Efficiency analysis of tomato crop in District Sheikhupura, Punjab Pakistan

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Abstract

Agriculture sector still plays an important role in the economies of developing countries. Pakistan is not an exception. Vegetables are an important source of food security and livelihood for the masses. This study aimed to improve the tomato cultivation. The objectives were to: estimate cost of production of tomato and benefit cost ratio; estimate domestic terms of trade; identify issues faced by the farmers; and suggest policy implications. Both primary and secondary data were collected. Primary data were collected from 100 farmers of District Sheikhupura based on the share of the district in tomato production. Data were analyzed using economic and statistical techniques such as profitability, BCR, comparison of means and frequency distribution. The efficiency analysis was conducted by using Data Envelopment Analysis through DEAP software. Economic analysis showed that, large farmers were getting more benefits with highest BCR i.e. 1.06 followed by small farmers 1.04 and medium farmers 1.01. There was very little difference among all farmers according to economic efficiency. It was found that the profitability of tomato production has gone down over the years. Farmers in the study area produced higher yields than the national average, but significantly less than the global average. The most important issue faced by the farmers was input-output prices along with timely availability of quality seed. The efficiency analysis showed that the technical and economic efficiency of small farmers were high. Technically small farmers were 98 percent efficient. It means that 2 percent outputs can be increased by using same inputs. The medium and large farmers were 94 and 91 percent efficient respectively. Results of Tobit model showed that Tomato growers' efficiency is improved by factors such as age,

education, agricultural experience, and tube-well ownership. This study suggests rectify the imbalances in the input and output markets especially in the seed market.

Keywords: Economics of Production. BCR. Terms of Trade. Small Farmers. Tomato. Sheikhupura. Punjab. Pakistan.

1. Introduction

Agricultural sector is still amongst the largest contributing sectors toward the national GDPs of developing countries (Diao *et al.*, 2005; Katircioglu, 2006). It provides livelihoods to the majority of the rural people which improves the living standards by reducing hunger and poverty (Birkhaeuser *et al.*, 1991; Owens *et al.*, 2003). For this, the agricultural sector need to grow on a reasonably high pace which emphasizes the role of smallholder farmers (Deller *et al.*, 2003). In most of the cases, such farmers performed efficiently in both developed and developing countries (Diao *et al.*, 2005).

In case of Pakistan, agricultural sector contributes about 19% towards its national GDP. In order to meet the growing food requirements of the population which is growing at 2.4% per annum, higher growth of agricultural sector is important. The sector grew by a meager amount of 0.85% as against the previous year's growth and target of 3.8% during 2018-19. The crops sector experienced a negative growth of -4.43% as compared to last year's of 3.8% and the target of 3.6% (GOP, 2018).

Tomato is one of the most important vegetables throughout the world. Its products are commonly used in kitchen and or as a supplement of fried food. These products include: tomato paste, juice, ketchup, etc. It contains rich amount of vitamins A and C and is widely used in cooking (AVRDC, 1996). On average, based on 2000 calories diet, tomatoes provide about 20% of the vitamin C requirements. Furthermore, it contains an antioxidant named Lycopen which is useful to avoid the growth of different cancer types (Adenuga *et al.*, 2013).

Total tomato production of the world is about 200 million tonnes (Global Tomato Industry Report, 2020) with China the most productive country (59.6 million tonnes) followed by India (20.7 million tonnes), Turkey (12.7 million tonnes), United States of America (10.9 million tonnes) and Egypt (7.3 million tonnes (FAOSTAT, 2019). Tomato is grown in all the provinces of Pakistan and is available to the consumers around the year (Chohan and Ahmad, 2008). Pakistan ranks 34th in terms of tomato production and 11th in terms of area under cultivation (GOP, 2015). Majority of the tomato production comes from the smallholder farmers having 1-2 hectares of land (Schlenker *et al.*, 2005; Furuya *et al.*, 2009). In peak

seasons, farmers usually get very low prices besides heavy post-harvest losses due to perishable nature of the crop. Lack of processing facilities further deteriorates the situation which results high prices for the consumers (Kirby *et al.*, 2016).

It is, therefore, necessary that a comprehensive economic and efficiency analysis be conducted of the tomato production in order to identify the economic benefits to the farmers and issues faced by them. This study aims to improve the tomato cultivation for which the objectives are to:

- estimate economics of tomato production
  a. estimate profitability of tomato production
  b. identify yield gaps and issues faced by the farmers
  c. estimate domestic terms of trade
- estimate technical and economic efficiency of tomato production
- suggest policy implications

2. Literature Review

Tomatoes are the most extensively produced garden crop globally. It is an essential element in many people's diets. It is a good source of vitamin C, potassium, folate, and vitamin K, as well as antioxidants like lycopene. Tomato is a seasonal crop and its availability restricted during specific seasons. Tomatoes can be used in a variety of ways, both fresh and cooked (Gastelum-Barrios et al., 2011; Soytong et al, 2021). In terms of area, yield and commercial use tomato is one of the most important vegetables (Qasim et al, 2018). In comparison, the tomato production is two times higher as compare to potatoes and four times as compare to rice. Tomato is the most processed crop in the world. Every year, about 39 million tonnes of tomatoes are processed in factories belonging to the world's most prestigious food brands (FAO, 2019).

Nearly, 200 million tons of tomatoes are produced globally with revenue of about $190 billion. Global exports of tomatoes stand at 7.3 million tons. Over the years, the total export volume has increased by 1.6 percent annually. Mexico is one of the leading exporters and the United States is the leading importer of tomatoes (Global Tomato Industry Report, 2020).

