The determinants of technical efficiency of peach growers: evidence from Khyber Pakhtunkhwa, Pakistan

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Abstract

This study employed translog stochastic production frontier model to examine the technical efficiency and its determinants of peach farmers in Khyber Pakhtunkhwa province of Pakistan. Results of the study reveal that peach farmers displayed much variability in technical efficiency ranging from 64% to 95% with a mean technical efficiency of 81%, which suggested a substantial 19% of potential output can be recovered by removing inefficiency. For an agriculture based country like Pakistan, this gain could help increase income and ensure a better livelihood for the farmers. The results suggest that farmers' age, experience, education, membership, cellphone usage, livestock ownership, credit access, extension services, the role of non-government organization and soil quality perception have a positive influence on technical efficiency. In contrast, off-farm income, household size, price volatility perception, natural disaster risk perception, and weather shocks awareness have a negative influence on technical efficiency. Hence, the study proposed that technical efficiency of peach farmers can be increased by an appropriate choice of input combinations, improving the present level of inefficiency determinants and elimination of errors in the production process through efficient management practices.

Keywords: Technical efficiency. Translog stochastic frontier. Peach.

1. Introduction

Pakistan is an agrarian country. The agriculture sector has traditionally sustained a satisfactory growth to ensure food security for the growing population. This sector accounting for 19.5% of the Gross Domestic Product (GDP), employs 42.3% of the labour force and add to the foreign reserve of the country (GOP, 2017). Within agriculture, the horticulture is an important sub-sector of the agricultural economy. Pakistan Horticulture sector produces approximately 12 million tonnes per year production of fruits, vegetables and spices. High value and great potential fruits are grown in different varieties and delicious in taste. These are apples, mangoes, peaches, grapes, citrus, dates, and cherries. Other prominent fruits that have huge export potential are loquat, pears, plums, and guava (PHDEC, 2017).

Peach *(Prunus persica)* is a member of the Rosaceae family; originated in China, have been cultivated for more than 3000 years and spread to the rest of the world by means of seeds (Royan et al., 2012; Ghatrehsamani et al., 2016). It is the most important among the stone fruit and is temperate in nature. It is a remarkable fruit having different attributes i.e. sweetness, juiciness, fleshiness, attractive in flavour and aroma. Due to these attributes, it is very delicious in taste (Yu et al., 2015). Fresh peach is comprised of very healthy nutrient. It has a rich source of vitamins A and C and also contains potassium and fibre. The fruit has over 80% water and one average sized peach has 7% of the dietary fibre which is required each day (Habib, 2015). Khyber Pakhtunkhwa province of Pakistan is blessed with a wide range of fruits and is the largest producer of delicious fruits. The soil and climatic conditions of this province quite favour peach cultivation and it is a traditional crop of this region. According to Agricultural Statistics of Pakistan (GOP, 2015), the total area under fruits cultivation was 764.26 thousand hectares for the year 2014-15 in Pakistan. Out of the total area under fruits, 5.7 thousand hectares is under peach. The total fruits production was 7018 thousand tonnes among them peach fruit contributes 66.4 thousand tonnes for the year 2014-15 in Pakistan. Figure 1 shows the peach production of Khyber Pakhtunkhwa and Pakistan from the year 1990-91 to 2013-14.

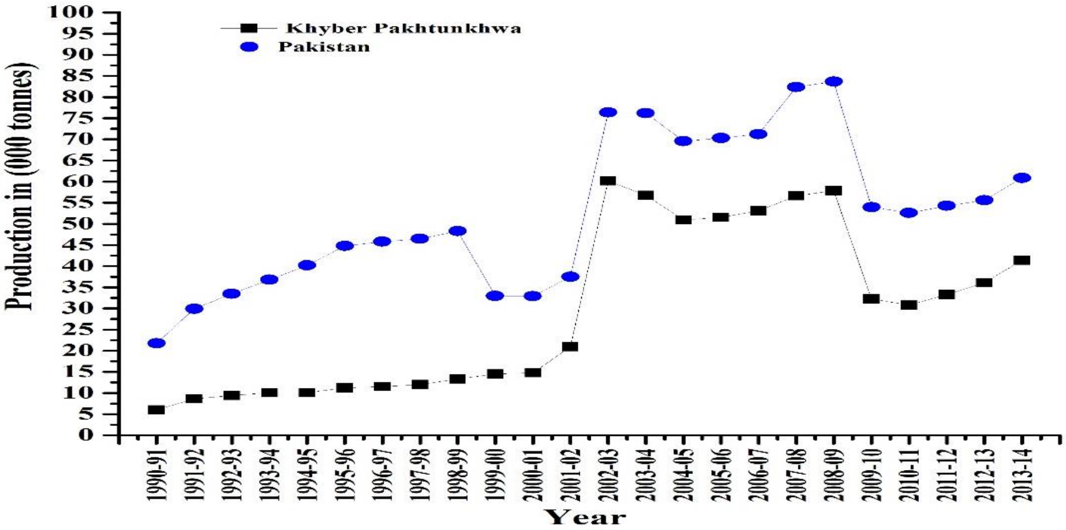

Figure 1: Production of peach in Khyber Pakhtunkhwa and Pakistan.

It is generally believed that the per hectare productivity of fruit orchard in Pakistan is low from other developed nations (Memon et al., 2015). Accordingly, in spite of peaches various uses and benefits, its cultivation and productivity are declining day by day both in acreage and yield in Khyber Pakhtunkhwa. The major causes of low productivity are low returns to farmers and higher costs of production, slow rate of technological innovation and limited adoption of progressive farming techniques. Furthermore, with the passage of time, these challenges have been further complicated due to the severe impact of ongoing climate change (GOP, 2015).

Raising the agricultural productivity for the reduction of poverty are intertwined challenges and enduring issues in the world, particularly in developing countries (World Bank, 2016). Therefore, the development of policies that target increasing agricultural productivity is the government’s typical domestic reaction to the challenge of reducing poverty in rural areas. The adoption and dissemination of innovative farming practices eventually contribute to improvements in productivity and returns of the farmers (Karimov, 2014). Moreover, farmers may increase their returns by decreasing the cost of production. Theoretically, there are three possible ways to decrease the cost of production. Firstly, to minimise the cost of inputs. Secondly, to develop cost effective high yielding technologies. Thirdly, to adopt best management practices. Factually, in Pakistan, an increase in prices of agricultural inputs has been much higher than the increase in prices of agricultural outputs. In this scenario, there is little expectation of a decrease in prices of agricultural inputs. As far as development of new agricultural technologies, particularly high yielding varieties, is concerned it is a long-term process. It takes several years to develop a new variety and in its formal approval for distribution to farmers (Bashir et al., 2005). Nonetheless, there is room for decreasing the cost of production through improvement in the management practices. When economists talk about improvement in the management practices they talk in terms of technical efficiency and defined as the measure of the ability of a firm to produce maximum output from a given set of inputs (Pinello et al., 2016).

