Estimation of economic and production efficiency of potato production in central Punjab, Pakistan.

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Abstract

Potato is the fourth most produced crop in the world after wheat, rice and maize. This study aimed to estimate the economics of potato production in Okara District, Punjab Pakistan. Primary data from 100 potato farmers were collected using a stratified random sampling technique. Data were analyzed using economic and statistical techniques such as profitability, BCR, comparison of means and frequency distribution. It was found that for the previous two crops, farmers received meager profits in 2018 and had to bear losses in 2019. The BCR in case of profit was too low i.e., 1.00: 1.03. The domestic terms of trade over the years had deteriorated indicating issues in input and output markets. The efficiency analysis showed that the technical and economic efficiency of larger farmers were high. Technically large farmers were 12.35% efficient as compared to small farmers. There was little difference among all farmers according to economic efficiency, larger farmers were 3.11% efficient with respect to small farmers. Tobit results showed that age had negative impact on technical efficiency while experience showed positive impact. 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 potato 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. Efficiency analysis.

1. Introduction

Agricultural sector plays an important role in the economies of developing countries (Diao *et al.*, 2005; Katircioglu, 2006). It provides shelter and livelihoods to the rural masses which in turn helps reduce hunger and poverty (Birkhaeuser *et al.*, 1991; Owens *et al.*, 2003). A reasonably high agricultural growth rate is required for sustainable provision of livelihood to rural masses. Small scale rural farms can serve as a catalyst in this regard (Deller *et al.*, 2003). Such farms are found to be efficient, with exceptions, in both the developed and developing countries (Diao *et al.*, 2005). Pakistan's economy relies greatly on its agricultural sector that contributes about 19% towards its national GDP. A high agricultural growth rate is necessary to meet up the food and fiber requirements of a highly growing population (2.4%). During the previous year, agricultural sector grew by 3.8% which was slightly better than the set target of 3.5% for the year. The crops sector grew at rate of 3.8 %. This is mainly due to the availability of certified seeds, quality pesticides, fertilizers and timely availability of credit. Furthermore, attractive output prices and supportive public policies acted as a catalyst (GOP, 2018). Potato is the most important non cereal food crop of the world. It is the fourth most important crop grown worldwide after wheat, rice and maize (Hong *et al*., 2017). Potato was cultivated over an area of 19 million hectares that produced over 388 million tonnes of potato. In Pakistan, it was grown on 0.184 million hectares with a production of 4.142 million tonnes (FAOSTAT, 2019). Pakistan ranks 20th in potato production (Memon, 2017). Punjab is the leading potato producer of the country with 3.8 million tonnes of production.

In order to maximize potato production, farmers are applying extensive farming practices that enhanced the use of chemical fertilizers and pesticides. This in turn increases the cost of production of the farmers hence reducing the profit margins. The recent crises of bumper crop of potato left farmers in huge losses (Mahmood, 2019). There are a few studies on the assessment of profitability of potato crop from different dimensions i.e., economies of scales, sustainable agricultural practices, input output ratios, benefit cost ratios, etc (Ahmad *et al*., 2005; Iqbal *et al*., 2015). It is important that a periodic economic analysis be conducted of the crop in order to identify the issues in input-output markets, and relationship of costs and benefits. Data envelopment analysis is a non-parametric, linear programming method that estimates a production frontier from the best practice observed in a sample. It estimates the distance of every decision-making unit to this frontier, and allows multiple inputs and outputs

to be used in the analysis (Tingley *et al*, 2013). Technical Efficiency (TE) is the ratio of the real and potential output of production unit. Efficiency measurements are then basically calculated by comparing observed performance with some given standard performance notion. TE can be characterized as a production unit's capacity and willingness to achieve the maximum possible performance. Farrell (1957) performed the first empirical research to calculate TE for a cross-section of production units using a deterministic/non-parametric border method and, subsequently, comparisons of border efficiency have become synonymous with the term "Farrell measurement of efficiency." Farrell suggests that either a non-parametric piece-wise linear technology or a parametric function such as the Cobb-Douglas form can be calculated from the sample data (Shanmugam and Venkataramani, 2006). This study aims to improve the onion cultivation for which the objectives are to:

I. To estimate economics of potato production
   a. To estimates profitability of potato production
   b. To identify yield gaps and issues faced by the farmers
   c. To estimate domestic terms of trade
II. Estimate technical and economic efficiency of potato production
III. Suggest policy implications

2. Literature Review

2.1. Background

Potato is an important crop with high yield all over the world. In Pakistan, potato production and consumption are growing day by day. To illustrate the current potential of this crop, various economists have conducted an economic analysis of this crop. The potential benefits are declining due to some market inefficiency. Potato is a perishable commodity, so the absence of storage facilities and high availability almost makes it less expensive during the crop season, which hurts farmers. The study of productivity helps to analyses the technological and economic effectiveness of farmers. The crop yield is decreasing by low-quality inputs including land and irrigated water. Batter management practices and input used improved technical efficiency. Market perfection improves economic efficiency.

