Efficiency analysis of chilies production in district Sheikhupura, Punjab Pakistan

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Abstract

Vegetables are an important part of agricultural sectors across the world for their nutritional and health benefits. Chillies are grown across the world and are mostly used as spices and flavoring agent. They are a rich source of natural colors, antioxidants, vitamins, carotenoids, capsaicinoids and phenolic compounds. Pakistan is the world's fourth largest producer. Despite the fact, Pakistan's chillies cultivation remained fluctuating mostly due to price volatility. The main objectives of the study were to: estimate economics, domestic terms of trade, and efficiency of chillies production; identify issues faced by the farmers; and suggest policy implications. Both secondary and primary data were used. Secondary data were collected from Government of Pakistan, FAO and World Bank's online sources. Primary data were collected from 100 chillies farmers from District Sheikhupura 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 the profitability of the chillies farmers has deteriorated along with the domestic terms of trade. The mean technical efficiency for small, medium, and large farmers was 0.88, 0.92, and 0.96, respectively, while the mean economic efficiency was 86, 91, and 95 percent, respectively. Farmers can boost their output and economic benefits with available resources, according to an efficiency analysis. Results of Tobit model explained that the age, education, experience, family size, and distance from main road all have a positive impact on chillies technical efficiency. The distance between the farm and the input/output market is inversely related to technical efficiency. The economic efficiency of chillie farmers can also be improved with appropriate infrastructure. The farmers' major concern was the instability of output prices. This study emphasizes the importance of correcting imbalances in the input and output markets, particularly in the seed market.

Keywords: Economics of Production. BCR. Terms of Trade. Technical efficiency. Economic efficiency. Small Farmers. Chillies. Sheikhupura. Punjab. Pakistan.

1. Introduction

Vegetables are an important part of agricultural sectors across the world for their nutritional and health benefits (Ogunniyi and Oladego, 2011; Ibrahim and Omotesho, 2013). Over the past decades, the per capita vegetable production has seen an increment of 60%. To feed the ever increasing population of the world which is expected to cross 9 billion in 2050, it is crucial that the vegetable sector expands at a reasonable rate. (Naik *et al.*, 2017). In this regard, the role of smallholder farmers becomes important (Deller *et al.*, 2003) who, in most of the cases, are performing an efficient job in both developed and developing countries (Diao *et al.*, 2005). Furthermore, vegetables can play a vital role as their cultivation period is relatively short and more than one crop can be obtained in one season (Akter *et al.*, 2011).

Chillies are an important horticultural crop whose various species are grown across the world. They are mostly cultivated by the small and marginal scaled farmers (Ghoraba *et al.*, 2013). Chillies are mostly used as spices and flavoring agent (Bokkisam *et al.*, 2010). They are also a rich source of natural colors, antioxidants, vitamins, carotenoids, capsaicinoids and phenolic compounds (Howard *et al.*, 2000; Iqbal *et al.*, 2009).

After India, China, and Maxico, Pakistan is the fourth greatest producer of chilies. In Pakistan, Chilies are cultivated in all four provinces with Sindh at the top followed by Punjab, Baluchistan and KPK (Roche, 2016). The area under cultivation of chilies continuously fluctuates mainly due to price volatility (AMIS, 2006). Farmers profits play an important role in maximizing chillie production. There are hardly a few studies on this aspect. The use of inappropriate inputs and technology in chili production is reducing the chilies yield. Environment no doubt also contributing in reducing the chili yield, but to manage the weather related issues is beyond the farmer’s capacity. Farmers can increase their chili yield with appropriate use of inputs (Usman and Kasimin, 2021). However, the production of chillies in Pakistan decreased by 26.7 percent. The area of chillies was declined from 60.8 to 45.7 thousand hectares and production declined from 141.5 to 103.7 thousand tones (GoP, 2021).