There is a growing literature on the technical efficiency in agriculture sector of developing countries. In this context, Rauf (1991) estimated the technical efficiency of irrigated area of Pakistan using the Cobb-Douglas production model. The study results revealed that higher education is an important variable for improving agricultural productivity. Kalirajan (1991) used translog frontier production function to estimate the technical efficiency of rice farmers in India. It was concluded that technical efficiency can be improved by improving the research and extension services and adoption of new technology. Asogwa et al. (2011) investigated the technical efficiency of small scale farmers in Nigeria. The study results concluded that extension services and new crop technologies are the major factors of technical efficiency. Essilfie et al. (2011) measures the technical efficiency using the stochastic frontier approach of small scale maize producers in Ghana. It was concluded that farmer’s education, age, family size and off-farm income had a strong influence on technical efficiency. Chiona et al. (2014) investigated the technical efficiency of maize producers in Zambia. It was concluded that farmers age, hybrid seed usage, extension services, off-farm income and credit access are the major determinants sensitive of technical efficiency. Karimov (2014) examined the technical efficiency of cotton producers in North-western Uzbekistan. Results of the study show that credit access, manure application, size of the farm, farmer’s education, water services, off-farm income, poor drainage system and water facilities were significantly associated with technical efficiency. Carrer et al. (2015) examined the technical efficiency of citrus producers in Brazil using the translog frontier production model. It was concluded that personal characteristics and aspects of decision-making processes are significant determinants of technical efficiency.

Khyber Pakhtunkhwa province produces good quality and high production of peach fruit. However, till date, there are not sufficient economic research has been carried out on peach farming in Pakistan. Therefore, this study is important in aspects of how to improve productivity and efficiency of peach growers in this province. Among the prevailing literature (Khan et al., 2008; Khalil et al., 2014; Zeb and Khan, 2008) discuss the main causes in the context of Pakistan peach production. Hence, the existing literature is rather indecisive, which suggests a need for further research. To mitigate poverty, hunger, and food insecurity pressure has prompted significant research efforts to investigate the technical efficiency of agricultural production in Pakistan, but specifically, in the context of peach does not exist. In this study, we adopt the concept of "Technical efficiency" to investigates the factors influencing peach farmer's productivity.

This study has two main objectives. The first objective is to estimate the technical efficiency of peach growers in Khyber Pakhtunkhwa province of Pakistan using Stochastic Frontier Analysis (SFA). The second objective is to investigate the influence of inefficient determinants on technical efficiency among those farmers. The remainder of the paper proceeds as follows. The next section describes the materials and methods. Results and discussion are given in Section 3. Finally, Section 4 provides conclusions and policy implications.

2. Technical efficiency

Technical efficiency refers to the firm's ability to attain the highest possible level of output given a set of inputs and technology. In contrast, technical inefficiency reflects the failure of producing maximum output given inputs and technology. A large number of frontier models have been developed based on Farrell's (1957) work. These can be classified into two types (1) parametric, and (2) non-parametric. First one has specific functional form and second type does not have a specific form. Another important distinction is made between deterministic and stochastic frontiers. The deterministic model assumes that the deviation from the frontier is due to inefficiency, while the stochastic model allows for statistical noise (Ouattara, 2012).

Most of the researchers adopt the Farrell (1957) approach to measure the technical efficiency. This is an interesting idea to define output of the efficient firms as the production frontier for all firms, while the neoclassical theory assumes that all firms to be fully efficient in technology use. Figure 2 presents the Farrell approach to determine the technical efficiency in case of two inputs and a single output.

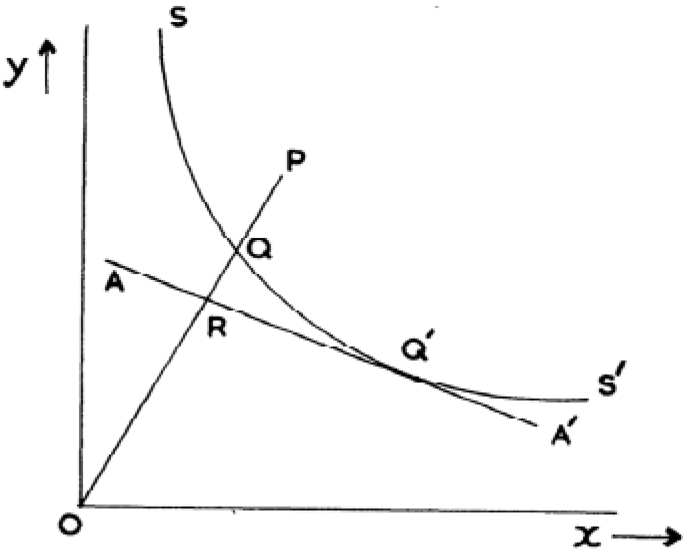

Figure 2: Farrell's measure of technical efficiency.

In this method, under the condition of constant returns to scale, Farrell (1957) considered a firm that uses two factors of production X and Y to produce a single output P. Figure 2 illustrates a single isoquant SS′ shows various combinations of the two factors of production that a perfectly efficient firm uses to produce an output. The point P gives the units of two inputs, per unit of output that the firm observes to use. Isoquant SS′ also presents a lower bound of a scatter that indicates the same level of output and Q and P are on the same isoquant. The point Q represents an efficient combination of two factors that firm uses in the same ratio as P. The firm produces the same output as P using only a fraction OQ/OP as much of each input. It produces OP/OQ times as much output from the same inputs. Therefore, OQ/OP is the technical efficiency of firm. The technical inefficiency of the firm is represented by the distance QP. It is the amount by which all factors could be proportionally reduced without a reduction in output. The firm is said be technically efficient if the ratio is equal to 1. The firm is inefficient if this ratio is less than 1. Now considers the budget line represented by line AA′ having slope equal to the ratio of the prices of the two factors of production. Therefore, that is the optimum combination of two factors of production where the isoquant curve is tangent to the budget line AA′. Point Q′ is the optimum combination of two factors of production and the firm is technically efficient at this point.