In order to understand the exact state of an economy, economic analysis is necessary (Busari et al, 2012). Economic analysis focuses mainly on how much profit is generated through any production process. It provides a clear picture of the current economic conditions prevailing in the market (Tolno et al, 2015). It required to decide the best way to allocate the

scare resources (Coyle et al, 2003). One of the techniques for calculating profitability is cost-benefit analysis (Mishra et al, 2009, Peer et al, 2013). The key problems faced by potato farmers were lower potato prices during the harvesting season, price instability, capital shortages, high cold storage charges, lack of good quality seeds, potato perishability, bad storage facilities, higher input prices and lack of marketing facilities (Mukul *et al*, 2013). The potential yield of this valuable crop is diminished by low quality soil and irrigation water and plant disease (Majeed and Muhammad, 2018).

The analysis of yield gap is a valuable tool to determine to what degree, if all variables are regulated, output may be increased. It is the mathematical difference over some defined spatial and temporal scales between the potential yield and the actual yield of farmers (Quiroz *et al*, 2014). Therefore, if inputs are used to their fullest potential, major improvements will be made by improving technological performance (Wassihun *et al*, 2019). A farm's efficiency can be defined and calculated as the ratio of observed production to maximum feasible output from a region (Dolisca and Jolly, 2008). Increasing technological effectiveness reduces the use of inputs and increases gross return, which is the driving force for the incentive of producers to implement new techniques. Improving the efficiency of price and supporting the targeted application of fertilizers, pesticides and machinery helps to rise crop yield (Mardani and Salarpour, 2015).

2.2. Economic Efficiency

It has long been a concern of agricultural economists to calculate the efficiency of crop production (Bakhsh et al, 2006). The efficiency estimation enables the non-parametric approach to calculate an appropriate output function. (Ruggiero 2007). DEA is a non-parametric approach incorporates linear programming (Shavgulidze et al, 2017). The goal of the efficiency model of the DEA is to estimate the gap between efficient and actual points of output.

To evaluate the degree of efficiency, the distance of each production unit from an effective point on the production frontier is calculated (Anouze and Bou-Hamad, 2019). DEA is strictly deterministic, and it is endogenously determined by the output function. However, statistical noise is not taken into account, rendering it vulnerable to noise and errors in calculation (Noonari et al, 2016, Ahmad et al, 2012). It has been noted that farmers are economically efficient in growing potatoes, and it may not be possible to increase production

under current technology. Only improved and advanced technology will increase the production of potatoes in this situation (Begum et al, 2010).

The calculated stochastic frontier model of production suggested that the area of the plots, the quantity of NPS fertilizers, the quantity of seeds and the man-day labor were positive and important determinants of the level of production. Improving successful cropping expertise and financial capacity enhanced technical efficiency (Dube et al, 2018). Efficiency also affected by different socio-economic and institutional factors (Mezgebo et al, 2019). Consultation with extension staff contributes greatly to improving technical performance (Bakhsh et al, 2006). Important factors that affect the technological effectiveness of potato growers are plant conservation measures and the use of quality seeds (Shavgulidze et al, 2017).

3. Material and Methods

3.1. Data collection

Potato is grown on largest area in Sahiwal division (i.e., 0.242 million acres) and produces over 2 million tonnes of potato. Out of the three districts, Okara is the largest district of the division in terms of area of production (i.e 0.137 million acres) and a production of 1.34 million tonnes of protato (GOPb, 2018). Hence, Okara was selected purposively as study area. A stratified random sampling technique applied to select 100 farmers from the three Tehsils of the district i.e., Okara, Depalpur and Renala Khurd. Out of each stratum, four villages were randomly selected i.e., 12 villages in total (Table 1). A total of 100 farmers were interviewed using a well-structured questionnaire.