Data envelopment analysis is used to calculate technical efficiency (DEA). To determine efficiency, individual observations are compared to the best observations in the same sample. They believed that by integrating these individual observations, they could obtain the most effective combination of inputs to yield the greatest output with the fewest resources available (Krasachat and Vaisawarng, 2021). Because resources are scarce, reallocating current resources to achieve higher output is a must. It allows for the production of a specific level of output at the lowest possible cost without changing the manufacturing procedures. However, data on how to use inputs efficiently in chili production is scare. (Huq and Arshad, 2010). The agriculture sector's ability to gain efficiency through improved technical efficiency is a key driver of growth. (Hossain, 2016).

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

I. Estimate economics of chillies production
   a. Estimate profitability of chillies production
   b. Identify yield gaps and issues faced by the farmers
   c. Determine the domestic terms of trade
   d. Estimate technical and economic efficiency of chillies production

II. Suggest policy implications

2. Literature Review

Spices are used in food all around the world to enhance flavor. Chili is a cash crop and widely growing in Pakistan. The global chili production was predicted to be 7 million tonnes. India is the major producer of chili and producing 25 percent of total chili production in the world. China is producing 4 million tonnes, Mexico is producing 3 million tonnes, and Pakistan is producing 2 million tonnes (Iqbal et al., 2021). Spices and minerals play a vital role in boosting immunity to battle COVID-19 in a pandemic condition. Chili crops have the power to treat a variety of diseases, including cancer (Rana et al., 2021). Chili is a major crop in Sindh, which accounts for more than 86 percent of Pakistan's total red pepper production. Sindh Kunri, a small town in the Umarkot district, grows red chilies. It produces over 85 percent of Pakistan's red chilis and is one of Asia's largest chilli producing areas (Channa et al., 2020).

Several factors influence farming revenue, including farm size, input use in production activities, and the price of the cultivated farming commodity (Sundari, et al., 2021). The profitability of chilli production is heavily influenced by price volatility (Muflikh et al., 2021). Sindh Province is the world's leading producer of chillies. The properties of the soil are ideal for chilli production. Chillies are a high-yielding crop with substantial economic benefits (Channa et al., 2020). Increasing farming's competitiveness and profitability requires a high level of technical efficiency (Taufik et al., 2021).

Efficiency assessments are performed to assess a farm's competitiveness and ability to increase output while reducing resource consumption (Barath et al., 2020). Farmers with similar resources produce differential yields per acre. This is due to inefficient input utilization and inadequate infrastructure (Abate et al., 2019). Technical efficiency is a measure of how well input resources are used. Improvement in technical efficiency is influenced by a variety of elements such as information, experience, and education (Bravo-Ureta et al., 2007). The most efficient utilization of limited resources is referred to as economic efficiency. Economic efficiency suffers as a result of climate change. Improving economic efficiency is a vital first step toward long-term growth (Koengkan et al., 2022). Asravor et al., (2016) calculated the technical, economical and allocative efficiency of chili in Ghana. The results showed that the technical efficiency was 70.97 and allocative efficiency was 92.65 percent. The economic efficiency was 65.76 percent only.

3. Materials and methods

3.1. Data collection

Both secondary and primary data were collected for the study. Secondary data were collected from Government of Pakistan, FAO and World Bank's online sources. The primary data were collected from 100 chillies farmers from district Sheikhupura of the Punjab province using a stratified random sampling technique. The district is comprised of five Tehsils i.e. Sheikhupura, Ferozewala, Muridke, Sharaqpur and Safdarabad. Two Tehsil Sheikhupura and Ferozewala were randomly selected. Ten villages were selected from each Tehsil. Five farmers were randomly interviewed from each village. Total 50 farmers were interviewed from each Tehsil and total sample size was 100 farmers. Farmers were further categories into small farmers having land upto 5 acres, medium farmers having land 5-12.5 acres and large farmers with landholding above 12.5 acres.

