Nexus between Human Capital and Technical Efficiency of Cauliflower Growers in Soon Valley, Punjab: A Panel Data Analysis

Samina Shaheen
Ph. D Student
Department of Economics
University of Sargodha, Pakistan

Maqbool H. Sial
Dean and Professor
Department of Economics
University of Sargodha, Pakistan

Ghulam Sarwar
Ph. D Student
Department of Economics
University of Sargodha, Pakistan

Rahila Munir
Ph.D Student
Department of Economics
University of Sargodha, Pakistan

Abstract

The present study was conducted to determine technical efficiency of cauliflower farmers in "Soone Valley". The study used data collected from two villages of Soone Valley of district Khushab, Punjab. Frontier production function was used and its parameters were estimated with maximum likelihood estimator. The results of production coefficients showed that tractor hours, seed, plant protection measures, irrigation and labor had positive impact on cauliflower production. The results of technical efficiency showed that education and experience had positive affect on technical efficiency. But age had negatively related to the technical efficiency. Mean technical efficiency was 51 percent indicating that there existed a great potential to increase cauliflower production, with available resources and technology.

Key Words: Stochastic Frontier, Production Function, Technical Efficiency, Punjab, Pakistan

1. Introduction

Education plays a vital role in human capital formation. It raises productivity and efficiency of individuals and thus produces skilled manpower that is capable of leading the economy towards the path of sustainable economic development [Pakistan Economic Survey, 2009-10]. Human capital is expected to improve productivity in all spheres of activities including agriculture. Education decreases rural poverty by increasing the productivity of the poor farmers. An educated farmer is able to adopt modern farm inputs and prefer high-return production technologies. Pakistan is pre-dominantly agricultural country. In Pakistan the share of small farmers in the total number of holding was increased from 82 percent in 1990 to 86 percent in 2000 (Pakistan Agricultural Censes 2000). And the number of such small land holdings farmers has been gradually increasing under the growing population pressure and subdivision of landholding.

The small farmers choose to cultivate those crops which give high returns in short duration such as high value crops like vegetables having low cost of production. Since, vegetable production is labor intensive, it also engages landless and unskilled labor force in the rural areas. Pakistan's different climatic condition provides an occasion of growing fruit and vegetables in all seasons around the year in all provinces. Vegetable cultivation is the main strategy to reduce poverty as well as to overcome food security problems due to small landholdings and labor force availability in the rural areas of Pakistan. The vegetable crops are cultivated only on two percent of total area in Punjab (Government of Punjab, 2000). Cauliflower is one of the most popular vegetable which is cultivated in Punjab. Cauliflower is a winter season crop, closely related to broccoli, cabbage, and mustard. It grows best in a relatively cool temperature with a wet atmosphere.Indian occupies first position in the production of cauliflowers and Pakistan ranked 22nd in area and 19th in production of cauliflower in the world.

Its share in vegetables production of the world is 1.09 percent (FAO 2008). The present study is related to "Soone Valley" where mostly off season vegetables are grown. The cauliflower is grown in winter season as well as off- season. In "Soone Valley" the climate suited off-season vegetables especially cauliflower. Off-season vegetables obtain good price but face risk of adverse climate causing decline in production or even crop failure. Price fluctuation is also very high during the off-season. In "Soone Valley", seasonal crop cultivated area was 306 acres and seasonal production was 2479 tones and per acre production was 8100 kg. Off-season. I crop cultivated area was 1175 acres and production was 7740 tones and per acre production was 7200 kg. Off-season II crop cultivated area was 1315 acres and production was 8285 tones and per acre production was 6300 kg (Department of Agriculture Khushab, 2008). Efforts by researchers to measure the technical efficiency of farmers based on panel data are relatively few in the Pakistan, very little research efforts have been directed for the issue of technical efficiency. Efficiency score of firm or farmer is usually estimated by stochastic frontier approach. This approach is based on the seminal work of Aigner et al. (1977).

The present study will use panel data to investigate education as a source of technical efficiency in the production of cauliflower by estimating a stochastic frontier production function for cauliflower growers. Another aspect of the study is to examine different factors limiting cauliflower production. The data collected from Soone Valley district Khushab, where mostly off season vegetables are grown, will be use. The objectives of the study (i) Estimate the relationship between human capital and productivity in agriculture; (ii) Investigate education as a source of technical efficiency in the production of cauliflower by estimating a stochastic frontier production function for cauliflower growers; (iii) Determine the socioeconomic chrematistics that influence the cauliflower farm level efficiency and identify factors affecting technical inefficiency. The rest of the study is organized in the following fashion. Section 2 reviews the literature on technical efficiency. Section 3 discusses inefficiency frontier model for panel data while the data source and the methodology is presented in section 4. Section 5 reports the empirical results. Concluding remarks and recommendations finish the study.

