Efficiency analysis of onion crop: the case of District Okara

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Abstract

Vegetables are considered to be safer, healthier and cheaper food. They provide almost all the essential nutrients i.e., vitamins, minerals, antioxidants, and fiber. They are a source of earning relatively high incomes as compared to other conventional crops. In this backdrop of information, the aim of the was to estimate the economics of onion production; its domestic terms of trade and issues faced by the farmers. Primary data from 100 onion farmers were collected using a stratified random sampling technique. Benefit cost ratio, comparison of means, frequency distribution and Data Envelopment Analysis was used to analyze the data. It was found that for the previous two crops of onion, farmers received profits in 2018 and 2019. The BCR of total sample is 2.85. The domestic terms of trade over the years had deteriorated indicating issues in input and output markets. According to the efficiency analysis, larger farmers have high technical and economic efficiency. Technically large farmers were 14 % more efficient as compare to small farmers. There was little difference among all farmers according to economic efficiency, larger farmers were 9.3 % more efficient with respect to small farmers. Tobit results showed that Age and tube well ownership had positive significant impact on technical efficiency of onion production. The most important issue faced by the farmers was fluctuation of output price followed by the costly inputs and lack of credit and storage facilities. It is recommended that the imbalances in the input and output markets must

be corrected. Furthermore, periodic assessment of profitability of onion production should be carried out in order to identify the standings of the farmers in the market.

Keywords: Economics of Production. BCR. Terms of Trade. Small Farmers. Onion. Okara. Punjab. Pakistan.

1. Introduction

Vegetables are assumed to be a safer, healthier, and more affordable food source (Losio et al., 2015). They contain nearly all of the essential nutrients required by humans (Dias, 2012). They are a source of earning relatively high incomes as compared to other conventional crops (Ali and Abedullah, 2002). The demand for labor to cultivate vegetables is also high compared to other conventional crops, hence more employment is generated (Abedullah et al., 2002). Small farmers play an important role (Deller *et al.*, 2003) in vegetable production (Ahmad et al., 200). In terms of performance, small farmers are considered to be efficient globally (Diao *et al.*, 2005).

In Pakistan, the issue of diminishing landholdings is becoming prominent (Adil et al., 2007). More than 90% of the farmers possess small landholdings (GoP, 2010). The decline in land holding is most likely due to the division and sub-division within the family, sale and resale of the agricultural lands, and rapid urbanization (Adil et al., 2007). Small farmers are also known as subsistence farmers who are diversifying their agriculture in order to maintain a minimum livelihood level (Sibhatu and Qaim, 2017).

In Pakistan, four vegetables are being used as condiments i.e., onion, chilies, potato, and tomatoes. These are the most important ingredient of Pakistani kitchen. But their per capita consumption is low as compared to the minimum acceptable standards. Furthermore, they are amongst the leading vegetables which can earn high profits to the farmers (Fatima et al, 2015). Out of these vegetables, onion is the most important ingredient of Pakistani cuisines (Baloch et al., 2014). Pakistan is the 8th largest producer of onion following China, India, USA, Iran, Russia, Turkey and Egypt (FP, 2016). Onion is cultivated in all the provinces of the country with the highest share of the production from Sindh followed by Balochistan, Punjab and KPK (Lohano et al., 2005). Due to the perish ability and inelastic demand of onion, its price is observed to be highly fluctuating, that some time hurts the farmers. Productivity, defined as the ratio of output to input volume, is one of the most important indicators of the economy as a whole. It is significant because it measures input efficiency.

The technical efficiency of inputs measures efficient use of inputs. It has agreed to cut costs while increasing productivity (Hamilton et al. 2019).

This study aims to improve the onion cultivation for which the objectives are to:

I. Estimate economics of onion production
   a. Estimate profitability of onion production
   b. Identify yield gaps and issues faced by the onion grower
   c. Estimate domestic terms of trade
II. Estimate technical and economic efficiency of onion production
III. Suggest policy implications

2. Literature Review

Onion is one of the most commonly used ingredients in all households. Onions can be consumed in raw, fried, or pickled form. Onions are used to season foods, as well as in soups and sauces (Yousafzai et al., 2019). Between 2000 and 2019, global vegetable production increased by 65 percent, or 446 million tonnes, to 1128 million tonnes. During the time period, the onion accounted for 9 percent of the total (FAO, 2021). Onion cultivation covers 2.3 million hectares worldwide. Onion is grown on 153.8 thousand hectares in Pakistan, with a total production of 2,099.6 thousand tonnes (GoP, 2021).