China is the largest producer of tomato accounting 52 percent of total production. Pakistan's contribution to world tomato exports was negligible in the year 2000. In 2007, tomato exports grew significantly (Tahir et al, 2012). Pakistan is the 33rd largest tomato

producer and the 52nd largest tomato exporter in the world. It accounts for 1.3 percent of global tomato area, 0.33 percent of global production, and 0.06 percent of global export. In the international tomato production, Pakistan ranks quite low in terms of per ha yield, export-production ratio, and export price. Its yield is only around a quarter of the global average. Pakistan is a net importer of fresh and processed tomatoes and the country is facing growing trade deficit. It grew from US$0.33 million in 2001 to US$114.9 million in 2016, before falling to US$32.4 million in 2017. During the period 2001-17, the country's tomato trade imbalance grew at a rate of 49 percent a year on average (TCFTS, 2020). Fresh veggies are Mexico's most important agricultural export (Bayard et al, 2009). In comparison to rain-fed locations, tomatoes are more profitable and economically effective when grown under irrigation. Increased access to land, herbicides, and improved seeds will help the crop in the research area to be more profitable (Ayools, 2014). Cost of tomato production consists on land preparation cost, inputs cost (seeds, fertilizer, weedicide, manure and irrigations) and harvesting costs (Biswas et al., 2015).

The ability of transforming input into output is known as efficiency (Tabe-Ojong and Molua (2017). The efficiency analysis helps to understand the potential improvement in farm production (Ogunniyi and Oladejo, 2011). The difference between what farmer is producing and what he can produce with the existing resources is calculated by technical efficiency (Khan and Shoukat, 2013). Efficiency can be measured by parametric and non-parametric approaches. Farm efficiency is normally measured using a non-parametric approach known as Data Envelopment Analysis (DEA). The efficiency of Decision Making Units (DMU) is measured in relation to the optimal production units in the DEA. It is an input-oriented and output-oriented approach. Input-oriented DEA approach minimizes the inputs use for a certain production. Output-oriented DEA approch maximize the output with available inputs (Uzundumlu et al. 2021). DEA uses linear programming to create a piecewise linear envelopment frontier (Parlakay and Çimrin. 2021).

According to the available literature, most farmers, regardless of the size of their holdings, have technical inefficiency issues. Technical efficiency was positively influenced by education, age, and the adoption and use of agronomic practices (Tabe-Ojong and Molua, 2017). Khan and Shoukat (2013) used a stochastic frontier approach to calculate technical efficiency of tomato grower. In the Pakistani district of Peshawar, tomato growers were found to be 92 percent effective on average. Technical efficiency of tomato growers in Nigeria was estimated by Zalkum et al., (2014). Tomato growers had a technical efficiency of 0.69. Due to differences in technical efficiency, 31.03 percent of farmers were below the frontier level.

Donkoh et al., (2018) conducted a study to assess tomato growers' technical efficiency in Northern Ghana. The average technical efficiency was 0.93, indicating that production can be enhanced by 7 percent using present inputs. The technological efficiency of tomato growers in Karnataka, India, was assessed by Murthy et al., (2009). Small tomato growers were found to be cost-effective, whereas medium-age growers were found to be technically efficient due to reduced production costs. Furthermore, the majority of the larger farmers were inefficient in terms of technology. Farmers were unable to adopt current technology, so they relied on what was available at the time, resulting in lower tomato production and inefficiency. Farmers who adopt innovative technologies get a higher return on investment and higher output.

Tomato producers in Nowshera, Khyber Pakhtunkhwa, were observed for their technical, allocative, and economic efficiencies (Khan, 2020). Tomato growers had a technical and allocative efficiency of 65 and 56 percent, respectively. Tsoho et al. (2018) investigated the factors that influence the technical and economic efficiency of vegetable farmers in Nigeria's Sokoto state. The location of the farm, the frequency of extension visits, the cropping pattern, and irrigation were all found to have a substantial impact on technical and economic efficiency. The average technical efficiency of tomato growers in Peshawar, KPK, was calculated. 92 percent of farmers attained technical efficiency, with a growing return to scale (Khan and Ghafar, 2019).

3. Materials and methods

3.1. Data collection

Lahore division contributes the highest tomato production (i.e. 24,678 tonnes) out of which District Sheikhupura contributes 20,306 tonnes (GoPb, 2018). The district is comprised of five Tehsils i.e. Sheikhupura, Ferozwala, Muridke, Sharaqpur and Safdarabad. Out these tehsils, two were randomly selected i.e. Sheikhupura and Safdarabad. From each tehsil, 5 villages were randomly selected. From each village 10 farmers were selected randomly. This made a total sample size of 100. A well-structured questionnaire was used to interview the farmers.

Table 1: Selection of respondents

Sr. No.	Strata	Villages	Respondents	
1	Sheikhupura	5	10 farmers	50
2	Safdarabad	5	10 farmers	50

Total	2	10	100

Based on the final selection of the farmers, they were categorized into small (up to 5 acres of land), medium (from 5 to 12.5 acres of land) and large (above 12.5 acres of land) farmers. Majority of the famers (53.0%) were small followed by medium (29.0%) and large (18.0%).