Technical efficiency is a relative and not an absolute concept. It gives the output level of the i^{th} farmer relative to output level of the efficient farmer's using the same set of inputs. The efficient best production frontier is considered as stochastic which considers two-sided error term with the intention of exogenous factors that are not controlled by the farmers. It is not possible for all the farmers to produce frontier output level. So an additional error term is familiarized to signify technical efficiency. This paper uses translog frontier production approach to determine the technical efficiency.

3. Materials and Methods

3.1. Specification of the model

The productivity of farms is important for many reasons. Aside from providing more food, increasing productivity of farms have a strong influence on economic prospects i.e. growth and competitiveness in the agricultural market, income distribution, savings, and labour migration. Therefore, to increase agricultural productivity implies a more efficient distribution of scarce resources. As farmers adopt new techniques and modifications, the more productive farmers benefit from an increase in their welfare while farmers who are not productive enough will exit the market to seek success elsewhere (Mundlak, 1992). Coelli et al. (2005) stated that productivity is the ratio of the outputs that it produces to the inputs that it uses [Productivity = Outputs / Inputs]. When we refer to productivity, we are referring to total factor productivity (TFP). TFP growth shows the relationship between the growth of output and growth of input, calculated as a ratio of output to input. In other words, productivity is raised when growth in output increase from growth in inputs. Productivity growth without an increase in inputs is the best growth to aim for rather than attaining a certain level of output (Pratt et al., 2008). Furthermore, with a given index of inputs, a larger index of outputs means a higher productivity (Yao and Li, 2010). However, measuring the total inputs and total outputs is both conceptually and empirically difficult. Recently, most common methods to estimate productivity and efficiency are evaluated mainly using two different analytical approaches, non-parametric analysis represented by the data envelopment analysis (DEA)(Yang et al., 2014; Svitalkova, 2014; Detotto et al., 2014; Fu et al., 2013; Coelli and Wagga, 2007) and parametric Analysis represented by the stochastic frontier analysis (SFA) (Bozoğlu and Ceyhan, 2007; Latt et al., 2011; Karimov, 2014; Carrer et al., 2015). The one approach we use in this paper is the stochastic frontier analysis (SFA). This method is not strictly preferable to the others. On the one hand, compared to DEA, SFA allows taking account of random factors and is able to perform quantitative analysis of the effects of random factors (for example contractual practices, and so on) on the technical efficiency. However, DEA ignores the effects of random factors on the technical efficiency. Moreover, the efficiency values of SFA are not generally the same and do not equal to 1. SFA makes full use of the information of each sample and its results are stable. So, SFA has the advantages of high comparability and reliability. On the other hand, the main disadvantage of SFA is that it assumes that the boundary of the production possibility set can be represented by a particular functional form with constant parameters. Nevertheless, we consider that the fact that SFA imposes an explicit functional form and distribution assumption on data is less of an issue since our large sample size allows us to run a translog function, which is a very flexible functional form. The objective of this study was achieved through the estimation and analysis of the stochastic production frontier model, originally proposed by (Aigner et al., 1977), and (Meeusen et al., 1977). The single stage model proposed by (Battese and Coelli 1995) and its general form of the SFA model:

$$y_i=f(x_i;\beta)\,exp(\upsilon_i+u_i) \qquad (1)$$

Where y_i and x_i denote production outputs and inputs respectively; β represents estimated coefficients; υ_i is statistical random error, assumed to be normal distribution, $\upsilon_i \sim N(0, \sigma^2_\upsilon)$ and it captures the effects of random shocks outside the farmers control (e.g. weather, disease outbreaks, measurements errors, etc.); u_i denotes technical inefficiency, assumed to be truncated normal distribution, $u_i \sim |N(0, u_i\ \sigma^2_u)|$; υ_i and u_i are assumed to be independent; $i=1,\ldots,N$; N is number of measurement unit (MU_i), i.e. total samples. Following Battese and Coelli (1995), u_i can be represented as:

$$u_i=z_i\delta+W_i \qquad (2)$$

Where z_i is a p x 1 vector of variables which may influence the efficiency of the i^{th} firm, δ is a 1 x p vector of parameters to be estimated and W_i is the random variable defined by the truncation of the normal distribution with mean 0 and variance σ^2_u. Technical efficiency is defined as the ratio of the observed output (y) to the corresponding frontier output (y*) conditional on the levels of inputs used by the firm. In the context of the stochastic frontier production function Equation (1), technical efficiency is given by

$$TE=\frac{y_i}{y_i^*}=\frac{y_i}{[f(x_i;\beta)exp\{\upsilon_i\}]}=exp(-u_i) \qquad (3)$$

Aigner et al., (1977) suggest using a likelihood function to allow for two variance parameters, $\sigma^2=\sigma^2_u+\sigma^2_\upsilon$ and $\lambda=\sigma_u/\sigma_\upsilon$ in the stochastic frontier production function. Values of γ must lie between zero and one with values of 0 indicating the deviations from the frontier are entirely due to noise, and values of 1 indicating that all deviations are due to technical inefficiencies. We can arrive at Eq. (4) by obtaining a logarithm from both sides of Eq. (1)

$$lny_i = lnf(x_i;\beta)\ exp(\upsilon_i + u_i) \tag{4}$$

Where Eq. 4 can assume translog production function form. Translog stands for transcendental logarithmic', and it refers to the functional form that is assumed. In particular, notice that the translog production function is all in terms of the logs of the variables:

$$f(x_i;\beta) = exp\left(\beta_0 + \sum_{k=1}^{K} \beta_k lnx_k + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta kl lnx_k lnx_l\right)\forall_i \tag{5}$$

Translog production functions are most useful for empirical analysis. The fact that they have a linear representation in terms of logs makes this type of function very nice for estimating its parameters by means of standard econometric methods. The flexible translog form was applied to represent the technology/production function to identify the effects of inefficient variables on the efficiency of peach growers.