Onions is one of the most common vegetables that make up the daily diet. In Pakistan, onion is a major commercial crop widely cultivated in various parts of the country (Bibi., et al 2021). Pakistan is currently the world's sixth largest producer of onions, with China leading the way, followed by India (Khan et al., 2021). As a condiment and vegetable, onion is a must-have in any kitchen. The onion bulb contains a high concentration of phosphorus, calcium, and carbohydrate minerals. Onions also contain proteins and vitamin C. (Khan et al., 2021: Baloch et.al, 2014: Khokhar et al., 2006). The climate has a significant impact on onion cultivation in Pakistan. In 2020, for example, onion prices rose sharply as a result of a shortage of onions caused by a series of heavy rains in Sindh and Baluchistan provinces, which severely reduced onion production. In Pakistan, there is a scarcity of high-yielding, easy-to-store seeds that are pest and disease resistant (FAO, 2019).

Pakistan can export these goods. Vegetable production is profitable because it is labor intensive. Vegetables provides income support, particularly for small farmers, and opportunities for landless workers to be employed in rural areas (FAO, 2008). Onion exports peaked in 2011, with a global shipment of 173,152 tonnes, placing the country among the top

onion exporters. The onion is one of the most important exports of developing countries. Pakistan contributes about 2.5 percent of global output each year (Khan et al., 2021).

Data Envelopment Analysis (DEA) and stochastic frontier analysis (SFA) are the two most commonly used approaches for measuring the efficiency of decision-making units. The SFA is a parametric approach that requires a functional form, whereas the DEA is a nonparametric linear programming approach. The production function in DEA is determined endogenously, making it purely deterministic. It is a more effective tool than SFA (Baree 2012: Ray et al., 2016). DEA calculates the distance between each decision-making unit and the frontier and allows for the use of multiple inputs and outputs in the analysis (Tingley et al, 2013). Technical Efficiency (TE) is the ratio of a production unit's actual and potential output. Then, efficiency is calculated by comparing observed performance to some predefined standard performance notion (Shanmugam and Venkataramani, 2006).

3. Data Collection

Primary and secondary data were collected for the analysis. The Primary data were collected from 100 onion farmers were collected from Okara district of the Punjab province using stratified random sampling technique. There are three Tehsils in District Okara i.e., Okara, Depalpur and Renala Khurd. Out of each stratum (tehsil), four villages were randomly selected i.e., 16 villages in total (Table 1). Data were collected from total of 00 farmers using detailed and well-structured questionnaire.

Table 1: Distribution of respondents

Sr. No.	Strata	Villages	Respondents	
1	Okara	4	8 farmers	32
2	Depalpur	4	8 farmers	32
3	Renala Khurd	4	9 farmers	36
Total				100

In terms of land holding, the farmers were classified as small, medium, or large. Farmers with up to 5 acres of land are considered small farmers, while those with 5 to 12.5 acres are considered medium farmers, and those with more than 12.5 acres are considered large farmers.

Table 2: Distribution of the farmers with respect 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%

4. Economics of Onion Production

4.1. Profitability of onion production

The economics of onion production was estimated using the detailed information about each farming practice and market prices. Following the economic analyses of various crops by Olukosi and Erhabor, 1998; Khan *et al.*, 2011; Sehto *et al.*, 2018, the average total cost of production was calculated using the following formula:

$$TC = \sum_{i=1-9}^{n} CoP - Onion_i \qquad 1$$

Where,

TC = Total Cost

CoP - Onion = categories of expenditures (nine sub-operations of production process i.e. land preparation, seed bed preparation, seed and sowing operations, fertilization, plant protection, irrigation, interculture, 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 includes the expenditures on chemical fertilizers i.e. urea, DAP, Potash, etc.