Table 1: Selection of respondents

Sr. No.	Strata	Villages	Respondents	
1	Okara	4	9 farmers	36
2	Depalpur	4	8 farmers	32
3	Renala Khurd	4	8 farmers	32
Total				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	%age
Small Farmers (< 5 Acres)	53	53.0
Medium Farmers (5 to 12.5)	29	29.0
Large Farmers (>12.5 Acres)	18	18.0
Total	100	100.0

Secondary data for the prices of four inputs (Ploughing, Wage rate, DAP and Urea) were obtained from various reports and surveys including APCOM / API policy reports and Economic Surveys. The data on output price were collected from Agricultural Marketing Information System of the Government of the Punjab for the years 1994-2019.

3.2. Estimation of the economics of potato production

a. Profitability of potato production

The economics of potato production was estimated using the comprehensive information on each farm practice. Following various studies on the topic of economic analyses of different crops (see for example Olukosi and Erhabor, 1998; Khan *et al.*, 2011; Alam *et al.*, 2013; Sehto *et al.*, 2018), the average total cost of production was calculated using the following formula:

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

Where,

TC = Total Cost

CoP - Potato = 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 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 = 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.

$$TR = Y_{i=1-100} * FgP \qquad 2$$

Where,

TR = Total Revenue

$Y_{i=1-100}$ = Average yield of the 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).

b. Yield Gaps and issues faced by the farmers

Yield gaps were estimated by comparing the average yields of neighboring countries and world average to the yield of the sample farmers.

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

c. Domestic Terms of Trade

Pakistan has the potential to substantially increase the production of fruits and vegetables that have global demand (Husaini and Rehman, 2020). A comparison of domestic prices is indicated by the domestic terms of trade (De Silva et al, 2013). The definition has been used in the domestic domain to represent the contrast between the prices of products produced and sold domestically (Sotelo, 2020). 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 (Tyagi, 1987; Akhtar *et al*, 2013).

3.4. Economic and thechnical efficiency of popato production

By running a variable returns to scale DEA model, technical efficiency was determined. To estimate technical efficiency in this analysis, an output-oriented DEA model was used under the assumption of variable returns to scale. Estimated efficiency scores are ranging from 0 to 1 (Ai *et al*, 2018, Bahta, 2020). This implies that when the efficiency score is one, a farm works under completely productive conditions, when score is zero it means that the farmers is unproductive (Umanath and Rajasekar, 2013). The stochastic production frontier analysis begins with specifying a log-linear production function as follows

The model for stochastic frontier analysis of production is defined as a log-linear production function.

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

Where:

Y_i= Out put

β = Parameters

X_i= Input variables (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.

3.5. Tobit Model

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. If the dependent variable is bounded between zero and one, it cannot take values less than zero and greater than one (Odah *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 Potato

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)

4. Results and Discussion

4.1. Economics of popato production

On average, total expenditures of the farmers were PKR 92,549/- with slight differences in the expenditures of small, medium and large farmers (87,283/-, 92,738/- and 97,553/-, respectively). The comparisons of means test was non-significant explaining that there is no statistical difference in the farming categories. The largest share of expenditures of all the categories was seed and sowing operations followed by harvesting and fertilization. For the season 2018, the average farm gate price was PKR 10 per Kg. With this price, there was meager profit of PKR 2,461 per acre on an average. While it was PKR 1,817/- for small farmers, PKR 3,562/- for medium and PKR 2,097/- for large farmers. Again, the comparison of means test was not significant. The average benefit cost ratio (BCR) was about 1.03 which

is very low. For small farmers, it was 1.021, for medium famers it was 1.04 and for the large farmers it was 1.03. If the farmers do not calculate the land rent and family labor, then their BCR improve. It can be said that the land rent and family labor costs are the real profit of the farmers. However, this is not the right way to interpret the economic situation. The farmers are continuing to farming due to this reasoning along with the fact that they generate food for the family. While there was a small difference in fertilizer prices due to routine fluctuation, but the average prices remained the same for the next season (2019). This kept the expenditures as the same for all the farming categories. However, due to market glut at the time of harvesting, the farm gate price was reduced to PKR 5.5 per Kg. This in fact made the farmers to bear a loss of an average of PKR 40,294/- per acre with a loss to small farmers of PKR 38,278/-, medium farmers PKR 39,773/- and large farmers PKR 42746/-. The benefit-cost ratio (BCR) went down to 0.60 that shows the gravity of the problem. Similar situation was confronted in 2005 as reported by Ahmad et al. (2005).