The proposed econometric model can be expressed as:

$$\begin{aligned} lny_i =& \beta_0 + \beta_1 lnx_{1i} + \beta_2 lnx_{2i} + \beta_3 lnx_{3i} + \beta_4 lnx_{4i} + \beta_5 lnx_{5i} \\ &+ \beta_{11}(1/2\, ln^2 x_{1i}) + \beta_{12} lnx_{1i} lnx_{2i} + \beta_{13} lnx_{1i} lnx_{3i} + \beta_{14} lnx_{1i} lnx_{4i} \\ &+ \beta_{15} lnx_{1i} lnx_{5i} + \beta_{22}(1/2\, ln^2 x_{2i}) + \beta_{23} lnx_{2i} lnx_{3i} + \beta_{24} lnx_{2i} lnx_{4i} \\ &+ \beta_{25} lnx_{2i} lnx_{5i} + \beta_{33}(1/2\, ln^2 x_{3i}) + \beta_{34} lnx_{3i} lnx_{4i} + \beta_{35} lnx_{3i} lnx_{5i} \\ &+ \beta_{44}(1/2\, ln^2 x_{4i}) + \beta_{45} lnx_{4i} lnx_{5i} + \beta_{55}(1/2\, ln^2 x_{5i}) + \upsilon_i + u_i \end{aligned} \tag{6}$$

Where y_i represents the production of the i^{th} firm; x_i is a vector of logarithms of physical quantities of inputs used by the farmers (Area, labor, capital, fertilizers, and pesticides), as defined in Table 1; β is a vector of the parameters of the production function to be estimated; υ_i is a random error term, independent and identically distributed; u_i is an asymmetric non-negative random error associated with the technical inefficiency of the i^{th} farm; and i denotes the i^{th} of number of respondents in the sample.

The Battese and Coelli (1995) model specification can be described as by following the specific form:

$$\begin{aligned} \mu_i =& \delta_1 z_{1i} + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 z_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} + \delta_8 z_{8i} \\ &+ \delta_9 z_{9i} + \delta_{10} z_{10i} + \delta_{11} z_{11i} + \delta_{12} z_{12i} + \delta_{13} z_{13i} + \delta_{14} z_{14i} + \delta_{15} z_{15i} \end{aligned} \tag{7}$$

The inefficiency term u has a positive truncated normal distribution with a constant scale parameter σ^2_u and a location parameter u that depends on additional explanatory variables in which δ is an additional parameter vector to be estimated and z is a vector of explanatory variables that can affect the inefficiency of the peach farmers, as defined in Table 1. We used the statistical software package Stata version 12 for the frontier analysis.

3.2. Selection of the study area

This study was carried out in Khyber Pakhtunkhwa province of Pakistan. This province is situated between 31^{o} 15’ and 36^{o} 57’ North latitude and 69^{o} 5’ and 74^{o} 7’ East longitude. The maximum length of the province between the parallels is 408 miles and the maximum breadth between the meridians is 279 miles (Khan, 2012). It lies at the junction of three mountain ranges; Himalaya, Karakorum, and Hindukush. The geographical area of the Province is 10.17 million hectares i.e. 12.8% of the total area of Pakistan (Khan, 2012). Figure 3 shows the selected study districts in Khyber Pakhtunkhwa, Pakistan. Furthermore, the selection of study area and peach crop in our research was based on two reasons: first, Khyber Pakhtunkhwa province is blessed with wide range of fruits and is the largest producer of delicious fruits in Pakistan; second, peach is the leading fruit crop among the fruit crops /orchards of all categories in this province.

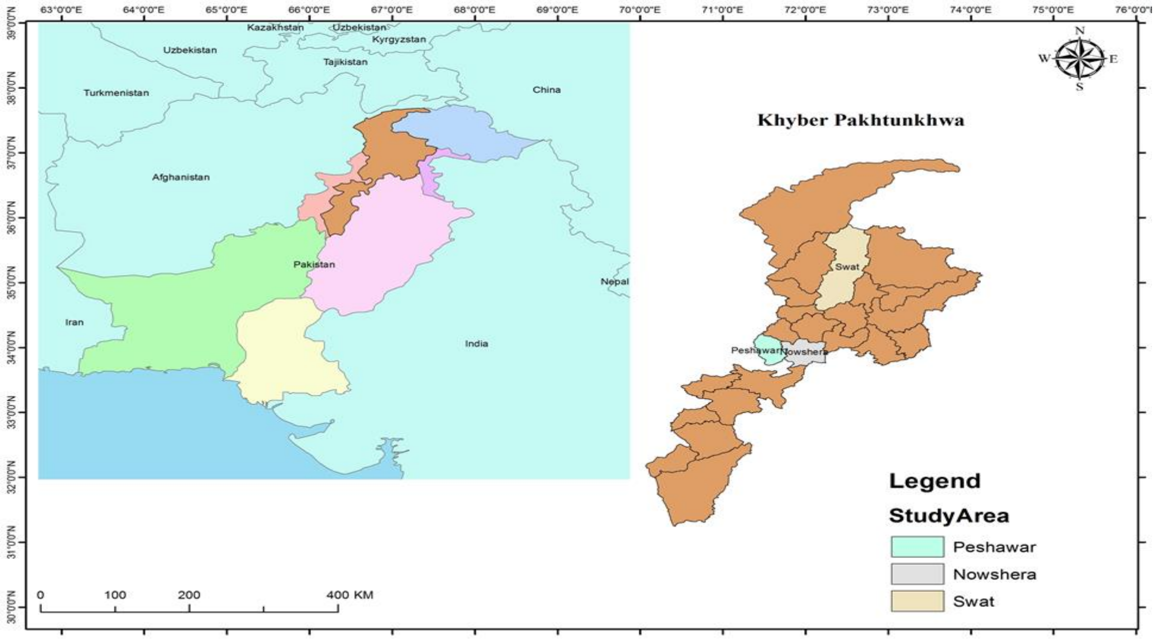

Figure 3: Selected study districts in Khyber Pakhtunkhwa, Pakistan.

3.3. Sampling technique and data samples

The data was collected using a multi-stage sampling design. In the first stage, the northern region of Khyber Pakhtunkhwa province (traditional peach producing belt) was selected. In the second stage, three districts namely Peshawar, Nowshera, and Swat were selected purposely according to their relative importance in fruit production. In the third stage, main towns and union councils were selected from purposively-selected districts. Finally, a total number of 21 villages were selected based on more peach fruit plants, a large number of practising peach growers and orchard owners in these villages. Direct elicitation method was employed for data collection to ask the production aspects of peach and inefficiency factors. The interviewer applied a structured and comprehensive questionnaire. The data collection was carried out from 270 respondents using proportional sampling allocation technique, referring to the crop year 2013/14 (cross-sectional data).