5 = Plant protection expenditures include insecticide and fungicide costs

6 = Irrigation expenditures include canal water charges (aabiana), and tube well expenditures

7 = Interculture expenditures include chemical weed control and labor for earthing up

8 = Harvesting includes handling, bags and transportation expenditures

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

$$TR = AvY_{i=1-100} * Mkt\_O \quad 2$$

Where:

TR = Total Revenue

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

Mkt_O = Average farm gate price on onion

Profit was calculated by total revenue minus total cost:

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

Where:

π = Profit

While the benefit cost ratio was calculated as:

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

Where:

BCR = Benefit-cost ratio

4.2. Comparison of means

In order to verify the difference in small, medium and large farmers' profitability, comparison of mean technique was applied. 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).

4.2.1. 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.
Frequency distribution and percentages were applied to identify the issued reported by the farmers.

4.2.2. Domestic Terms of Trade

A comparison of domestic prices is indicated by the domestic terms of trade. The definition has been used in the domestic domain to represent the contrast between the prices

of products produced and sold domestically. Ideally, in the two agricultural and non-agricultural sectors of the economy, a distinction must be made between the prices earned by the agricultural sector and the prices charged by the agricultural sector for transactions made by the non-agricultural sector. This comparison of the rates obtained and charged is commonly referred to as net exchange barter terms. Vegetables provide a source of income for the people of Pakistan and are essential for food security (Baloch et.al, 2014). Onion prices fluctuate throughout the year. Onion prices fell by approximately 39.57 percent in the year 2020-21 (GoP, 2021)

4.3. Economic and Technical Efficiency of Tomato Production

An output-oriented DEA model under the assumption of variable returns to scale was used to estimate technical efficiency in this study (Ai et al, 2018, Bahta et al, 2020). The efficiency scores range between 0 to 1. Zero means very poor efficiency and one means fully efficient. The input-oriented DEA which minimizes input use to achieve a specific output level. The following input-oriented linear programming model was used to calculate overall technical efficiency (Umanath and Rajasekar, 2013).

$$Y_i = \beta_o + X_i\beta_i + \alpha_i$$

$$\alpha_i = \mu_i - \varepsilon_i$$

Here:

Y_i= Out put

β = Parameters

X_i= Input variables (Total number of tillages, total number of fertilizers, total number of pesticide and seed rate).

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.

Tobit Model:

The Tobit regression model used when the dependent variable concerned between two values. In case of technical efficiency of onion, the value will not exceed from 1 and not less

than zero. The dependent variable's value cannot deviate from those bounds (Gebremariam et al., 2019). The Tobit model is given below:

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

Here

Y_i = Economic Efficiency of onion

X_1= Age (Years)

X_2 = Family Size (No.)

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

X_4 = Family members working on farm (No.)

X_5 = Education (Years)

X_6 = Experience (Years)

5. Results and Discussion

5.1. Economics of onion production

Seed and sowing operations sub-category of the expenditures (3) had the highest share in total cost with PKR 13,297. There was a slight difference in the expenditures on this category by small (PKR 16,760), medium (PKR 14,115) and large farmers (13,020). The comparison of means test results, however, showed that there is no significant difference. On average, PKR 11,101 were spent on fertilization. Small farmers spent the least i.e. PKR 8,226 followed by medium farmers (PKR 11,453) and large farmers (PKR 13,628). Similarly, small farmers spent the least on irrigation operations. The average expenditure by all the sample farmers were PKR 8,843 where small farmers spent PKR 8,610; medium farmers spent PKR 9,430 and large farmers spent PKR 8,490. The reason for low expenditures by the small farmers is their financial conditions (Abbas et al, 2020).

On the contrary, small farmers spent more on land preparation. The average expenditures by all the farmers in these categories were PKR 1,962 while small farmers spent PKR 2,107 as compared to medium (PKR 1,886) and large farmers (PKR 1,896). The main reason behind this could be the higher hiring costs of water and land preparatory machinery to the small farmers while majority of the medium and almost all large farmers own these machinery items and tube wells. Total cost of the whole sample was estimated to be PKR 55,045 per acre with small farmers spending the lowest i.e. PKR 50,927 followed by medium farmers (56,720) and large farmers (PKR 57,506). A detailed comparison is shown in Table 3

below. There were slight differences in yields. Small farmers had the lowest yield i.e. 9,615 kgs per acre while medium farmers had a yiled of 9,865 kgs per acre and larger farmers had a yield of 9,985 kgs per acre. Small farmers had the highest BCR (3.02) followed by medium (2.98) and large (2.97) farmers.

