance of the sector is not that much encouraging even the country is struggling to attain self-sufficiency in food. Being agriculture and quasi-agriculture country, Pakistan still imports a sizable portion of agriculture commodities like wheat, vegetable oils, pulses, and tea (GoP, 2019).

Nevertheless, it also occasionally imports vegetables like potatoes, garlic, leeks, cabbage, lettuce, chicory, onions, shallots, kale, carrots, turnips, and tomatoes. However, during recent Pakistan- India conflict, tomato price was high rock as India halted the export of tomato to Pakistan. And afterward it raised the prices of tomato as the domestic supply was far less to meet domestic demand which created inordinate challenge for the government.

Tomato (Solanum Lycopersicum) is edible red fruit that originated from South America, but later it was used as an edible commodity in Mexico and then it spread throughout the world. According to the report of United Nations agency on Food and Agriculture Organization (FAO, 2017), the top ten tomato producing countries were China, India, the United States, Turkey, Egypt, Iran, Italy, Brazil, Spain, and Mexico, respectively. Whereas the total tomato production of these ten countries were around 123 million tons, while the total global production was 163 million. Leading tomato exporting countries are Netherlands followed by Mexico, Spain, Turkey, France, Morocco, Jordan, the United States, Canada, and Belgium.

In 2018 the population growth rate of the country is 2.5 percent, and consequently every year almost 4 million people are placed into the pie of population (reference). Therefore, such a big chunk of inhabitants leads to spur the demand of food and vegetables. Nevertheless, the country has limited irrigation and cultivable land (reference). Henceforth, in the given circumstances to feed such huge population and achieve food self-sufficiency, the country has only one choice i.e. to expand per acre productivity by achieving farm level technical efficiency. In addition, increased farm level efficiency will also save precious foreign exchange for Pakistan. Moreover, a big segment of poor households is closely linked to agriculture, then the augmentation of farmer's efficiency is indispensable to maximize the farm profits and eradicate rural poverty. Therefore, the study intends to assess and investigates the technical efficiency of tomato farms in the district Lasbela, Balochistan.

Lasbela, as name which means 'LAS' a plain and 'BELA' a jungle, was notified as a district on 30th June 1954. It is situated on the edge of Sind-Balochistan border, bounded in the north by district Khuzdar, in the east by Malir and Karachi (West) districts of Sindh province, in the south by the Arabian Sea and in the west by Gawadar and Awaran districts. The 15,1534 square kilometer area of the Lasbela district is divided into three parts, the northeastern mountains and hilly areas, the southwestern hilly area and the central plain. In between the range's important valleys, the Winder valley, the Wirahab valley and the Hub valley are situated. It is drained by the rivers and streams flowing from the hills of Moro and Pub ranges in the north and east of the plain and Haro and Hala ranges lying close to the western boundary of the district.

The district is well-known for its agricultural production in the province, practically vegetables. This district supplies tones of vegetable every year to Karachi, which is one of the biggest markets of Pakistan. Moreover, Lasbela is very famous for its off-season tomato harvest, it not only produces quality tomatoes but ready for harvest in winter where in other parts of country tomato is not ready for harvest therefore gives best price to the farmers.

The current situation of Pakistan necessitates spurring the farmer's efficiency to meet the growing demand for food and to achieve self-sufficiency. This can also make it possible to achieve maximum output with minimum input by increasing per acre productivity and improved technical efficiency. Koopmans (1951); Debre (1951) and Farrell (1957), divided the economy into two categories: Allocative efficiency and technical measures. The technical efficiency provides evidence and variations between agricultural production. Allocative efficiency measures the gap between the farmers' actual yield and the yield that can be produced through the efficient use of agricultural resources. However, the allocative efficiency can be achieved by maximizing the output through minimized cost of input. Donkoh et al. (2008) further elaborated that economic efficiency can be derived from technical efficiency and allocation efficiency.

As mentioned before district Lasbela can prove to be most productive region for tomato production through educating farmers to utilize their lands and resources efficiently for highest possible benefits. If properly administrated this district can facilitate tomato demand both at domestic and international level. Therefore, it is utmost to investigate hurdles and determinants of effective production of tomato in Lasbela District.

The rest of the study is organized as follow. The upcoming section highlighted materials and methods whereas section three and four are devoted to results and discussion and conclusion, respectively.

2. Materials and Methods

The data of one hundred tomato growers was collected through a well-structured questionnaire. Nevertheless, the farmers were selected over a multi-stage random sampling. However, the tomato farmers of district are not consistent, and they easily switch from one vegetable/crop to another based on their perception, anticipation, and the price of vegetable/crop during the sowing season. Considering this situation, we first collected information of the farmers form agricultural center at Uthal and then approached the farmers those were engaged in tomato farming. Afterward, out of 300 tomato growers, we have selected 100 randomly and collected information from them as per procedure.