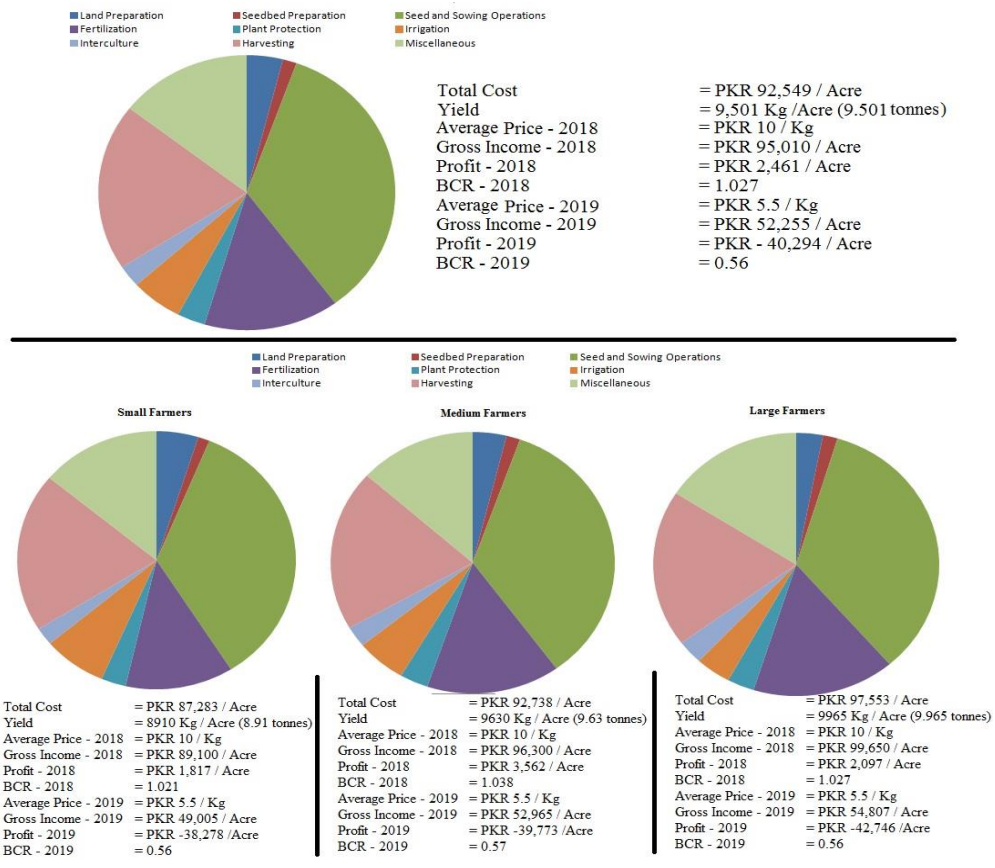

Figure 1: Cost of Production, Gross Income, Profit and Benefit-Cost Ratio

Comparing the BCRs with the earlier studies, the current BCRs are on the declining side not only in comparison with local (Pakistani) studies, but also in comparison the regional studies. Table 3 presents the comparative results of different studies with the results of current study. There are, however, a few studies available (to the best of our knowledge) on this subject both in Pakistan and the region. It is, therefore, necessary to have periodic studies on this issue.

Table 3: Comparison of BCR results with previous studies

Reference	Study Area	Total observation	BCR
Current Study	Okara	100	1.027 / 0.56
Sharma *et al*., 2017	Himachal Perdesh, India	60	1.39
Noonari *et al*., 2016	Sindh Pakistan	60	1.82
Iqbal *et al*., 2015	Okara, Pakistan	100	1.76
Begum *et al*., 2010	Bangladesh	100	1.54

4.2. Yeld gaps

As far as the yield per acre is concerned, the average yield in the study area remained above the world average i.e., 8.14 tonnes per acre. It was not only greater than the world average, but it was also better than the overall country (Pakistan) average and the neighboring countries' average. Table 4 presents this comparison.

Table 4: Yield gap analysis

	Tonnes / Acre	Maunds / acre
Current study	9.501	215
Pakistan Average	9.07	206
India Average	9.03	205
Bangladesh Average	8.07	183
China Average	6.96	158
World Average	8.14	185

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

4.3. Issues faced by farmers

The issues faced by the farmers are presented in Table 5. Majority (85 %) of the farmers reported that the low price of their product is the most important issue for them. The fluctuation in the prices especially towards the lower side creates problem for the farmers.