The results of the comparison on means, however, were not significant which explain that there is no difference in the farming categories. Hence, they can be regarded as the same.

Table 3: Economic analysis of onion crop

Activities (PKR)	Small Farmers n = 51	Medium Farmer n = 31	Large Farmers n = 18	Total Sample n = 100
Land Preparation	2,107	1,886	1,896	1,962
Seed bed preparation	1,450	1,530	1,600	1,526
Seed and sowing operations	16,760	14,115	13,020	13,297
Fertilization	8,226	11,453	13,628	11,101
Plant protection	3,262	3,770	4,300	3,776
Irrigation	8,610	9,430	8,490	8,843
Harvesting	5,464	5,488	5,524	5,492
Miscellaneous	9,048	9,048	9,048	9,048
Total Average Cost	54,927	56,720	57,506	55,045
Yield / acre (Kgs)	9,615	9,865	9,985	9,821
Average Farm gate price (PKR / Kg)	16	16	16	16
Gross Income / acre	153,840	157,840	159,760	157,137
Net Profit	98,913	101,120	102,254	102,091
BCR	2.80	2.78	2.78	2.85
F-Test		2.57		
P-value		0.08		

The overall benefit cost ratio has improved slightly in comparison to the results of previous studies (Table 4). The authors were only able to find two studies on this important topic which indicates the ignorance of onion profitability analyses.

Table 4: Comparison of BCR results with previous studies

Reference	Study Area	Total observation	BCR
Current Study	Sheikhupura, Punjab	100	2.85
Baloch et al., 2014	Awaran, Balochistan	60	2.30
Ahmad et al., 2008	Muzaffarabad, Azad Kashmir	80	2.37

5.2. YIELD GAPS

The yields of farmers in the study area were not only above the average Pakistani yields but also from Bangladesh, India, China and Worlds' average yields (Table 5).

Table 5: Yield gaps

	Tonnes / Acre	Maunds / acre
Current study	9.821	245
Pakistan Average	5.38	122
India Average	6.95	158
Bangladesh Average	4.07	92
China Average	8.94	203
World Average	7.61	173

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

5.3. Issues faced by farmers

Farmers reported their problems in the production process of onion which are presented in Table 6. According to these results, 85% of the farmers complained about the volatile nature of the out price. A little over the two third of the famers were complaining about the high input prices due to which the production process becomes un-bearable economically for them. About 60% of the farmers said that the issue of absence of market structures (both infrastructure and economic structure) hinders a reasonable profit margin to the farmers.

Table 6: Issues reported by the farmers

Sr. #	Issues	Frequency	Percentage
1	Output price volatility	85	85
2	High input prices	76	76
3	Absence of market structure	63	63
4	Cumbersome credit procedures	60	60
5	High cost of storage facilities	50	50

5.4. Domestic terms of trade

The cost of ploughing, farm labor, and fertilizers includes Urea and DAP are shown in Figure 1. Results showed that the cost of ploughing and the wage rate have risen over time.