Table 1: Selection of respondents and their distribution according to landholdings

Sr. No.	Strata	Villages	Respondents	
1	Sheikhupura	5	10 farmers	50
2	Ferozwala	5	10 farmers	50
			Total =	**100**

Frequency distribution of farmers with respect to their land holdings

	Frequency	Percentage
Small (< 5 Acres)	56	56.0%
Medium (5 to 12.5)	25	25.0%
Large (>12.5 Acres)	19	19.0%
Total	100	100.0%

3.2. Estimation of the economic of chillies production

3.2.1. Profitability of Chillies Production

The economics of chillies production was estimated using the comprehensive information on each farming practice related to the production process. Following the economic analyses of various crops by 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:

$$TC = \sum_{i=1-9}^{n} CoC - Chillies_i \qquad 1$$

Where,

TC = Total Cost

CoC - $Chillies_i$ = 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 furrow turning, cultivator, levelling and planking.

2 = Seed bed preparation expenditures include cultivator and planking expenditures

3 = Seed and sowing operations include the expenditures on seed, nursery raising, bed making and transplanting charges.

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

5 = Irrigation expenditures include aabiana, and tube well expenditures

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

7 = Plant protection expenditures include insecticide and fungicide costs

8 = Harvesting includes harvesting, bags/ baskets, handling and transportation expenditures

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

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

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:

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

Where,

π = Profit

While the benefit cost ratio was calculated as:

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

Where,

BCR = Benefit-cost ratio

Comparison of means

The mean comparison technique was used to distinguish between the profitability of small, medium, and large farms. This technique is commonly employed in comparative analysis (Baba *et al.*, 2014; Hyblova and Skalicky, 2018; Mogula and Mishili, 2018; Arru *et al.*, 2019).

3.2.2. Yield gaps and Issues faced 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.

3.2.3. Domestic Terms of Trade

The domestic terms of trade show a comparison of domestic prices. The term has been used in the domestic context to describe the disparity in prices between products produced and sold within the country. In an ideal world, a distinction should be made between the prices earned by the agricultural sector and the prices charged by the agricultural sector for transactions conducted by the non-agricultural sector in both the agricultural and non-agricultural sectors of the economy. The term "net exchange barter terms" refers to the comparison of the rates acquired and charged (Akhtar *et al*, 2013). The price of chili varies significantly. Prices will rise if the supply of chili is reduced or falls short of the demand (Bangun., 2021). Green chili prices range between Rs800 and Rs1200 per 60kg bag, in the year 2021 which does not cover the cost of cultivation. Chili is sold in two key markets in Pakistan. Green chili is distributed with in Sultanabad in Mirpurkhas, while red chili is sent to the main Kunri market in Umerkot district (Khaskheli J. 2022).

3.3. Economic and technical efficiency of chili production

The ability of decision-making units (DMUs) to choose suitable input combinations based on relative prices, are known as efficiency. The capacity of a DMU to optimise output given a set of inputs is referred to as technical efficiency (Mizala et al., 2002). DEA model with variable return to scale was used to calculate the technical efficiency of chilli farmers. The efficiency score ranges from 0 to 1. The value 1 was assigned to the most efficient DMUs, whereas the value closest to 0 was assigned to the least efficient DMUs (Barath et al, 2020; Krasachat and Yaisawarng 2021). The stochastic production frontier analysis starts with the specification of a log-linear production function, as shown below.

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

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

Where:

Y_i= Out put

β = Parameters

X_i= Input variables

The disturbance term ε_i has two different factors, u_i and α_i. u_i measured the inefficiency, and α_i is a stochastic error term. The inputs variables includes operational land holding (Acres), numbers of ploughing, numbers of rotavator, number of laser leveling, number of urea bags, number of DAP bags, numbers of nitrate, potash bags and number of pesticides application.