In the literature, both parametric and non-parametric techniques have used to assess technical efficiency. The parametric approaches can be applied with the help of econometrics methods while the non-parametric methods (DEA) use mathematical practices to estimate technical efficiency. Both methods have their own advantages and disadvantages, as elaborated by Battese (1992), Coelli et al. (1999) and Bravo-Ureta et al. (1997). Nevertheless, a parametric approach is likely to retain a distinction between natural random error and farm-specific technical inefficiency. On other hand, a non-parametric technique combines both random noise and technical inefficiency. The parametric model confines the misspecification of functional forms, such as technology and inefficiency, but also carries greater responsibility (Ali and Khan, 2014). Additionally, from the literature; it appears that econometric models have been extensively used to evaluate the technical efficiency of farms. However, due to compound error structure of the Stochastic Frontier Approach (SFA) production must be analyzed using the maximum likelihood (MLE) techniques (reference).

Stochastic limit analysis

The specification of the SFA provides in equation (1) which was individually intended by Meeusen et al. (1977) and Aigner et al. (1977). Hence, the well-intended formula of SFA is given below.

$$Y_t = f(X_i;\beta_i) + \varepsilon_t, i = 1,2,3,4,\dots\dots,n \quad \dots(1)$$

Whereas; (Y_t) shows tomato output in kg per acre, (X_i) vector of the explanatory variables (β_i) expected coefficient of the variables and finally (ε_t) shows error term. Irrevocably, the specification of the Cobb-Douglas production function (CDPF) is revealed underneath. Furthermore, for the assessment of the model, the MLE methods used, as it provides the estimates of the parameters that are unbiased estimator.

$$lnY = \alpha_0 + \alpha_1 L_t + \alpha_2 SP_t + \alpha_3 TH_t + \alpha_4 TIR_t + \alpha_5 PS_t + \alpha_6 UR_t + \alpha_7 HS_t + \varepsilon_t \dots(2)$$

Whereas; (Y) is tomato yield in kg per acre, (L) labor, (SP) seed price, (TH) tractor hours, (TIR) type of irrigation, (PS) pesticide, (UR) urea, ((HS) Dummy of Hybrid seed and (ε_t) technical inefficiency error term; α_0 and α_i signify intercept and coefficients of the explanatory variables respectively in regression line. Similarly, the model of technical inefficiency is specified as given below.

$$u_i = \beta_0 + \beta_1 AGE_t + \beta_2 exp_t + \beta_3 EDU_t + \beta_4 ART_t + \beta_5 CTP + \beta_6 DPA + \epsilon_t$$

Whereas: μ_i represents technical inefficiency error term; while (AGE) Age, (EXP) experience, (EDU) Education, (ART) Area under tomato (acres), and (CTP) cost of tomato production, (DPA) Diammonium phosphate while (β_t)∧(ϵ|□|t) are expected coefficients, and random error respectively. Furthermore, with the help of this formula (TE_t=Y_t/Y_t) the technical efficiency of the tomato farmers was estimated. Moreover, (TE) stands for technical efficiency while its values rangers from 0 to 1; while *Yt* and*Yt* are the observed and frontiers output. However, for sole farmer the technical inefficiency can be estimated as: (Tl_i=*1-TEi*).

3. Results and Discussion

Table 1 displays the descriptive statistics of the variables used in the model. The variables which are used to estimate the technical efficiency include seeds price, labor, tractor hours, type of irrigation, pesticides, urea, farmers' experience, farmers' age, farmers' education. tomato cultivation area and production costs.

The average seed rate was 333.55 grams per acre while average hours of the tractor and workforce are also fairly tall, which ranged from 51 to 58 working days

with a standard deviation of 2.09 business days. The average urea and DAP used were 135.27 kg and 36 kg respectively. Moreover, for irrigation type we used dummy variable, nevertheless all the farmers were used tube well of their irrigation of field. Likewise, the average age and experience of the farmers are 25 and 22 years, respectively. It shows that the farmers are both young and experienced cultivators. However, the average cultivated area under the tomato crop and total cost of tomato are also overwhelming i.e. 5 acres and twenty thousand, respectively. Moreover, the high strand deviation of total cost and cultivated area indicate that there are significant disparity of holding land and investing of the crop among the farmers.

Table 1: Descriptive statistics of the variables.

Variable	MOUM	Min	Max	S. D
SP	Gms 333.55	258	342	12.91
L	MD 54.80	50	60	1.98
TH	Hrs	8.321	12.09	9.01
TIRR	Dummy			
PS	Litres	3.812	4	7
UR	Kgs	98.71	142.9	134
FYM	Kgs	5418.21	6512	5321
AG	Yrs	22	60	35
EDU	Yrs	Primary	Masters	---
EX	Yrs	25	3	24
AR	Acre 1.47	1	16	1.234
DAP	Kgs	65.2	86.21	165
TC	PKR	20,000	150,000	12000

Where: SP: Seed Price; L: Labor; TH: Tractor hours; TIR: type of irrigation; PS: Pesticide; UR: Urea; FYM, AG: Age; EDU: Education; AR: Area; DPA: Diammonium phosphate; TC: Total Cost and MOUM: mean of unit of measurement.