3.4. Description of the variables

The variables included in the analysis of household characteristic is described as follows. There are two categories of variables: the given inputs and output of production with regard to peach productivity, and the explanatory variables for explaining inefficiency effect.

The given inputs variables (land, labour, capital, fertilizers and pesticides) were included in the estimation of the frontier production function and the explanatory variables tested as determinants of the technical efficiencies of the farmers. Furthermore, the explanatory variables were divided into three groups: (i) socio-economic characteristics (e.g., age, experience, education, household size, off-farm income, membership, cell phone usage and livestock ownership) (ii) institutional variables (e.g., access to credit, extension services, role of non-government organization (NGOs) and price volatility perception) (iii) climatic factors variables (e.g., natural disaster risk perception, soil quality perception, and weather shocks awareness). The output (peach production) was measured in kilograms.

The inputs were measured as: (1) area of the peaches trees in acre; (2) labor employed in peaches production in man-days; (3) Capital (annual service flow of tractors, equipment and main agricultural implements) in machine-hours; (4) chemical fertilizers (DAP, SSP, NPK) in kilograms; (3) pesticides in liter.

3.5. Descriptive statistics

The descriptive statistics of the inputs and output variables are presented in Table 1. It is evident that the sample consists of 1.5 to 8 acres of farms, with high variations in peach production and endowments of production factors. These results suggest that there is considerable room for improving average peach production in this area. Labor is the total number of man-days (1 day is equal to 8 hours) of farmer/family labour, as well as regular, hired and casual labour. Total working days were accumulated from over-all activities such as pruning, thinning, irrigating, weeding, fertilizing, and harvesting. Farmers had used pesticides in order to anticipate spreading of the peach flat-headed borer, *Sphenoptera dadkhani* (Oben.) is the most serious insect of peach fruit orchards (Zahid et al., 2015).

Table 1: Descriptive statistics of the variables

Variables	Unit	Mean	S.D.	Min.	Max.
Output variable					
Production (y)	Kg	16752.59	10317.63	1600.00	45000.00
Inputs Variables					
Area (x_1)	Acre	3.27	1.20	1.50	8.00
Labor (x_2)	Man-days	138.90	116.98	30.00	555.00
Capital (x_3)	Machine hours	166.65	128.22	14.00	625.00
Fertilizers (x_4)	Kg	137.41	137.42	50.00	1500.00
Pesticides (x_5)	Liters	382.67	115.13	50.00	820.00
Inefficiency Variables					
Socio-economic characteristics					
Age (z_1)	Years	42.19	11.30	25.00	67.00
Experience (z_2)	Years	7.98	6.76	2.00	31.00
Education (z_3)	Years	3.65	4.60	0.00	16.00
Household size (z_4)	Number of persons	6.56	1.90	2.00	11.00
Off-farm income (z_5)	Dummy (0 = no, 1 = yes)	0.75	0.43	0.00	1.00
Membership (z_6)	Dummy (0 = no, 1 = yes)	0.28	0.45	0.00	1.00
Cell phone usage (z_7)	Dummy (0 = no, 1 = yes)	0.90	0.30	0.00	1.00
Livestock ownership (z_8)	Dummy (0 = no, 1 = yes)	0.37	0.48	0.00	1.00
Institutional variables					
Access to credit (z_9)	Dummy (0 = no, 1 = yes)	0.39	0.49	0.00	1.00
Extension services (z_{10})	Dummy (0 = no, 1 = yes)	0.36	0.48	0.00	1.00
Role of NGOs (z_{11})	Dummy (0 = no, 1 = yes)	0.19	0.40	0.00	1.00
Price volatility perception (z_{12})	low =1, medium = 2, high =3	1.71	0.90	1.00	3.00
Climatic factors variables					
Natural disasters risk perception (z_{13})	low =1, medium = 2, high =3	2.34	0.83	1.00	3.00
Soil quality perception (z_{14})	low =1, medium = 2, high =3	2.63	0.53	1.00	3.00
Weather shocks awareness(z_{15})	low =1, medium = 2, high =3	1.21	0.56	1.00	3.00

Source: Author's calculation

Table 1 also presents the summary statistics of the variables used in the inefficiency function. Farmers’ age is an important socioeconomic factor for adopting or rejecting a new technique or practice. The average age of farmers in the study area was 42 ranging from 25 to 67 years. This indicates that most of the respondent were relatively young. Education plays an important role in the behaviour formation, improving specific skills, rational use of scarce resources amicable to production.

The mean education level of the farmers was 3.65 years, ranged from 0–16 years. This shows that the average level of education in the sample was relatively low. The average household size of peach farmers was 6.56 persons, ranged from 2-11 persons. This illustrates that household size of peach farmers was relatively high. With the development of non-farm economies in rural areas, a large proportion (75%) of farmers had alternative sources of income. Farming experience is also considered as one of the socioeconomic characteristics that affect farmers’ decision regarding inputs use and other farm practices. The average experience value of the respondents was 7.98 years, ranging from 2-31 years, which is quite substantial in peach farming. In our sample, 64% of peach farmers did not have access to extension services, while 36% received technological advice and/or training. We find that 28% of the survey peach farmers had a membership or affiliation with any sort of agricultural organization. The cell phone usage was very popular among the peach farmers of the surveyed area.

We find that 90% farmers had a cell phone. Similarly, we find that 37% of the surveyed peach farmers perceived the positive effects of the raising their own livestock but it needs more labour and income as the surveyed farmers concluded. On an average, 39% of farmers expressed easier access to credit. Furthermore, we find that 19% surveyed farmer had acknowledged the role of NGOs. Therefore, a considerable room is available for NGOs, to contribute and deliver to the peach farmer. The average value for price volatility perception was punched is 1.71 ranged from 1-3. This indicates price volatility perception is approaching towards medium which is not a good sign. In addition, the average value of natural disaster risk perception was computed 2.34. This shows that farmers had very unpleasant perception regarding natural disaster risk possibly due to the destruction of 2010 floods in the history of this area (PDMA, 2014). The average value for soil quality perception was computed 2.63 ranged from 1-3. This means that the soil quality perception of the farmer is approaching towards high-quality soil, in other words, suitable soil conditions. The average value for weather shocks awareness was calculated 1.21. This indicates that peach farmers were aware of the of the weather shocks.