3.4. Tobit Model

The technical and economic efficiency of chili was measured using a DEA model. DEA, on the other hand, has limited utility in identifying factors that influence efficiency. This study splits the investigation into two parts in order to dig further into the aspects that influence technical efficiency. DEA calculates the efficiency in the initial stage. The Tobit model is used in the second step to investigate potential underlying factors that influence technical efficiency. The Tobit model used to investigate the primary determinants that influencing the technical efficiency. The econometric model is determined by the type of the dependent variable. The technical efficiency value lies between 0-1. When the dependent variable is censored between two values the Tobit is most suitable model (Mazibuko and Antwi, 2019).

The Tobit model is as follow:

$$Yi = \beta_0 + \beta_1 \ln(age)_i + \beta_2 \ln(education)_{2i} + \beta_3 \ln(Experience)_i + \beta_4 \ln(familysize)_i + \beta_5 \ln(\text{distance from main road})_{i+} \beta_6 \ln(\text{distance from city})_{i+} \beta_7 \ln(\text{distance from market})_i$$

Here

Y_i is the technical efficiency of chilli production, Age and education is in years; family size is in numbers and all the distance were measured in kilometers.

4. Results and Discussion

4.1. Economic of chillies production

Seed and sowing operations sub-category of the expenditures (3) had the highest share in total cost with PKR 15,926. The cost of production was slight differ by small (PKR 13,860), medium (PKR 15,790) and large farmers (18,130). The results of comparison of means showed that there was no significant difference in expenditures. On average, PKR

10,826 was spent on fertilization. Small farmers spent the least, PKR 8,901, followed by medium farmers (PKR 11,453) and large farms (PKR 12,128). Third most contributing expenditures were on irrigation on which average expenditures of PKR 9,650 were incurred. Small farmers spent the most on irrigation operations (PKR 11,030) followed by medium (PKR 9,430) and large (PKR 8,490) farmers. The reason may be water rent, inefficient irrigation system and pumping equipment (Abedullah *et al.*, 2006; and Iqbal, 2015).

Small farmers spent more on land preparation. The average expenditures by all the farmers in this category were PKR 2,053 while small farmers spent PKR 2,252 as compared to medium (PKR 2,058) and large farmers (PKR 1,850) . 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 73,181 per acre with small farmers spending the lowest i.e. PKR 70,505 followed by medium farmers (73,629) and large farmers (PKR 75,404). A detailed comparison is shown in Table 2 below. There were slight differences in yields. Small farmers had the lowest yield i.e. 3,000 kgs per acre while medium farmers had a yield of 3,200 kgs per acre and larger farmers had a yield of 3,450 kgs per acre. Small farmers had the lowest BCR (1.03) while medium farmers had 1.04 and large farmers BCR remained 1.07.

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 2: Economic analysis of chilli production

Activities (PKR)	Small Farmers n = 56	Medium Farmer n = 25	Large Farmers n = 19	Total Sample n = 100
Land Preparation	2,252	2,058	1,850	2,053
Seed bed preparation	1,470	1,530	1,600	1,533
Seed and sowing operations	13,860	15,790	18,130	15,926
Fertilization	8,901	11,453	12,128	10,826
Plant protection	3,260	3,770	4,300	3,776
Irrigation	11,030	9,430	8,490	9,650
Harvesting	5,464	5,488	5,524	5,492
Miscellaneous	9,048	9,048	9,048	9,048
Total Average Cost	70,510	73,629	75,404	73,181
Yield / acre (Kgs)	3,000	3,200	3,450	3,217
Average Farm gate price (PKR / Kg)	19	19	19	19
Gross Income / acre	57,000	60,800	65,550	61,116
Net Profit	1,715	2,233	4,480	2,812
BCR	1.03	1.04	1.07	1.05

4.2. Yeldgaps

The yields of farmers in the study area were significant lower than the world's and China's average yields i.e. 56% and 66%. However, the yield was nearly equal to India's average yield.