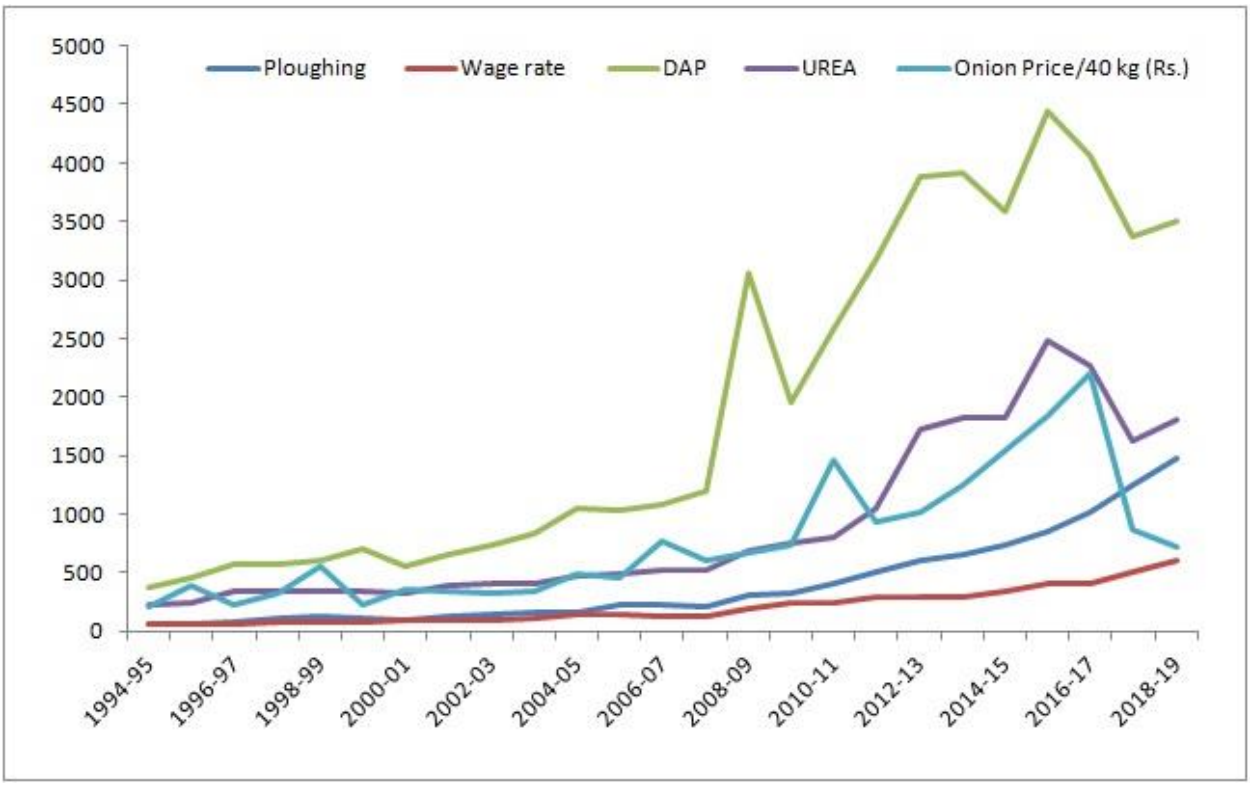

Figure 1: Input-output price trends

Similarly, the amount of produce in lieu of purchasing one kg of the inputs has gone up. Figure 2 explains this phenomenon.