4. Results and Discussion

4.1. Maximum-likelihood estimates of translog production frontier

The results of the maximum-likelihood estimated parameters for translog production frontier Equation (6) with inefficiency effects Equation (7) are shown in Table 2. Estimate of variance parameter γ (which measures the proportion of the variation in output due to inefficiency) is significantly different from zero, meaning that the inefficiency effects are significant in determining the level of output variability in the model (Coelli and Battese, 1996). The estimated value of the variance parameter ($\gamma = 0.85$) was close to 1, with statistical significance at 1% level, which indicates that inefficiency term (u_i) is important to explain the deviation of the firms in relation to the production frontier. Based on statistical tests (Wald test and likelihood-ratio test) for model specification, the Cobb–Douglas function is rejected in favour of the translog function at 1% level of significance. Both the null hypotheses that Cobb-Douglas specification is preferred over translog specification and the technical inefficiency effect is absent in the surveyed peach farms are rejected at 1% level of significance. Thus, it is possible to conclude that stochastic model with the inclusion of inefficiency term is a better model without the inefficiency term.

Table 2: Maximum-likelihood estimates for the parameters of the translog production frontier and inefficiency effects model

Variables	Parameter	Coefficient	Standard Error	Z-Value
Constant	β_0	2.31	1.17	1.97**
$\ln x_1$	β_1	1.91	1.12	1.71*
$\ln x_2$	β_2	1.02	0.41	2.49**
$\ln x_3$	β_3	1.03	0.57	1.81*
$\ln x_4$	β_4	0.76	1.17	0.65
$\ln x_5$	β_5	-2.84	1.53	-1.86*
$\ln x_1 \times \ln x_1$	β_{11}	-2.21	2.29	-0.97
$\ln x_1 \times \ln x_2$	β_{12}	3.05	1.3	2.35**
$\ln x_1 \times \ln x_3$	β_{13}	2.03	1.25	1.62
$\ln x_1 \times \ln x_4$	β_{14}	-2.12	1.14	-1.86*
$\ln x_1 \times \ln x_5$	β_{15}	-0.12	0.31	-0.39
$\ln x_2 \times \ln x_2$	β_{22}	1.98	1.11	1.78*
$\ln x_2 \times \ln x_3$	β_{23}	-3.21	1.12	-2.87**
$\ln x_2 \times \ln x_4$	β_{24}	0.21	0.09	2.33**
$\ln x_2 \times \ln x_5$	β_{25}	1.09	0.97	1.12

$\ln x_3 \times \ln x_3$	β_{33}	1.71	0.95	1.80*
$\ln x_3 \times \ln x_4$	β_{34}	-2.86	1.07	-2.67***
$\ln x_3 \times \ln x_5$	β_{35}	1.12	0.52	2.15**
$\ln x_4 \times \ln x_4$	β_{44}	-0.06	0.12	-0.50
$\ln x_4 \times \ln x_5$	β_{45}	-2.27	1.08	-2.10**
$\ln x_5 \times \ln x_5$	β_{55}	4.31	2.17	1.99*
Inefficiency variables				
Z_1	δ_1	-0.21	0.11	-1.91*
Z_2	δ_2	-0.32	0.12	-2.67***
Z_3	δ_3	-0.07	0.03	-2.33**
Z_4	δ_4	0.16	0.09	1.78*
Z_5	δ_5	0.13	0.22	0.59
Z_6	δ_6	-0.72	0.25	-2.88***
Z_7	δ_7	-0.72	0.32	-2.25**
Z_8	δ_8	-0.08	0.21	-0.38
Z_9	δ_9	-0.07	0.03	-2.33**
Z_{10}	δ_{10}	-0.19	0.22	-0.86
Z_{11}	δ_{11}	-0.48	0.26	-1.85*
Z_{12}	δ_{12}	0.03	0.11	0.27
Z_{13}	δ_{13}	0.04	0.12	0.33
Z_{14}	δ_{14}	-0.34	0.19	-1.79*
Z_{15}	δ_{15}	0.51	0.21	2.43**
Variance Parameter				
σ_s^2		0.79		
Sigma-v		0.15		
Sigma-u		0.87		
γ		0.85		
Log-Likelihood		-184.00		
Efficiency mean		0.81		

Note: ***, **, * indicates significance at the 1, 5 and 10% levels, respectively.
Source: Author's calculation

Results of estimation showed the expected signs of first-order coefficients of the translog production function. The coefficients of land, labour, capital, and fertilizer confirmed the expected positive signs except for pesticides. The mean scaled variables for the output *(y)* and input factors *(x_n)* were used in the estimation of the translog function, which is usually performed in empirical analyses (Alvarez and Arias, 2004; Carrer et al., 2015). This implies that others factors remain constant, an increase in peach cultivation land, labour, capital, fertilizer, and pesticides would increase peach output. The sum of the elasticities for each farm represents their returns to scale (RTS). The calculated RTS for the total sample is 1.88 (>1), indicating that peach farms are operating under increasing returns to scale (IRTS) (Table 2). This implies that assuming other inputs are kept constant, a 1% joint increase for all inputs will bring about more than (1.88%) increase in peach output. This result is quite interesting and shows that majority of the peach farms could benefit by expanding their scale of operation. The average output elasticities are more responsive to a change in area (1.91) relative to a change in capital (1.03), labour (1.02) and fertilizer (0.76). However, the elasticity of pesticides (-2.84) is negative, meaning that this input has already reached its optimal level.

4.2. Range of technical efficiency

The technical efficiency scores of the peach farms were between minimum 64% and a maximum of 95 % with a mean of 81%. The average technical efficiency scores suggest that a 19% increase of peach output could be attained by improving technical management at the prevailing inputs level. Improved efficiency would reduce production costs and increase the gross margin on peach production. Percentage frequency distribution of technical efficiency is shown in Figure 4 and the indices showed that 14.44% of the sample farms had technical efficiency 69% or less. Whereas 11.85% of farms had a technical efficiency level 91% or more. The rest had a technical efficiency level between 70% and 90%. This means that the technical efficiency is highly skewed. Variation in technical efficiency estimates is an indication that most of the farmers are not using inputs efficiently in the production process because they are affected by the inefficiency determinants.