Table 2: Distribution of the farmers according to their landholdings

	Frequency	Percentage
Small Farmers (< 5 Acres)	51	51.0%
Medium Farmers (5 to 12.5)	31	31.0%
Large Farmers (>12.5 Acres)	18	18.0%
Total	100	100.0%

3.2. Estimation of the economics of tomato production

3.2.1. Profitability of tomato production

The cost of production of tomatoes was estimated using a comprehensive information on farming practices. Following the economic analyses conducted by Olukosi and Erhabor, 1998; Khan *et al.*, 2011; Alam *et al.*, 2013; Sehto *et al.*, 2018, for different crops, the average total cost of production was calculated as:

$$TC = \sum_{i=1-8}^{n} CoP\_Tomato_i \qquad 1$$

Where,

TC = Total Cost

CoP _ Tomato = categories of expenditures (eight sub-operations of production process i.e. land preparation/ preparatory tillage, seed bed preparation, seed and sowing operations, fertilization, plant protection, irrigation, harvesting and miscellaneous)

1 = Land preparation expenditures include the expenditures on deep ploughing, ploughing / cultivator and leveling.

2 = Seed bed preparation expenditures include ploughing and planking expenditures

3 = Seed and sowing operations include the expenditures on seed, planting with ridger and labor charges.

4 = Fertilization include the expenditures on chemical fertilizers i.e. urea, DAP, Potash, etc.

5 = Plant protection expenditures include insecticide and fungicide costs

6 = Irrigation expenditures include aabiana, and tube well expenditures

7 = Harvesting includes handling, bags and transportation expenditures

8 = Miscellaneous include expenditures like land rent, agricultural income tax, market commission, etc.

Total revenue was estimated:

$$TR = AvY_{i=1-100} * FGP \qquad 2$$

Where,

TR = Total Revenue

$AvY_{i=1-100}$ = Average yield of sample farmers

FGP = Average farm gate price

Profit was calculated by subtracting total costs from total revenues:

$$\pi = TR - TC \qquad 3$$

Where,

π = Profit

While the benefit cost ratio was calculated as:

$$BCR = TR / TC \qquad 4$$

Where,

BCR = Benefit-cost ratio

3.3. Comparison of means

Comparison of mean technique was applied in order to differentiate between the profitability of small, medium and large farmers. This technique is widely used in comparative analysis see for example (Baba *et al.*, 2014; Hyblova and Skalicky, 2018; Mogula and Mishili, 2018; Arru *et al.*, 2019).

3.3.1. Yield gaps and issues faced by Farmers

The yield gaps were calculated by comparing the yields of the farmers in study area with the average country yields of Pakistan, India, Bangladesh, China and World.

To identify the issues faced by the farmers, frequency distribution and percentages were used.

3.3.2. Domestic terms of trade

Domestic trade is different from international trade. It refers to the exchange of domestic goods within a country's borders (Pellegrina and Sotelo, 2021). This can be broken down into two types: wholesale and retail. Wholesale commerce entails purchasing large quantities of items from manufacturers, dealers, or producers and reselling them in smaller numbers to others, such as retailers or consumers. Selling things to the final consumer is known as retail trade. Tomato prices are extremely variable. During the peak period, tomato prices plummeted. Farmers who have been harmed by the drop in pricing during the peak session have decided to cease harvesting their crops due to a lack of revenue (Khan, 2021).

3.4. Economic and technical efficiency of tomato production

Farrell (1957) calculated the technical efficiency for the first time. For efficiency analysis, two approaches are used; one is a parametric approach, while the other is a non-parametric one. Econometric techniques are employed in the parametric approach, while mathematical programming is employed in the non-parametric approach (Uzundumlu et al, 2021). The main advantage of the parametric approach is that it allows for a stochastic error term in the model. The DEA is used in a non-parametric method. It evaluates each decision-making unit's relative efficiency in contrast to the best-case scenario (Gutierrez et al., 2017). The DEA method has an input and output orientation approaches. Input oriented model

emphasize to minimize the use of inputs achieve a constant output. In output-oriented model used to maximize the output by using given inputs (Mukhtar, 2018). The model is given as below

$$Y_i = \beta_o + X_i\beta_i + \alpha_i$$
$$\alpha_i = \mu_i - \varepsilon_i$$

Where:

Y_i= Out put

β = Parameters

X_i= Input variables

The error term α_i has two components, u_i and ε_i . u_i is a non-negative random variable measuring inefficiency, and ε_i is a stochastic disturbance term.

3.5. Tobit Model:

The Tobit model deals with a continuous dependent variable that is constrained in nature. Tobit Regression Analysis used instead of Logit and Probit Regression because of censored dependent variable of Efficiency. The Tobit regressions are suitable for modeling, in which the dependent variable is bounded between two values. The value of the dependent variable cannot move away from those boundaries. Mostly the dependent variable is bounded between zero and one, it cannot take values less than zero and greater than one (Benmehaia et al (2017); Weldegiorgis et al. (2018).

$$Yi = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i}$$

Here

Y_i = Economic Efficiency of tomato

X_1= Age (Years)

X_2 = Family Size (No.)

X_3 = Tube-well ownership (Yes=1, No=0)

X_4 = Education (Years)

X_5 = Experience (Years)

4. Results and Discussion

4.1. Economics of tomato production

Average total cost of the tomato production was estimated as PKR 73,181 while the average total cost of small farmers was estimated as PKR 70,510, medium farmers as PKR 73,629 and of large farmers as PKR 75,404. The comparison of means results, however, explained that there is no statistical difference in small, medium and large farmer's cost of production. The highest share in total cost was of harvesting sub-category (7) with an amount of PKR 28,655. There was a slight difference in the cost of harvesting of small, medium and large farmers i.e. PKR 25,132, 29070 and 31,764, respectively.