Earlier, Ahmad *et al*., (2005), ranked low price of the output as the number one constraint. High input prices were the second most important constraint reported by 76 % of the farmers. Earlier, it was ranked 4th most important constraint by Ahmad *et al*. (2015). More than 60 % of the farmers complained about the non-availability of quality seed. Due to low quality seed, the production potential remained unachievable. It was the 8th most important constraint earlier as reported by Ahmad *et al*. (2005).

Lack of access to credit facilities due to difficult and cumbersome procedures was next important constraint as it was reported by 60 % of the farmers. About 50 % of the respondents complained that the cost of storage facilities is very high due to which they had to market their produce at the time of harvest which creates glut in the market forcing the output price to fall. Earlier, it was ranked as 6th most important constraint by Ahmad *et al* (2005). Furthermore, the 30 % of the farmers were not happy with the grading system of the markets. Due to which their produce goes for cheap prices.

Table 5: Issues reported by the farmers

Sr. #	Issues	Frequency	%age
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 2 - 4. Figure 2 presents the trends in the prices of selected inputs and market price of potatoes. There is an increasing trend. The prices of DAP, Urea and Ploughing operations increased at faster rate as compared to the wage rates and per 40 Kg market prices of the produce. This indicates that the profit margins of the farmers have gone done considerably. Annual data on farm gate prices was not available, if that were available the situation of the farmers would have been more clearly understood.

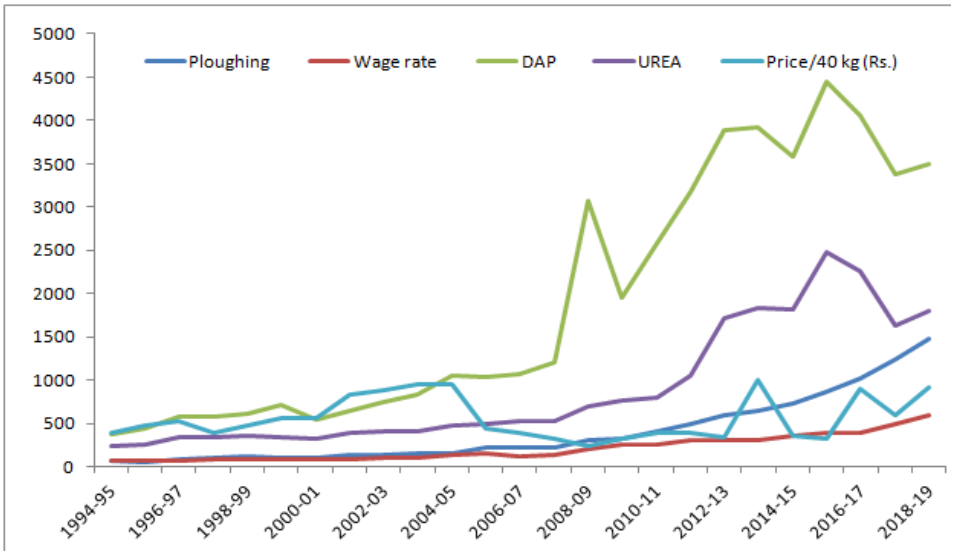

Figure 2: Trends in input and output prices

Over all there is a fluctuating trend in terms of the physical terms of trade for the produce and major inputs. But still the trends are slightly on the increase. showing that physical terms of trade have gone up. Figure 3 presents the physical terms of trade.