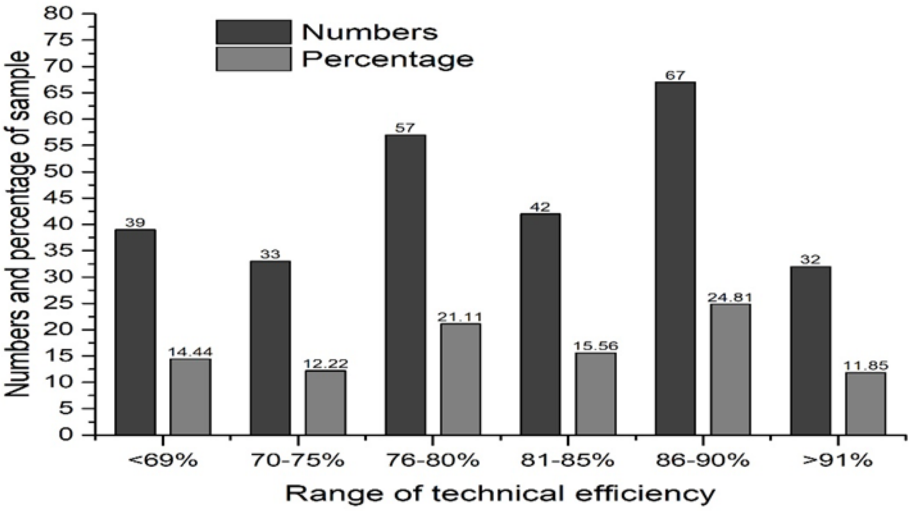

Figure 4: Percentage frequency distribution of technical efficiency scores for peach farmers.

4.3. Technical inefficiency effects estimate

The inefficiency effects model comprised of 15 variables and gives some insights about their influence on inefficiency levels of peach farmers (Table 2). Most of the estimated coefficients with respect to inefficiency determinants have confirmed the expected signs and significant results. A negative sign on a parameter indicates negative effects on technical inefficiency (and positive effects on technical efficiency). However, for convenience, this study used technical efficiency in explaining the outcomes. As a result, the sign of the explanatory variables is changed in the discussion.

Results in Table 2 indicates that farmers age had a positive and significant relationship with technical efficiency. This was in accordance with the a priori expectations that farmers age has a high effect on peach production. In general, younger farmers are more efficient than the older ones. This finding is consistent with the results of (Battese and Coelli, 1995; Mathijs and Vranken, 2000; Bozoğlu and Ceyhan, 2007). In contrast, several studies suggest that older farmers are more experienced in farming which is helpful to improve efficiency (Begum et al., 2013; Külekçi, 2010; Karagiannis et al., 2003; Mariano et al., 2011). The negative coefficient of experience has a positive and highly significant relationship with technical efficiency. This implied that most of the peach farmers had been into peach production over a long period of time which may necessitate the need to re-train farmers on improved techniques of production to increase output as farmers might still be attached to their regular old techniques of production. However, farmers with more years of farming experience tend to be more efficient in production.

The results also illustrate that the education of the farmers has a positive and significant result with technical efficiency. This suggests that obtaining a higher education positively affects technical efficiency. Education represents a human capital of the household head, is generally postulated to have a positive impact on efficiency (Lockheed et al., 1980). Higher education enhances the farmer's managerial skills and improves the efficient use of agricultural inputs. Educated farmers have the ability to perceive, interpret and respond to new technologies compared to uneducated farmers (Schultz, 1964; Demircan et al., 2010). Similar findings were reported by (Alwarritzi et al., 2015; Kalirajan and Shand, 1985; Binam et al., 2004; Zavela et al., 2005; Bozoğlu and Ceyhan 2007).

The finding of the two variables household size and off-farm income show a negative sign on technical efficiency. Larger household size in number seems to be more efficient than smaller families but larger household size has high living expenses. However, household size is associated with labour supply. The larger household size has a tendency to timely supply of family labour and is capable of readjusting to sudden changes at peak periods of labour demand. The simplifying assumption is that larger families are likely to be more efficient

(Abdulai and Eberlin, 2001). In contrast, larger household size has high off-farm income. In general, those who have engaged in off-farm activities achieved lower efficiencies. Non-farm employment in greater non-farm activities tends to exhibit higher levels of inefficiency. This possibly suggests that increases in non-farm work are accompanied by a reallocation of time away from farm-related activities, such as adoption of new technologies and gathering of technical information that is essential for enhancing production efficiency (Abdulai and Eberlin, 2001; Huffman, 1980).

Livestock ownership has also positives influence on technical efficiency. The results suggest that the farmer who raises own livestock can use manure on the peach farm. Obtaining organic manure is very difficult during the peak season of agriculture, as there is a shortage of supply in the livestock market (informal) and the price of manure is also high. Hence, there is a clear need for efficiently managing the crop residues and increasing the amount of animal waste produced on the farm (Blanchard et al., 2013; Ali et al., 2012). Additionally, raising of own livestock increase off-farm income. Eventually, improve the technical efficiency of peach farms. The usage of the cell phone has a positive and significant effect on technical efficiency. The finding suggests that farmers who use a cell phone for peach production have high technical efficiency. Scientific studies suggest that the one way to improve the efficiency in the agriculture supply chain is the adoption and use of cell phone. With the help of mobile phone usage, farmers get valuable suggestion during peach production process from other farmers without wastage of time. Furthermore, mobile phone usage enhances the contact among farmers. Usage of cell phone increase extension agent contact and consequently, increase farmers’ production capacity (Ogbeide and Ideba, 2015) (Bolarinwa and Oyeyinka, 2011). However, some farmers were reluctant to use the cell phone frequently describe that it increases the cost of peach production in the study area.

The access to credit is another very important indicator, which illustrates a positive and significant impact on technical efficiency. Timely availability and use of proper utilization of credit give support to the farmer’s budget constraint which could enable them to have enough liquidity to purchase and apply input resources efficiently (Alwarritzi et al., 2015; Binam et al., 2004; Zavela et al., 2005; Ogundari 2008). Access to formal credit permits a farmer to enhance technical efficiency by overcoming financial restrictions for the purchase of higher quality variable inputs, such as fertilizer or new technological package and high-yielding seeds. If a farmer fails to purchase fertilizer for increased productivity for his standing crop, output loss may be irretrievable. Credit, therefore, can help increase technical efficiency, while credit constraint decreases the efficiency of farmers by limiting the adoption of high-yielding varieties and the acquisition of information needed. However, credit may have no effect on efficiency if it simply displaces another source of finance, for example, savings (Carter, 1989).