On average, PKR 25,881 were spent on fertilization, plant protection and irrigation operations. Small farmers spent the least i.e. PKR 22,326 followed by medium farmers (PKR 24,589) and large farmers (PKR 30,742). A detailed comparison is shown in Table 3 below. There were slight differences in yields. Small farmers had the lowest yield i.e. 5,640 kgs/ acre while medium farmers had a yiled of 5,710 kgs/acre and larger farmers had a yield of 6,120 kgs/ acre. This made a difference in the total revenues and profits of these farming categories. As a result, large farmers had the highest BCR i.e. 1.06 followed by small farmers (1.04) and medium farmers (1.01).

Table 3: Cost of Production, Gross Income, Profit and Benefit-Cost Ratio

	Activities (PKR)	Small Farmers n = 51	Medium Farmer n = 31	Large Farmers n = 18	Total Sample n = 100
1	Land Preparation / Preparatory tillage	2,185	2,132	1,956	2,093
2	Seed bed preparation	1,450	1,450	845	1,249
3	Seed and sowing operations	7,219	5,770	5,779	6,256
4	Fertilization	6,966	10,499	11,732	9,732
5	Plant protection	7,260	7,560	7,760	7,526
6	Irrigation	11,250	8,100	6,520	8,623
7	Harvesting	25,132	29,070	31,764	28,655
8	Miscellaneous	9,048	9,048	9,048	9,048
	Total Average Cost	70,510	73,629	75,404	73,181
	Yield / acre (Kgs)	5,640	5,710	6,120	5,823
	Average Farm gate price (PKR / Kg)	13	13	13	13
	Gross Income / acre	73,320	74,230	79,560	75,700
	Net Profit	2,810	601	4,156	3,705
	BCR	1.04	1.01	1.06	1.03

The overall benefit cost ratio has gone down over the years. This is evident from the comparison of recent studies in Table 4.

Table 4: Comparison of BCR results with previous studies

Reference	Study Area	Total observation	BCR
Current Study	Sheikhupura	100	1.03
Ali et al., 2017	Faisalabad and Toba Tek Singh	70	2.52 (Off season)
Aslam and Hong, 2018	Khyberpakhtunkhwa	150	3.13
Aslam and Hong, 2018	Azad Kashmir	150	3.04
Kushwaha et al., 2018	India	60	1.68
Samshunnaha, et al., 2016	Bangladesh	60	1.91

4.2. Yeld gaps

The yields of farmers in the study area were above the average Pakistani yields but way less than the world average. The yields were slightly greater than the average yields of Bangladeshi farmers but about 50%, 62% and 75% less than Indian, World and Chinese farmers' average yields.

Table 5: Yield gap analysis

	Tonnes / Acre	Maunds / acre
Current study*	5.823	132
Pakistan Average	3.85	87
India Average	10.51	238
Bangladesh Average	5.69	129
China Average	23.35	530
World Average	15.22	345

Data source: FAOSTAT, 2019 converted from hg / ha to tonnes / acre and maunds / acre
* Field Survey

4.3. Issues faced by farmers

Farmers reported various issues which they faced during the production process of tomato. Majority (85%) of the farmers stated that the output price volatility is the most crucial issue they face once the crop is harvested. Over 75% farmers reported that high input costs is an issue of concern and must be taken care of. Little over 60% farmers complained the non-availability of quality seeds at the time of need.

Lack of access to credit facilities was another prominent issue faced by 60% of the farmers. Earlier studies have also pointed out similar issues with credit availability for different agricultural crops (see for example Hassan *et al.*, 2005; Abedullah *et al.*, 2006; Iqbal, 2015; Rehman *et al.*, 2015). Half the famers complained about higher costs of storage facilities / lack of storage facilities at the time of peak harvesting. Other issues included high transportation costs and lack of grading facilities.

Table 6: Issues reported by the farmers

Sr. #	Issues	Frequency	Percentage
1	Low output price / highly volatile output price	85	85
2	High input prices	76	76
3	Non availability of quality seed	63	63
4	Lack of access to credit facilities (difficult accessibility - cumbersome procedures)	60	60
5	High cost of storage facilities	50	50
6	High transportation costs	35	35
7	Lack of grading facilities	30	30

4.4. Domestic terms of trade

The analysis of the terms of trade with respect to plowing (traction), farm labor and fertilizers (Urea and DAP) is presented in Figures 1 - 3. The cost of plowing and wage rate has gone up over the years as evident from Figure 1. The trend lines explain a steady rise in these costs. The cost of plowing operation is steeper because of the rise in petroleum prices. Figure 2 explains the amount of tomatoes required in kgs to buy one unit of these inputs. The trend line shows an increase in the quantity required to buy the inputs. Similarly, Figure 3 shows the domestic terms of trade in PKR of input and output prices. This shows a gradual increase implying that farmers' profit margins have gone down over the years.