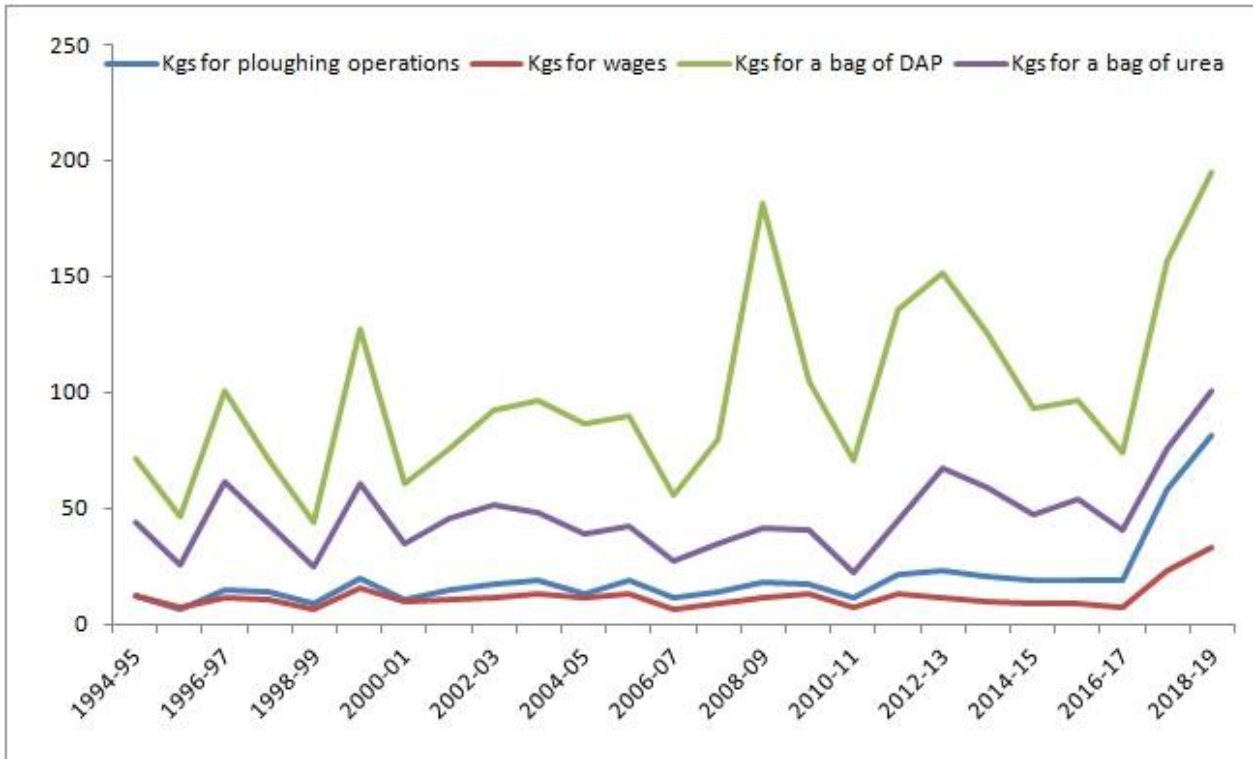

Figure 2: Domestic terms of trade

In terms of money value of input and output, the domestic terms of trade have worsened over the years. The trend line showed a stable increase in the price ratio. This implements that both the input and output markets and not functioning properly and needs to be corrected though a government intervention.