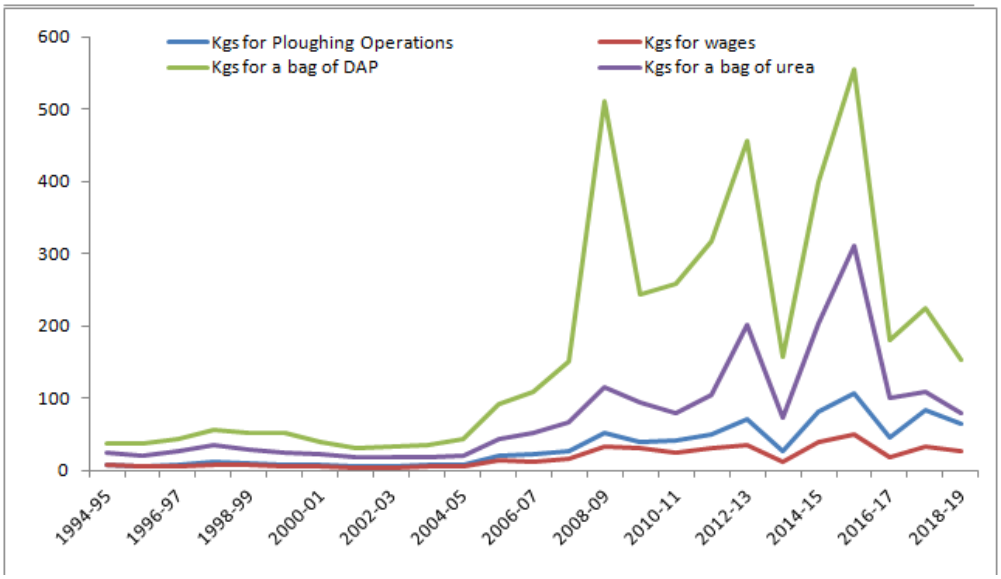

Figure 3: Physical domestic terms of trade

Figure 4 presents domestic terms of trade of potato production. The ratio of input-output prices is presented which shows an increasing trend. This implies that the production process is getting expansive for the farmers which is squeezing their profit margins. This conforms the results of field study above (i.e., the reduced BCR as compared to previous studies). The fluctuations are also representing the market price fluctuations. Here it is important to note that the output price for time series data is of the market and not of the farm gate. The situation would be worst for farm gate prices.

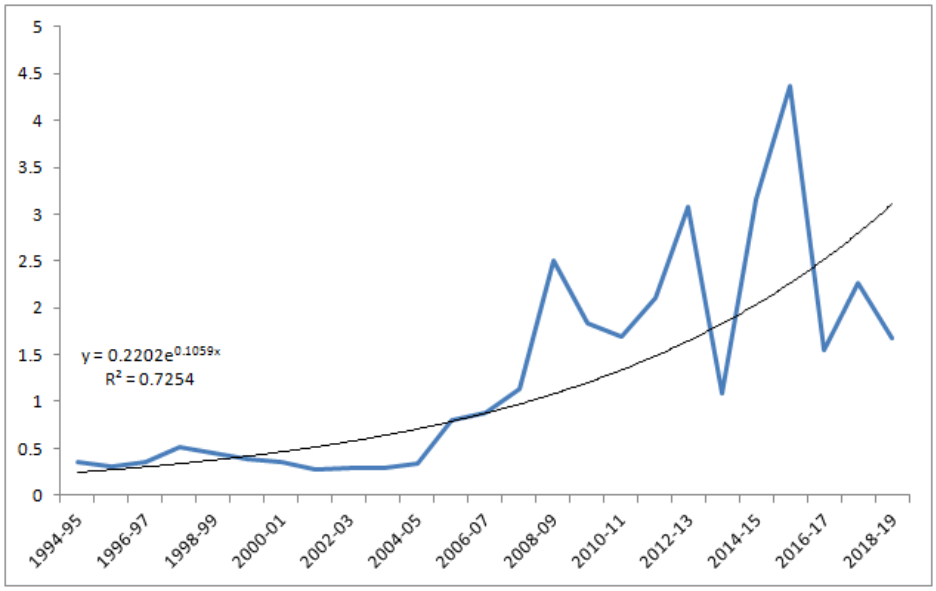

Figure 4: Input-output price ratio

4.5. Economic and technical efficiency

It is evident from Figure 6 that the mean technical efficiency of sample farmers is 0. 874.The results of the study imply that if the average farmers operated at the same technical efficiency as the most efficient farms in the sample, they could reduce, on average, their input use by about 13% and still produce the same level of output. Small farmers were 7.75% and 12.35% less efficient as compare to small and large farmers respectively. The medium farmers were 4.67% less efficient as compare to large farmers.