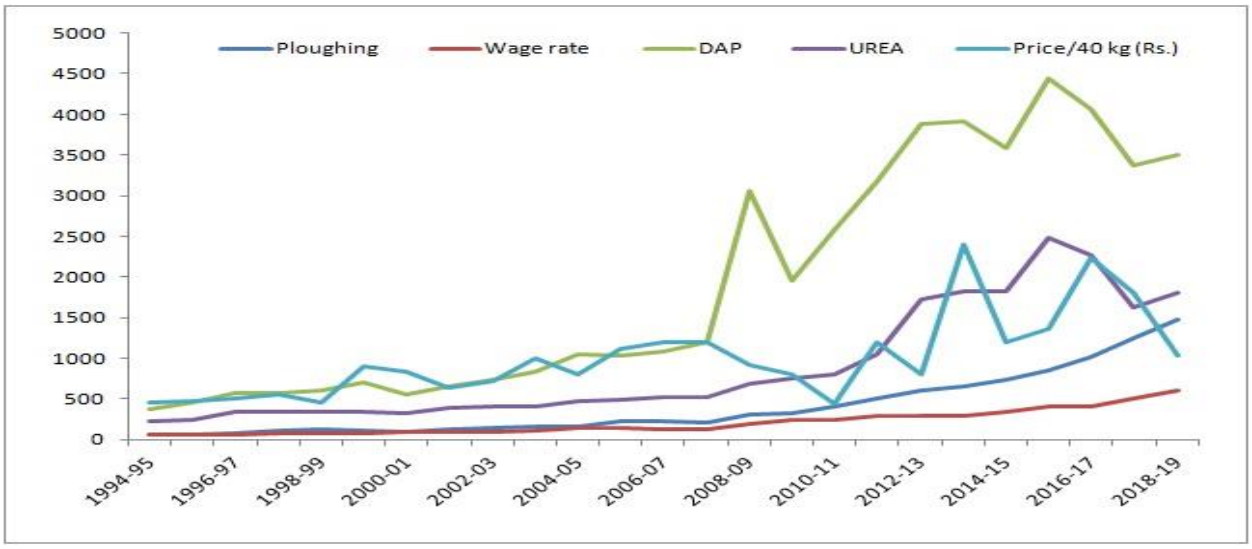

Figure 1: Input-output price trends

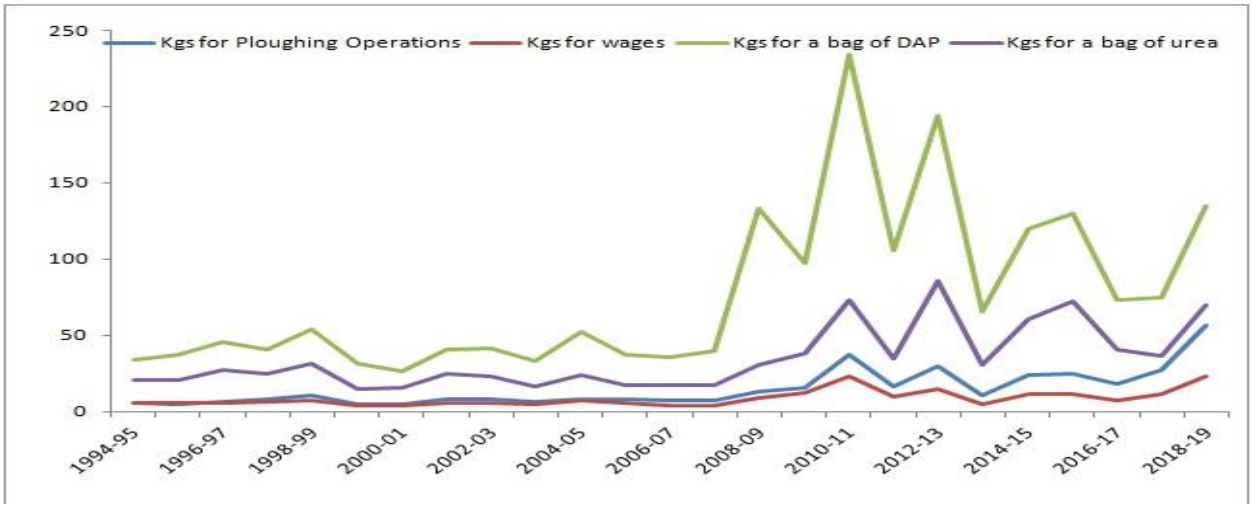

Figure 2: Domestic terms of trade

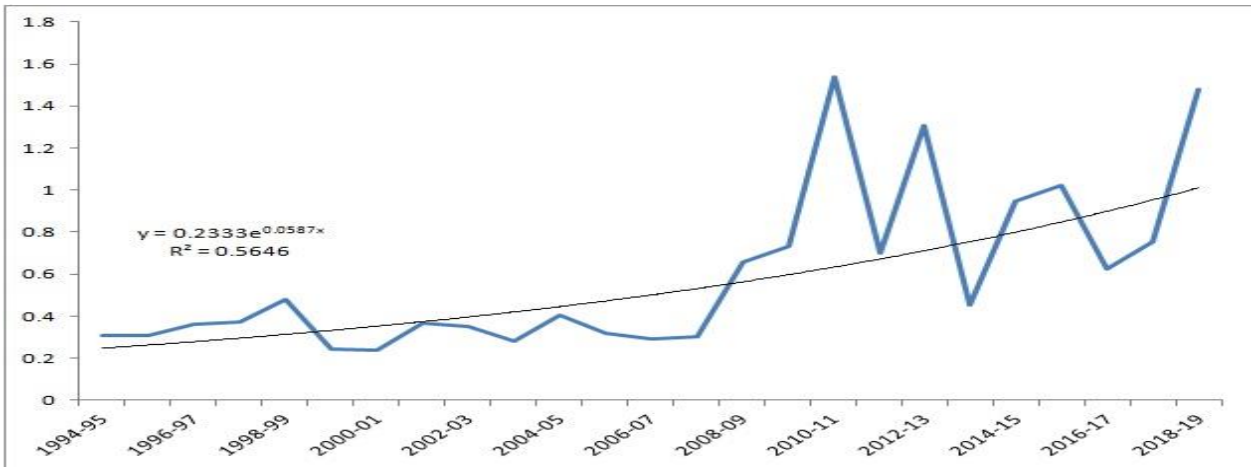

Figure 3: Input-output price ratio

4.5. Economic and technical efficiency

It is evident from **Table 7** that the mean technical efficiency of small farmers is 0.98.The results of the study imply that small farmers were attaining highest technical efficiency as compare to medium and large. The result was similar with the study done by (Murthy et al., 2009; Khan and Ghafar, 2019). The small farmer can increase their output by about 2 percent with the same inputs. Medium farmers were 4 percent and large farmer 7 percent less efficient as compare to small farmers.