Table 2 reports the results of technical efficiency and inefficiency of one hundred farmers in the district Lasbela.

Table 2: MLE results of the CDFP.

Variable	Coefficient	t-value	P-values
Intercept	0.32	0.814	0.781
SP	0.791	2.201	0.009
L	0.012	2.002	0.001
TH	0.167	2.051	0.002
TIRR	0.812	4.143	0.001
PS	-0.020	0.023	0.060
UR	0.118	5.809	0.000
HS	0.680	3.010	0.005

The results indicate that altogether explanatory variables of the model are statistically significant and having the appropriate sign as economics theory postulated apart from pesticide. The results of the MLE model shows that seed, work, tractor hours, pesticides, urea, and high bride seeds were significant and positively related to the tomato yield. It shows that one percent upsurge in seed rate, workforce, work hours of the tractor, type of irrigation, urea, and hybrid seeds typically on average had propensity to intensify the technical efficiency, by 0.79, 0.12, 0.16, 0.81, 0.12, and 0.68, respectively. However, the pesticide coefficient is insignificant and carries a negative sign, this may be due to the excessive and inappropriate use of pesticides, generally, as the farmers have limited knowledge and information about the use of the chemical.

Likewise, the results of technical inefficiency are presented in Table 3.

Table 3: MLE results of technical inefficiency effect model.

Variable	Coefficient	t- value	P-value
Intercept	0.320	0.814	0.831
AGE	0.250	2.890	0.059
EXP	0.230	3.084	0.001
EDU	0.100	0.091	0.015
ART	0.017	1.011	0.029
CTP	0.010	1.021	0.021
DAP	0.021	1.001	0.030

The results of the technical inefficiency show that there is an encouraging association between the farmer's age and technical inefficiency. It implies that an increase in the farmer's age upsurges inefficiency. Furthermore, projected result discovered that there is an adverse and statistically significant relationship between the farmer's experience and technical inefficiency, which infers that an upward surge in the farmer's experience cuts technical inefficiency and rises technical efficiency. The result of this study also in line with Khan and Ali (2013) and Mustapha and Sallihu (2015). The association between education, cultivated area, and DAP with technical inefficiency is adverse and insignificant, the results consistent with Adigbite and Adeoye (2015), Soloman et al. (2015), and Gichimu et al. (2015). Moreover, the connection between the cost of tomato production and technical inefficiency is positive and statistically insignificant (its significance is reported in table). The outcomes

of the maximum likelihood estimate elucidated the variance parameter, which is gamma with a value of 0.68%, and exhibited that the total production variation, 68% is due to the technical inefficiency of U1. Of farmers in the study the surface while, the rest 32% variation is because of natural uncertainty factor.

The frequency distribution of the technical efficiency is reported on Table 4.

Table 4: The Frequency distribution of technical efficiency.

TE	No	Percentage
0.75-0.80	25	25%
0.80-0.85	35	35%
0.85-0.90	33	33%
0.90-0.95	07	07%
Maximum	95	
Minimum	75	

The results in the table revealed that the average technical efficiency of tomato farm in the district is 0.85; nevertheless, the upper and lower limits of the technical efficiency are reported of 0.95 and 0.75, respectively. Henceforth, results of the technical efficiency mark that there is an overwhelming possibility for tomato cultivators to further spur their technical efficiency and production in the short-term. Moreover, the results of the table 04 further indicated that the 35% of the farmers' technical efficacy is between 0.80% to 0.85%, while, 33% of the farmers' technical efficiency is greater than 85% but less than 90%. Likewise, only 25% of tomato respondents have a technical efficiency between 0.75% and 0.80% whereas just a minor 07% famers technical efficiency have touched the maximum limits between 0.90% and 0.95%.

Conclusions and Recommendations

The result of the study discovered that the seed rate, workforce, work hours of the tractor, urea, and hybrid seeds typically and fertilizers are significant components to expand the production of tomato in the study area. In terms of inefficiency the factors which offshoot is the experience of farmers and shows a negative relationship with technical inefficiency. This means that agricultural experience is a noteworthy aspect that cuts the technical efficiency of tomato growers. Based on the results of this study, extension staff is encouraged to push tomato growers to improve seed rate, tractor's hours, and DAP application to expand the technical efficiency of the farmers. In addition, the study advocates that the government should provide best training and information about tomatoes farming to the tomato growers on scientific lines. Moreover, as tomato is a cash crop and requires a lot of labor, so provision of credit on easy terms to the farmers will support and enhance the capability of the farmers to buy appropriate and classy inputs for tomato production.

Authors Contribution

Khalid Khan, Marguerite Wotto, Saima Liaqat and Gulawar Khan designed and conducted the study. Balach Rasheed, and Sara Rafiq conducted analysis of data and provided final interpretation. However, Guo Xiangyu provided resources for study and did overall supervision.

Conflict of interest

The authors have declared no conflict of interest.

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