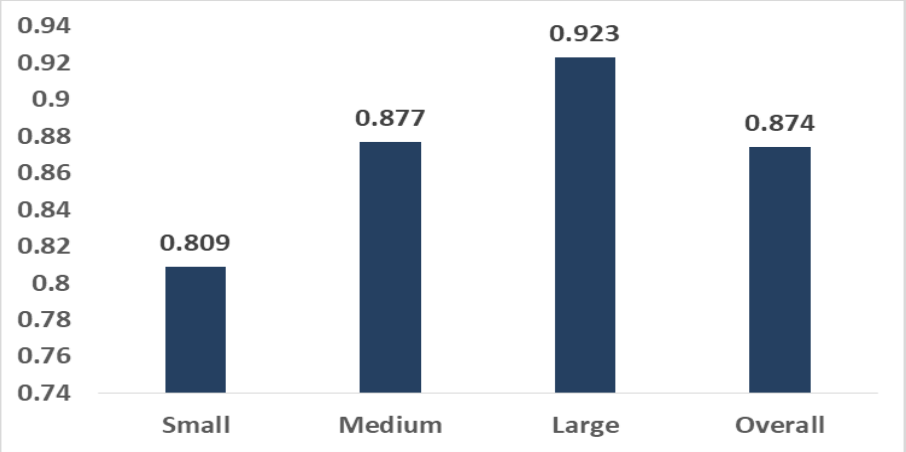

Figure 6: Technical efficiency of potato crop

Economic efficiency is the ratio of the minimum cost to the Observed cost. Economic efficiency was calculated by using (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 potato 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 intermediaries, 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. Our findings reveal that, if sample farms operated at full efficiency, they could reduce their cost of production by about 6.2% without reducing the level of output and with the existing technology.

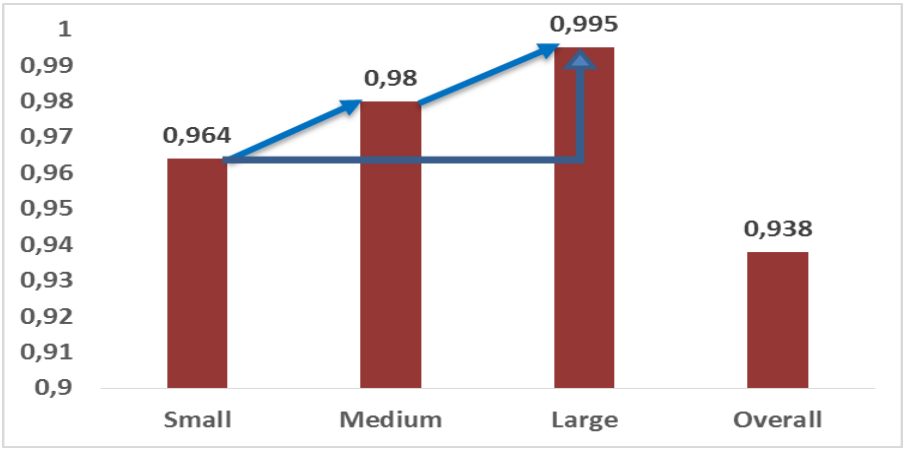

Figure 7: Economics efficiency of potato

4.6. Tobit model results

The Tobit model has shown that for small, medium and large farmers, age has a negative relationship with technical efficiency. 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 small farmers, schooling has demonstrated unexpected negative relationships. 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 potato crop efficiency.

Table 6: Tobit model results (P-Value in parentheses)

Variables	Small	Medium	Large
Age	-0.005	-0.003	-0.016
	(0.036)	(0.375)	(0.001)
Family Size	0.004	0.002	-0.005
	(0.279)	(0.489)	(0.450)
Tube-well ownership	0.005	-0.003	0.003
(Yes=1, No=0)	(0.008)	(0.168)	(0.273)
Family members working	0.05	0.005	-0.013
on farm	(0.018)	(0.833)	(0.807)
Education	-0.006	0.001	0.004
	(0.096)	(0.851)	(0.218)
Experience	0.004	0.002	0.020
	(0.092)	(0.509)	(0.000)
Constant	0.944	0.969	1.211
	(0.000)	(0.000)	(0.000)

5. Conclusions

This study aimed to investigate the economics of potato production in Okara District, Punjab, Pakistan. The results showed that farmers spent on an average PKR 92,549/- on potato 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. The comparative discussion of the results of this study showed that the profitability of the farmers has deteriorated over the time. The yields of the sample farmers were better than the averages of Pakistan, India, Bangladesh, China and World. Farmers reported seven major issues in the production process. In which the fluctuation of output prices was the top most constraint followed by higher input prices, non-availability of quality seed, lack of credit and storage facilities. The domestic terms of trade have deteriorated over time suggesting irregularities in the input and output markets. 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 potato production be carried out at a regular interval in order to identify major evils in the production system.

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