Table 7: The technical efficiency of tomato growers

Categories	Small	Medium	Large
0.71-0.80	-	-	8
0.81-0.90	-	10	-
0.91-1.00	51	21	10
Average	0.98	0.94	0.911

The economics efficiency of tomato grower is shown in Table 8. The mean economic efficiency for small, medium and larger farmers was 98, 97 and, and 98 percent respectively. It shows that economically farmer were equally efficient.

Table 8: The economic efficiency of tomato growers

Categories	Small	Medium	Large
0.71-0.80	-	-	-
0.81-0.90	5	4	1
0.91-1.00	46	27	17
Average	0.98	0.97	0.98

4.6. Tobit model results

The results showed that the efficiency will grow by 0.001 units for every unit increase in age as shown in Table 9. Technical efficiency of tomato growers is positively influenced by education and farming experience. The findings are in line with Gwebu and Matthewa's (2018) and Weldegiorgis et al., (2018). Family size has negative impact on technical efficiency. One unit increase in family size will reduced the technical efficiency by 0.016 units. Tube-well ownership was add in the farm of dummy variable owned tube-well positively affect the technical efficiency of tomato growers. Distance from market is negatively affecting the efficiency as reported earlier by Tabe-Ojong and Molua, (2017).

Table 9: Tobit model results

Variable	Coefficient	Std. Error	P-value
Age	0.001	0.003	0.527
Education	0.002	0.004	0.979
Farming experience	0.004	0.002	0.879
Family size	-0.016	0.005	0.003
Tube-well ownership	0.044	0.042	0.290
Distance from market	-0004	0.006	0.496
Constant	1.26	0.145	0.000

5. Conclusions

Tomato is one of the most widely consumed vegetable. The goal of the study was to improve tomato cultivation. The farmers were spending on an average PKR 73,181 on tomato production. There was a slight difference in the expenditures of small, medium and large farmers which was statistically non-significant. Similarly, there was a meager difference in their yields and profitability which was not statistically significant. Over time, the farmers' profitability has diminished. Furthermore, a significant gap was observed in average world yield and regional average yields. Though the average yield of the sample farmers was better than Pakistan's and Bangladesh's average yields, still there is a room to catch the gap between other neighboring countries' average yields and world average yield. Farmers reported seven major issues in the production process. In which the issues related to input-output prices and timely availability of quality seed were of major concern. The domestic terms of trade analysis indicates serious issues in both input and output markets. Efficiency analysis showed that small farmers were more efficient technically and economically. The factors like age, education, farming experience and tube-well ownership improve the efficiency of tomato growers. It is recommended that the market regulations both in input and output markets may be implemented in letter and spirit. Furthermore, research on different aspects of economics and policy of tomato production should be carried out at a regular interval in order to identify major evils in the production system.

6. References

ABEDULLAH, S.; KOUSER, K. M.; MAZHAR, M. Role of credit to enhance cotton production in Punjab, Pakistan. *Pakistan Journal of Agricultural Sciences*, v. 43, n. 3-4, p. 197-205, 2006.

ADENUGA, A.H.; LAWAL, A.M.; ROTIMI, O.A. *Economics and technical efficiency of dry season tomato production*. Agris on-line papers in Economics and Informatics in selected areas in Kwara State, Nigeria, v. 5, p. 11-19, 2013.

ALAM, M.K.; ABOKI, E.; GIDADO, E.H.; BUBA, D.D. Economic analysis of cotton production in selected local government areas of Taraba State, Nigeria. *Journal of Agricultural Sciences*, v. 4, n. 1, p. 27-31, 2013.

ARRU, B.; FURESI, R.; MADAU, F.A.; PULINA, P. Resreational services provision and farm diversification: A techi=nical efficiency analysis on Italian agritourism. *Agriculture*, v. 9, n. 2, p. 1-15, 2019.

AVRDC. Vegetable research networking in South Asia: Savernet Phase I final report; Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan 741, ROC. p.76, 1996.

AYOOLA, J. B. Comparative economic analysis of tomato (Lycopersicon esculenta) under irrigation and rainfed systems in selected local government areas of Kogi and Benue States, Nigeria. *Journal of Development and Agricultural Economics*, v. 6, n. 11, p. 466-471, 2014.

BABA, M. D.; YELWA, J.M.; YAKUBU, G.; SANCHI, I.D. Comparative profitability analysis of watermelon and pepper production in Danko-Wasagu local government area of Kebbi State, Nigeria. *Review of Knowledge Economy*, v. 1, n. 2, p. 39-47, 2014.

BAYARD, B.; CHEN, L.; THOMPSON, H. Free trade and a case of local tomato production. *Agricultural Economics Review*, v. 8, (389-2016-23310), 2009.

BENMEHAIA, A. M.; BRABEZ, F.; BENHARRATH, O. Production contract performance in tomato processing industry: analysis of Algerian case. *International Journal of Food and Agricultural Economics* (IJFAEC), v. 5, (1128-2018-071), p. 97-108, 2017.