Table 3: Yield gaps

	Tonnes / Acre	Maunds / acre
Current study	3.216	80.4
India Average	3.42	78
China Average	9.47	192
World Average	7.35	167

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

4.3. Issues faced by farmers

Farmers reported four major issues (Table 4). According to these results, 80% of the farmers complained about high cost of inputs. While, 73% said that the output price volatility is an issue of concern. About 65% of the farmers reported that non availability of quality / hybrid seed is an issue. High transportation cost was another issue according to 55% of the farmers.

Table 4: Issues reported by the farmers

Sr. #	Issues	Frequency	Percentage
1	High input prices	80	80
2	Highly volatility of output price	73	73
3	Non availability of quality (Hybrid) seed	64	64
4	High transportation costs	55	55

4.4. Issues faced by farmers

4.5. Domestic terms of trade

An examination of the domestic terms of trade for ploughing (traction), farm labor, and fertilizers (Urea and DAP) is presented and explained by the self-explanatory Figures 1 - 3. It can be noted that the costs of plowing and wage rate have increased over time (Figure 1) due to which the per KG requirement of chillies to buy on unit of these inputs has also increased (Figure 2). This disturbed the ratio of prices (input/ output) and made the farmers worse off.

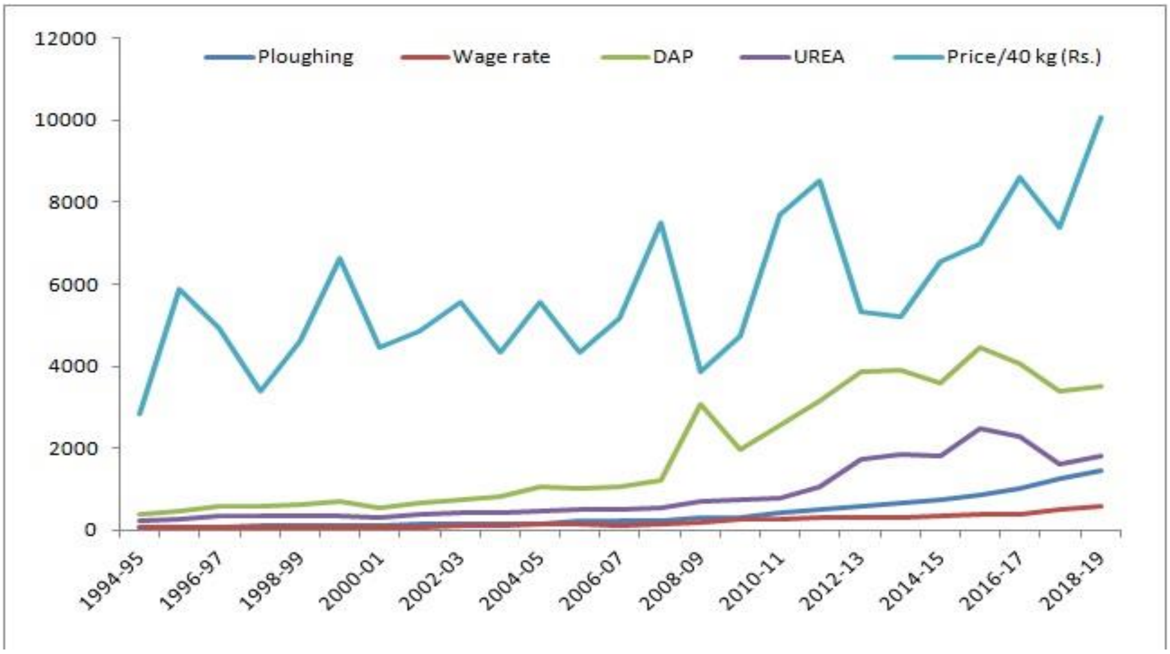

Figure 1: Input-output price trends

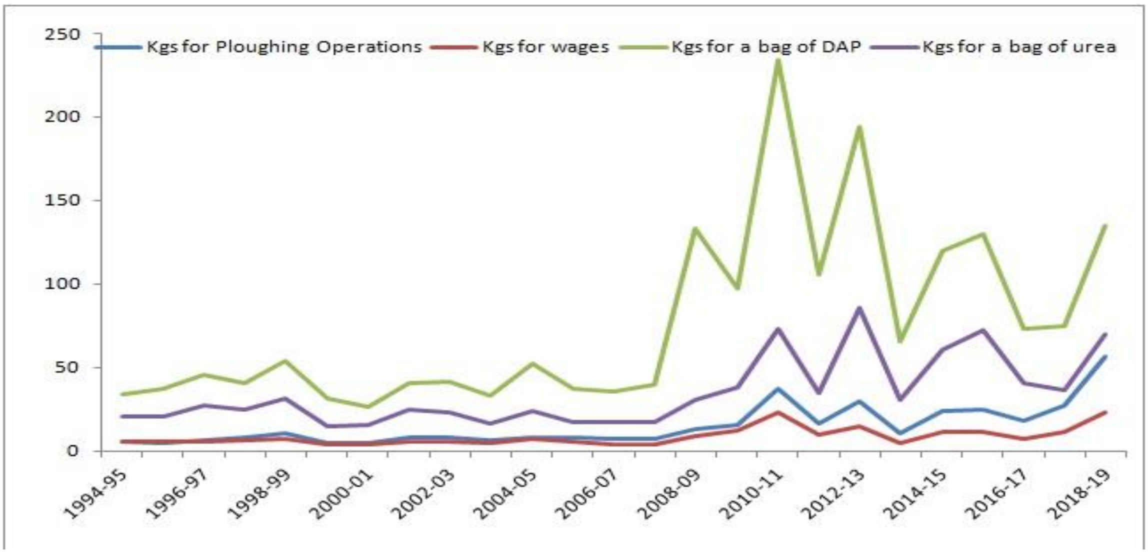

Figure 2: Domestic terms of trade

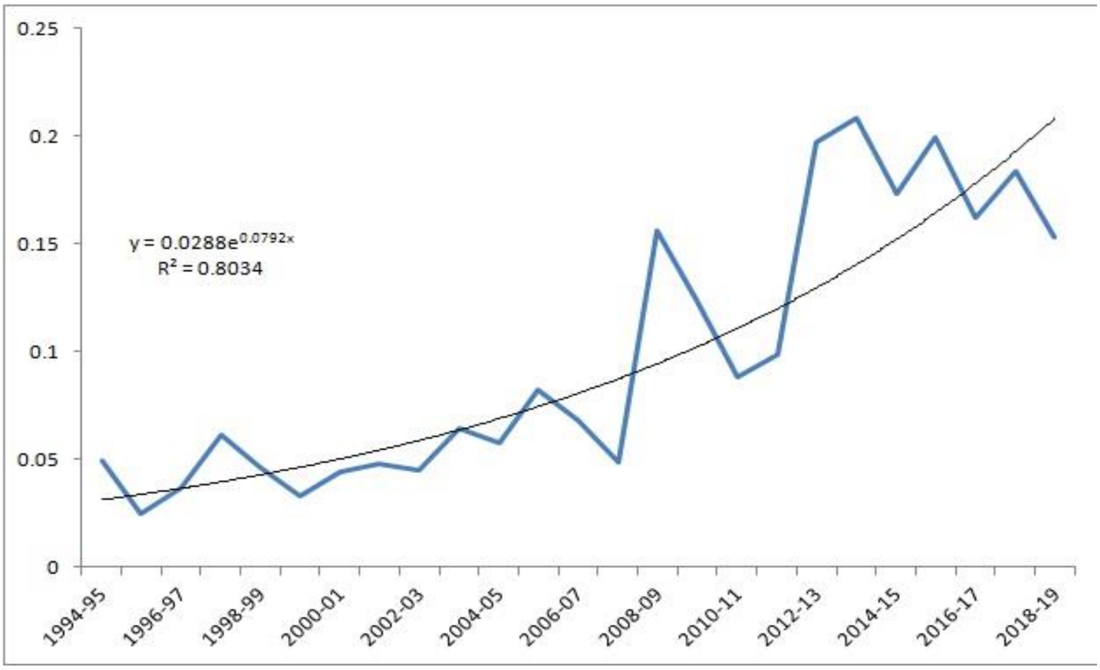

Figure 3: Input-output price ratio

4.6. Economic and technical efficiency