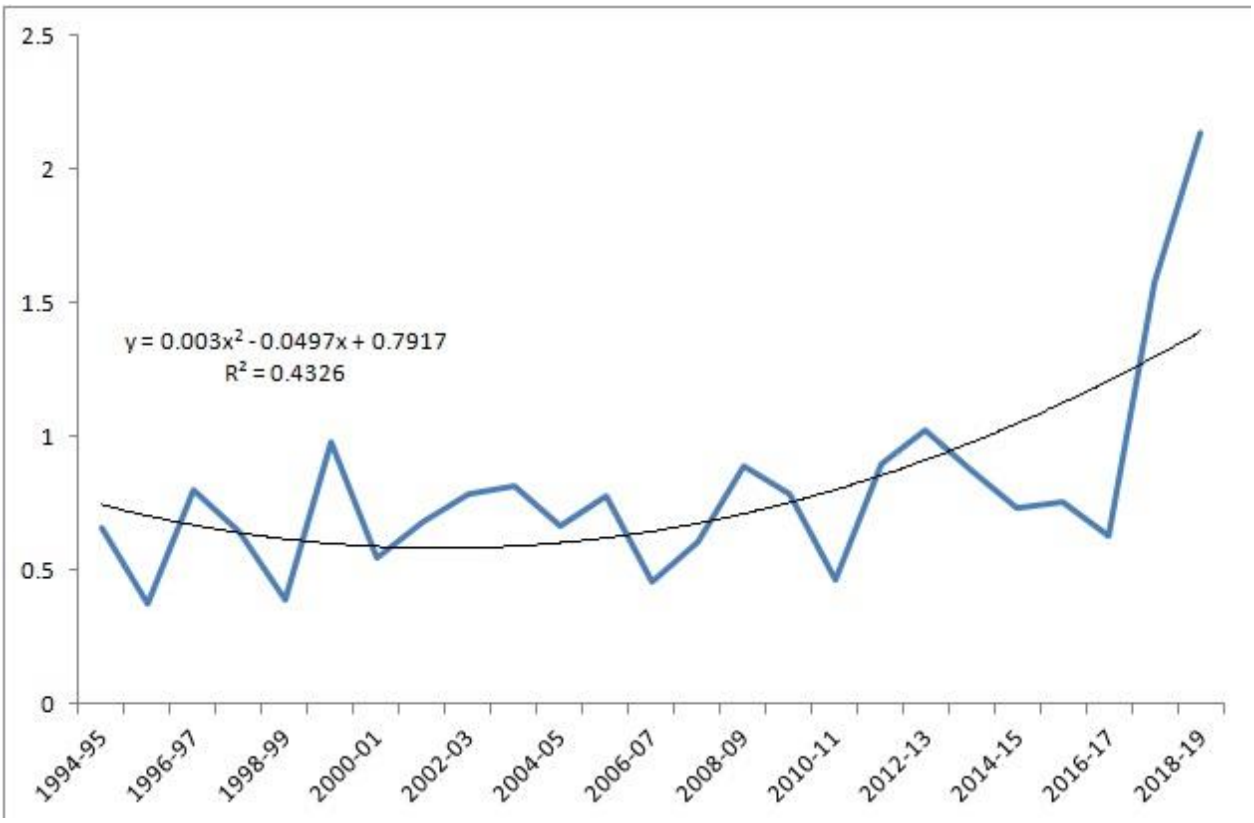

Figure 3: Input-output price ratio

5.5. Ecomonic and technical efficiency

The technical efficiency of the onion growers is shown in Figure 4. The overall average technical efficiency of was 0.946. It means that with the available resources the output can be increased by 6 percent. The technical efficiency of small, medium and large farmers was 0.82, 0.914, and 0.967 respectively. The small farmers were 8.7 percent less efficient as compare to medium farmers and 14 percent less efficient than large farmers. Medium farmers were 5.3 percent less efficient than large farmers.

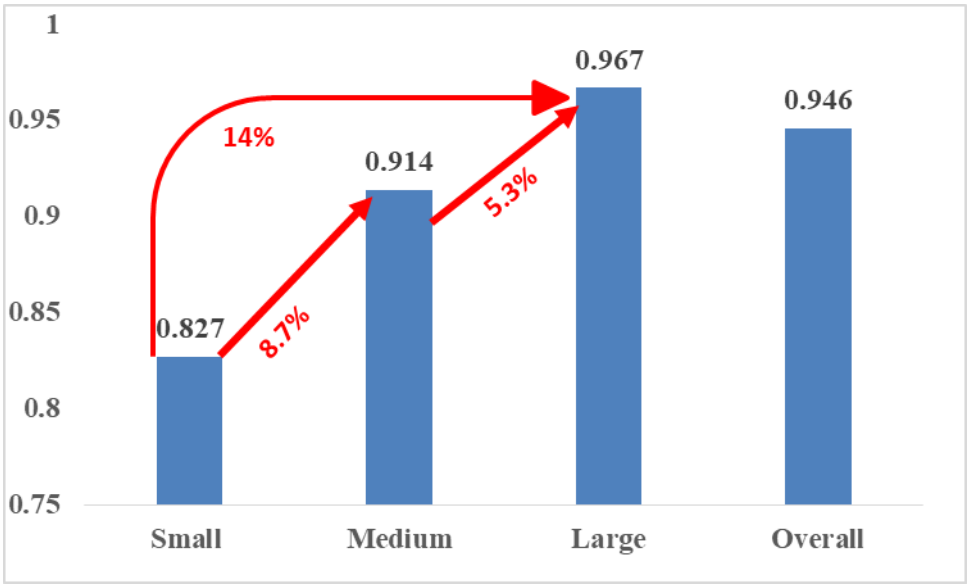

Figure 4: Technical efficiency of onion crop

Economic efficiency was calculated by using all possible input costs like, Land preparation cost, Seed cost, Irrigation Cost, fertilizer cost, and spray cost of pesticide, spray cost of weed and harvesting cost. Results showed that the larger farmers were economically efficient in producing onion as compare to small and medium producers. Variation is Economic efficiency is less as comparative to technical efficiency. Larger farmer's economic benefits reduce due to the role of market intermediators, while small farmers sell their output direct to the retailer. Observed variation in Economics efficiency was mainly due to the availability of storage capacity. Small farmers sell their crops to generate revenue for cultivating next crops. Variation in technical efficiency is due to variation in total cost of crop cultivation. Small farmers were hiring all the possible input that cost them higher as compare to larger farmers who have own technology. Findings revealed that, the small, medium and large farmers can reduce their cost by about 9.3, 6 and 3 percent respectively (Figure 5) without reducing the level of output and with the existing technology.