BIRKHAEUSER, R.; EVENSON, R.; FEDER, D. The economic impact of agricultural extension: a review. *Economic Development and Cultural Change*, v. 39, n. 2, p. 507-21, 1991.

BISWAS, S. K.; AKANDA, A.R.; RAHMAN, M.S.; HOSSAIN, M.A. Effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato. *Plant, Soil and Environment*, v. 61, n. 3, p. 97-102, 2015.

CHOHAN, T. Z.; AHMAD, S. An assessment of tomato production practices in Danna Katchely, Azad Jammu Kashmir. *Pak J Life Soc Sci*, v. 6, p. 96-102, 2008.

DELLER, S. C.; GOULD, B.W.; JONES, B. Agriculture and rural economic growth. *Journal of Agricultural and Applied Economics*, v. 35, n. 3, p. 1-8, 2003.

DIAO, X.; HAZELL, P.D.; RESNICK, J.; THURLOW, M.; ROCKMORE, M.; ABRENILLA, M. The role of agriculture in Sub-Saharan Africa – conventional wisdom, current debate and country studies. Draft paper, International Food Policy Research Institute, Washington, D.C. 2005.

DONKOH, S.A.; TACHEGA, M.; AMOWINE, N. Technical efficiency of tomato production: The case of Irrigation Company of Upper Region (ICOUR) in the Kasena Nankana district of Northern Ghana. Dep. Agric. Resour. Econ., Facul. Agric. Univ. Dev. Stud. Tamale, Ghana. 2018.

FAOSTAT. Compare data - 2017. Food and Agricultural Organization of United Nations, New York, USA. Online available at http://www.fao.org/faostat/en/#compare accessed on 27/05/2019. 2019.

FARRELL, M. J. The measurement of productive efficiency, *Journal of Royal Statistical Society*, v. 120, n. 3, p. 253-290, 1957.

FURUYA, J.; KOBAYASHI, S.S.; MEYER, D. *Impacts of global warming on the world food market according to SRES scenarios*. World Academy of Science, Engineering and Technology, 57, 2009.

GASTELUM-BARRIOS, A.; BORQUEZ-LOPEZ, R. A.; RICO-GARCIA, E.; TOLEDANO-AYALA, M.; SOTO-ZARAZUA, G.M. Tomato quality evaluation with image processing: A review. *African Journal of Agricultural Research*, v. 6, n. 14, p. 3333-3339. 2011.

GLOBAL TOMATO INDUSTRY REPORT 2020: Trends & Opportunities by Country, Consumption, Production, Price Developments, Imports and Exports (2007-2025) Dublin, Feb. 14, 2020 (GLOBE NEWSWIRE).

GOP. Economic survey of Pakistan 2014-15. Economic Advisor's Wing., Finance Division. Ministry of Finance, Islamabad Pakistan. 2015.

GOP. Economic survey of Pakistan 2017-18. Economic Advisor's Wing., Finance Division. Ministry of Finance, Islamabad Pakistan. 2018.

GOPb. Kharif crops final estimates data book 2016-17. Directorate of Agriculture, Crop Reporting Service, Punjab, Multan Road, Lahore. http://www.amis.pk/Agristatistics/DistrictWise/2016-17.pdf accessed on 29/03/2019. 2018.

GUTIERREZ, E.; AGUILERA, E.; LOZANO, S.; GUZMAN. G.I. A two-stage DEA approach for quantifying and analysing the inefficiency of conventional and organic rain-fed cereals in Spain. *Journal of cleaner production*, v. 149, p. :335-348, 2017.

GWEBU, J. Z.; MATTHEWS, N. Metafrontier analysis of commercial and smallholder tomato production: A South African case. *South African Journal of Science*, v. 114, n. 8, p. 55-62, 2018.

HASSAN, S.; TABASAM, N.; IQBAL, J. An economic analysis of wheat farming in Mixed Farming Zone of Punjab Province, Pakistan. *Journal of Agriculture and Social Science*, 2005, n. 1-2, p. 167-171, 2005.

HYBLOVA, E.; SKALICKY, R. Retuens on sales a nd wheat yields per hectare of European agricultural entities. *Agricultural Economics*, v. 64, n. 10, p. 436-444, 2018.

IQBAL, M. A. An investigation into crops improved seed availability, snags and future prospect for Pakistan. *American-Eurasian Journal of Agriculture and Environmental Sciences*, v. 15, n. 3, p. 308-314, 2015.

KATIRCIOGLU, S. T. Causality between agriculture and economic growth in a small nation under political isolation: A case from North Cyprus. *International Journal of Social Economics*, v. 33, n. 4, p. 331-343, 2006.

KHAN, H. Measurement of technical, allocative and economic efficiency of tomato farms in northern Pakistan. *J. Agric. Sci. Technol*. v. 2, p. 1080-1090, 2020.

KHAN, M.B.; CHAUDHRY, I.S.; AKHTAR, M.H. Cost-benefit analysis of cotton production and processing by stakeholders: The case of Multan and Bahawalpur regions. *American Journal of Scientific Research*, v. 13, p. 131-144, 2011.

KHAN, R. E. A.; SHOUKAT, G. Technical efficiency of tomato production: a case study of district Peshawar (Pakistan). *World Applied Sciences Journal*, v. 28, n. 10, p. 1389-1392, 2013.

KHAN, R.E.A.; GHAFAR, S. Technical efficiency of tomato production: A case study of district Peshawar (Pakistan). *World Appl. Sci. J*, v. 28, n. 10, p. 1389-1392, 2019.