The technical and economic efficiency of chili presented in Table 5. The mean technical efficiency of small, medium, and large farmers were 0.88, 0.92 and 0.96 respectively. It means that a 22, 8 and 4 percent increase in production was possible with the available input resources. Hence majority of the large farmers were more technical efficient. The mean economic efficiency was 86, 91 and 95 percent for small, medium and large farmers. It stated that farmers in the research area can lower production costs by 14, 9, and 5% without sacrificing productivity. The efficiency results suggested that large farms were slightly more economically efficient than medium and small farms.

Table 5: Technical and economic efficiency

Categories	Technical Efficiency			Economic Efficiency		
	Small (n=56)	Medium (n=25)	Large (n=19)	Small (n=56)	Medium (n=25)	Large (n=19)
0.50-0.60	2	0	0	5	0	0
0.61-0.70	14	4	0	10	3	0
0.71-0.80	12	5	5	14	4	3
0.81-0.90	18	6	5	14	7	6
0.91-1.00	10	10	9	13	11	10
Mean	0.88	0.92	0.96	0.86	0.91	0.95

4.7. Factors affecting efficiency of chili production

The Tobit results showed that age, education, experience, family size and distance from main road have positive impact on technical efficiency of chili. Distance from market and main city have negative relation with technical efficiency. Tobit model results are shown in Table 6.

Table 6: Results of Tobit regression model

Variables	Coefficient	Std. Error	Significance
Age	0.0132	0.0862	0.000
Education	0.0010	0.0028	0.042
Experience	0.0013	0.0030	0.001
Family size	-0.0060	0.0026	0.028
Distance from road	0.0014	0.0038	0.146
Distance from City	-0.0082	0.0033	0.015
Distance from market	-0.0005	0.0031	0.000

5. Conclusions