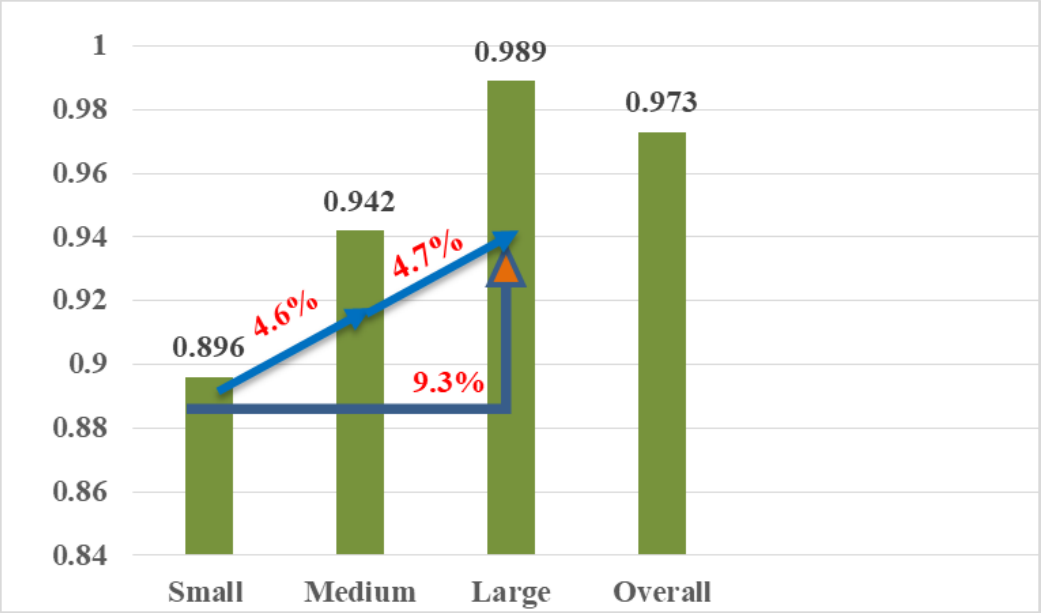

Figure 5: Economic efficiency of onion crop

5.6. Tobit regression model´s results

The Tobit model has shown that for small farmer age has positive relationship with technical efficiency and negative relationship for medium and large farmers. For small and medium-sized farmers, family size had a positive relationship with technical efficiency, although it showed a negative relationship with large farmers. For small and large farmers, tube-well ownership has a positive effect on technological efficiency but the case is reversed for medium farmers. Family work has a positive influence on efficiency. For medium and large farmers, schooling has demonstrated unexpected negative relationships for small farmers. A substantially negative effect of education on technical efficiency was also stated by Hasnah and Coelli (2004). The experience of farming has a positive influence on onion crop efficiency.

Table 7: Tobit Regression Model Results

Variables	Small	Medium	Large
Age	0.001	-0.001	-0.005
	(0.05)	(0.615)	(0.016)
Family Size	0.006	0.002	-0.005
	(0.032)	(0.496)	(0.232)
Tube-well ownership	0.015	-0.005	0.034
(Yes=1, No=0)	(0.035)	(0.725)	(0.020)
Family members	0.022	-0.003	-0.008
working on farm	(0.008)	(0.713)	(0.612)

Education	-0.001	0.0009	0.009
	(0.524)	(0.064)	(0.056)
Experience	0.002	0.003	0.003
	(0.182)	(0.142)	(0.281)
Constant	0.770	0.870	1.109
	(0.000)	(0.000)	(0.000)

(Figures in parentheses are P-Values)

6. Conclusions

The purpose of this study was to estimate the economic benefits of onion production in the Okara district of Punjab, Pakistan. its domestic trade terms, as well as the problems that farmers faced during onion production. A stratified random sampling technique was used to collect primary data from 100 farmers in the district of Okara. Farmers spent on an average of PKR 55,045 per acre on onion production. The expenditures of small, medium, and large farmers were almost same. Similarly, there was a slight difference in their yields and profitability. The benefit cost ratio for the onion production was also same. Farmers' yields were better than the neighboring countries even the world average. Farmers reported five major issues including: output price volatility, high input prices, absence of market structure, cumbersome credit procedures and high cost of storage facilities. The domestic terms of trade, however, deteriorated over the time indicating serious issues in market (input and output) functionalities. It is recommended that the market regulations in both the input and output markets may be implemented in letter and spirit. Efficiency analysis was done using DEA analysis. Larger farmers were efficient technically and economically. It is recommended that the market regulations may be implemented in letter and spirit. Furthermore, research on different aspects of economics and policy of onion production be carried out on a regular interval in order to identify major evils in the production system and to overcome those.

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