KIRBY, J. M.; MAINUDDIN, M.; MPELASOKA, F.; AHMAD, M.D.; PALASH, W.; QUADIR, M.E.; SHAH-NEWAZ, S.M.; HOSSAIN, M.M. The impact of climate change on regional water balances in Bangladesh. *Climate Change*, v. 135, p. 481–491, 2016.

MOGULA, J.; MISHILI, F. Profitability analysis of sustainable agriculture practices to smallholder maize farmers in Kilosa District, Tanzania. *International Journal of Scientific and Research Publications*, v. 8, n. 4, p. 381-389, 2018.

MUKHTAR, U. *Efficiency and profitability of pearl millet production in the north-west region of nigeria*. University putra malaysia. 2018.

MURTHY, D. S.; SUDHA, M.; HEGDE, M.R.; DAKSHINAMOORTHY, V. Technical efficiency and its determinants in tomato production in Karnataka, India. *Agric. Econ. Res. Rev*. v. 22, p. 215-224, 2009.

OGUNNIYI, L. T.; OLADEJO, J.A. Technical efficiency of tomato production in Oyo State Nigeria. *Agricultural Science Research Journal*, v. 1, n. 4, p. 84-91, 2011.

OLUKOSI, J. O.; ERHABOR, O. Introduction to farm management, principles and applications. Samaru, Zaria, Kaduna State, Nigeria: AGITAB Publisher, p.43-47, 1998.

OWENS, T.; HODDINOTT, J.; KINSEY, B. The impact of agricultural extension on farm production in resettlement areas of Zimbabwe. *Economic Development and Cultural Change*, v. 51, n. 2, p. 337-57, 2003.

PARLAKAY, O.; ÇIMRIN, T. Determination of technical efficiency in broiler production using Data Envelopment Analysis method: a case study of Hatay Province in Turkey. *Custos e @gronegócio on line*, v. 17, n. 1, Jan/Mar. 2021.

PELLEGRINA, H. S.; SOTELO, S. Migration, Specialization, and Trade: Evidence from Brazil's March to the West (No. w28421). National Bureau of Economic Research, 2021

QASIM, M.; FAROOQ, W.; AKHTAR, W. Preliminary Report on the Survey of Tomato Growers in Sindh, Punjab and Balochistan. 2018.

REHMAN, A.; JINGDONG, L.; CHANDIO, A.A.; HUSSAIN, I.; WAGAN, S.A.; MEMON, Q. Economic perspectives of cotton crop in Pakistan: A time series analysis. Journal of the Saudi Society of Agricultural Sciences, 2017.

SCHLENKER, W.; HANEMANN, W.; FISHER, A. The impact of global warming on U.S. agriculture: An econometric analysis of optimal growing conditions. *Review of Economics and Statistics*, v. 88, n. 1, p. 113-125, 2005.

SEHTO, G.N.; AHMED, A.M.; NAHIYOON, A.A.; LEGHARI, E.A.K.; RAJPUT, I.A.; ALI, A.; KOLACHI, M.M. Assessment of farmers' profitability on cotton crop at district Sanghar, Sindh, Pakistan. *International Journal of Natural and Social Sciences*, v. 5, n. 3, p. 87-90, 2018.

SOYTONG, M.; GUEVARRA, P.R.; MATEO, J.M.C.; GALVEZ, H. F. Evaluation of tomatoes fruits flesh colour, beta-carotene and lycopene content. *Technology*, v. 17, n. 2, p. 727-736, 2021

TABE-OJONG M. P. JR.; MOLUA, E.L. Technical efficiency of smallholder tomato production in semi-urban farms in Cameroon: A stochastic frontier production approach. *J. Mgmt. & Sustainability*, v. 7, n. 1, p. 27-39, 2017.

TAHIR, A.; SHAH, H.; SHARIF, M.; AKHTAR, W.; AKMAL, N. An overview of tomato economy of Pakistan: comparative analysis. *Pakistan Journal of Agricultural Research*, v. 25, n. 4, 2012.

TCFTS. Planning Commission of Pakistan, Ministry of Planning, Development & Special Initiatives February 2020.

TSOHO, B. A.; OMOTESHO, O.A.; SALAUAND, S.A.; ADEWUMI, O.M. Determinants of technical, allocative and economic efficiencies among dry season vegetable farmers in Sokoto State, Nigeria. *J. Agric. Sci*. v. 3, n. 2, p. 113-119, 2018.

UZUNDUMLU, A. S., M. TAMSEN AND A. BILGIC. (2021). Comparison of organic and conventional wheat in terms of efficiency and cost in Turkey: a case study of Erzurum Province. *Custos e @gronegócio on line* v. 17, n. 1, p. 217-238, 2021.

WELDEGIORGIS, L. G.; MEZGEBO, G.K.; GEBREMARIAM, H.G.E.; KAHSAY, Z.A. Resources use efficiency of irrigated tomato production of small-scale farmers. *International journal of vegetable science*, v. 24, n. 5, p. 456-465, 2018.

ZALKUM, J.; SINGH, R.; PARDHI, R.; GANGWAR, A. Analysis of technical efficiency of tomato production in Adamawa State, Nigeria. *International Journal of Agriculture, Environment and Biotechnology*, v. 7, n. 3, p. 645, 2014.

WELDEGIORGIS, L. G.; MEZGEBO, G.K.; GEBREMARIAM, H.G.E.; KAHSAY, Z.A. Resources use efficiency of irrigated tomato production of small-scale farmers. *International journal of vegetable science*, v. 24, n. 5, p. 456-465, 2018.

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