This study aimed to improve the chilies production in Pakistan. The cost of production, benefit cost ratio; domestic terms of trade was measured. The factors were identified identify that were reducing the farmers efficiency. Primary and secondary data were used for the analysis. Secondary data were collected from Government of Pakistan, FAO and World Bank's online sources. Primary data were collected from 100 chillies farmers from District Sheikhupura. Farmers were hardly getting profit per acre of chillies' cultivation. The benefit cost ratio was very low. Similarly, the findings of the domestic terms of trade analysis revealed that there are major problems in both the input and output markets as the terms of trade have deteriorated over time. The yield is 50-60% low than the world's and China's average yields indicating huge potential. Farmer reported four major issues including: high output price volatility, higher input prices, expensive quality (hybrid) seed availability and high transportation costs. It is recommended that the market regulations especially in seed market may be implemented in letter and spirit. Furthermore, research on different aspects of economics and policy of cotton production is carried out at a regular interval to identify major evils in the production system. The technical efficiency for small, medium, and large farmers, were 0.88, 0.92, and 0.96, respectively while the mean economic efficiency was 86, 91, and 95 percent, respectively. Efficiency analysis showed that the farmers can increase their yield and economic benefits with available resources. Age, education, experience, family size, and distance from main road all have a beneficial impact on chili's technical efficiency, according to the Tobit model. Technical efficiency has a negative relationship with distance from the market and the main market. The proper infrastructure can also improve the economic efficiency of chilli farmers.

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