As expected, the coefficient of extension services and farmer's association with any organization has a positive influence on technical efficiency. This means that the farmers who received more technical training/programs or technological advice from outreach agencies often exhibit higher efficiency in farming. The practical correlation between extension services and technical efficiency is to enhance farmer's capabilities for the planning and control of production in peach farming. The estimated results suggest that peach farmers who adopt extension services or associated with the agricultural organization have the ability to produce more output using the same level of inputs and production technology. In addition, farmer's managerial skill can be increased more, to gain high technical efficiency with the help of obtaining organizational skills and knowledge. The production and dissemination of latest knowledge through agricultural training is essential to validate the efficiency at farm level and to make the agriculture sector multifunctional. Primarily this is the responsibility of scientific research institution to share new technique and innovative methods with the farmers (Kienzler et al., 2011; Karimov, 2014).

The role of NGOs indicates a positive and significant relationship with technical efficiency. This study finds that NGOs is the suitable choice to stress the newly peach growers to assess farm management, production, and marketing practices. An additional focus on, access to credit services/facilities, technical advice and training facilities, input supplies, market information, and market linkages. Consequently, may improve the efficiency of the peach farmer. A very important variable in this study is price volatility perception and has a negative influence on technical efficiency. This is not surprising results because it decreases the technical efficiency. It implies that producers are more concerned about low prices, which may threaten their living standards as well as their longer-term viability when income is too low to provide for the farm family or for the operational needs of the farm. Uncertainty may result in less than optimal production and investment decisions.

Natural disasters risk and shows negative influence on technical efficiency. A natural event such as flood, drought, windstorm, disease/insect's outbreak, and weather events have a risk-increasing effect on output. Although the effect is statistically insignificant, the result provides weak evidence that the current farm resources are not satisfactory to enable farmers to better mitigate against natural disaster risk. In accordance with our expectation, the negative co-efficient of soil quality shows a positive and significant impact on technical efficiency. The peach tree is not tolerant of wet conditions. This stresses the importance of good and moderate soil conditions required for better farming. If farmers have bad soil on their fields, they wouldn’t want to incorporate costly inputs in order to avoid risks from bad soil conditions. As a result, peach production would decrease. Consequently, it will reduce the efficiency of the peach farmers. Thus, better quality soils can supply better nutrient to crops and can achieve more stable peach production compared with poorer soils. These findings are backed by earlier studies of (Latt et al., 2011; Yang et al., 2016). Weather shocks have a negative sign on technical efficiency. This illustrates that weather shocks for example high temperature and heavy rainfall damaged the peach production. Eventually reduced the technical efficiency of peach farms. Ali et al., (1994) indicated that climate effect on agriculture is related to extreme weather events during growing and harvesting seasons, which are not observed by farmers when choosing the output-input combination that optimizes their outcomes. Those extreme events can cause severe damages which divert farmers from their optimal allocation. The errors/deviations in the production decision are translated into lower profits for producers, causing inefficiencies.

5. Conclusions and Policy Implications

This study measures the technical efficiency and exploring the inefficient determinants of peach farmers in Khyber Pakhtunkhwa province of Pakistan by using the translog stochastic frontier model. The frequency distribution clearly displays that the technical efficiency is highly skewed. Variation in technical efficiency estimates is an indication that most of the peach farmers were not using the inputs efficiently in the production process because they were affected by the inefficiency factors. The average technical efficiency of peach farmers was estimated 81% ranged from 64% to 95%. This suggests that there would be a possibility to improve the peach output by 19 % with the available set of inputs. The calculated RTS for the total sample was 1.88 (>1), indicating that peach farmers were operating under IRTS. This infers that assuming other inputs constant, 1% joint increase for all inputs will bring about more than a unit (1.88%) increase in peach output. This is quite interesting and shows that majority of the peach farmers could benefit by expanding their scale of operation. The estimated inefficiency model shows that farmer’s age, experience, education, membership, cell phone usage, livestock ownership**,** credit access, extension services, the role of NGOs, and soil quality perception have a positive influence on technical efficiency. In contrast, off-farm income, household size, price volatility perception, natural disaster risk perception, and weather shocks awareness have a negative influence on technical efficiency.

Concluding remarks and for the future policy implications, three main issues emerge from the results of this study. Firstly, peach production can be improved by an appropriate choice of input combinations. The government should take interest and investment in the peach cultivation. The strategy should be given priority to bring more barren land under peach cultivation. On time provision of inputs should be ensured i.e. capital, fertilizers, and pesticides by the concerned institutions. Secondly, by improving the present level of inefficiency determinants of peach farmers. More attention is required to educate farmers to better manage the peach farms. This study results find that easier access to agricultural credit has a positive and significant impact on technical efficiency. However, credit facilities were limited and the existing facilities were not enough to fill the requirements of farmers in the study area. Therefore, the government should take proactive steps to facilitate the peach farmers with better access to credit to attain a high level of technical efficiency. The farmer’s managerial/technical ability can be increased by providing technical skills and knowledge. In this regard, the government should establish a policy to enhance the relationship among agriculture extension department and NGOs and the peach farmers. In recent years, this study area has seen a number of major natural disasters and it is likely that the higher frequency of extreme weather events may continue in the future would cause a negative impact on peach productivity. The result provides weak evidence that the current farm resources were not satisfactory to enable farmers to better mitigate against natural disaster risk and weather shocks. Moreover, another an important issue is the price volatility and fluctuation for the peach farmer, this problem requires special attention from state authorities. Thirdly, elimination of errors in the production process of peach farmers through efficient management practices. In conclusion, many of the peach farmers achieving high and consistent production and then by obtaining high technical efficiency. Therefore, present study strongly recommends that policy maker should give priority to improve price regulatory system, provide better technical and managerial skills to the farmers, increase awareness about weather shocks, vulnerability to natural disasters; in order to reduce the gap between the most technically efficient and the least technically efficient farmers.

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