2. Review of Literature

Battese and coelli Estimate technical efficiency by using panel data of paddy farms in India. The result showed that technical efficiency increased with time. The result showed that education has positive relation with technical efficiency (Battese and Coelli, 1992). Maudos *et al*. (1998) analyzed the role of human capital in the productivity gains of the countries of the OECD in the period 1965-90. The results showed that a higher level of human capital affects positively the rate of technical progress, associated with human capital. Mkhabela analyzed the technical efficiency of vegetable base cropping system in Msinga district Kwazulu-Natal. The results indicated that high education and more off farm income decreased the efficiency of farmer. This was due to much constraint such as productivity, technology and market which leads to decrease the farmer's income in vegetable based cropping system. It was suggested that production of vegetable can increase if government provide appropriate incentive (Mkhabela 2005).Stochastic Frontier Analysis is employed to calculated technical efficiencies of German frms at the industry level. The analysis shows that technical efficiency was not related to sales growth, R&D expenditures, capital intensity and proportion of East German firms in the industry and size of the firm (Badunenk and Andreas 2004).

Lachaal ,*et al*. (2005**)** were determined technical efficiency of olive production Olive production was labor and capital intensive output. The results indicated that intermediate input factors and labor had positive and significant impact on efficiency of olive production, on the other hand share of agriculture training and skilled labor variable all had significant and negative relationship with technical efficiency. The translogarithmic stochastic frontier production function was used for measuring efficiency of Arabica coffee production in Cameroon.The results of socioeconomic variables namely access to credit and education showed a negative relationship with technical efficiency Nchare (2007).

Burki and Shah (1998) determined technical efficiency in irrigated area farmers in Punjab Pakistan. The results reveled that abundance of canal water and education has positive relationship with technical efficiency while age of farmers showed no effect on technical efficiency while relationship. It was found that small operating land farmers were more efficient than larger farmers. It means that there was an inverse relationship between technical efficiency and farm size.To analyzed the investment strategies which were adopted in future for increasing the production of rice in Punjab, Pakistan using stochastic production frontier. The authors suggested that technical efficiency can be increased by increasing technical efficiency of olive production investment in education and improving tractor power policies Abedullah, *et al*. (2007).

Bakhsh, *et al*. (2006) conducted this study to estimate the factors which effected higher yields of radish. They concluded that the availability of good seed, more labor hours for weeding and more educated farmers who used latest technology can improve the production of radish.

3. Inefficiency Frontier Model for Panel Data

Stochastic frontier production function for panel data[1],

$$Q_{it} = \exp(M_{it}, \beta + C_{it} - D_{it}) \qquad (1)$$

where Q_{it} denotes the production at the t-th observation (t = 1,2,...T) for the i-th firm (i = 1,2,..., N). M_{it}, is a (1 X K) vector of values of known functions of inputs of production and explanatory variables associated with the i-th firm at the *t-th* observation β is a (K X 1) vector of unknown parameters to be estimated. C_{it},s are assumed to be iid $N(0,\sigma_v^2)$ random errors, independently distributed of the D_{it},s.

The D_{it},s are non-negative random variables, associated with technical inefficiency of production, which are assumed to be independently distributed, such that D_{it} is obtained by truncation (at zero) of the normal distribution with mean, h_{it},δ , and variance, σ_v^2 .h_{it}, is a (1 X *p)* vector of explanatory variables associated with technical inefficiency of production of firm over time and δ is an *(p x* 1) vector of unknown coefficients. Equation (1) specifies the stochastic frontier production function in terms of the original production values. However, the technical inefficiency effects, the D_{it},s are assumed to be a function of a set of explanatory variables, the h_{it},s and an unknown vector of coefficients, δ. The explanatory variables in the inefficiency model can be including some input variables in the stochastic frontier, provided the inefficiency effects are stochastic. The technical inefficiency effect, D_{it} , in the stocchastic frontier model (1) could be specified in equation (2)

$$D = \delta h_i + g_i \qquad (2)$$

where the random variable, g_{it} is defined by the truncation of the normal distribution with zero mean and variance, σ_v^2, such that the point of truncation is h_{it}, δ i.e., $g_{it} \geq$ -hi, δ. These assumptions are consistent with D_{it} being a non-negative truncation of the $N(h_{it}\delta,\sigma_v^2)$ distribution. If all elements of the δ vector are equal to zero, then the technical inefficiency effects are not related to the h-variables and so the half-normal distribution originally specified in Aigner, Lovell and Schmidt (1977) is obtained. If the first h-variable has value one and the coefficients of all other h-variables are zero, then this case represents the model specified in Stevenson (1980) and Battese and Coelli (1988, 1992).

The assumption that the D_{it}'s and the C_{it}'s are independently distributed for all t = 1, 2 , . . . T, and i= l,2,...N is obviously a simplifying, but restrictive, condition. Alternative models are essential to account for possible correlated structures of the technical inefficiency effects and the random errors in the frontier. The method of maximum likelihood is proposed for simultaneous estimation of the parameters of the stochastic frontier and the model for the technical inefficiency effects. The likelihood function and its fractional derivatives with respect to the parameters of the model are presented in Battese and Coelli (1993). The likelihood function is expressed in terms of the variance parameters $\sigma_s^2 = \sigma_v^2 + \sigma^2$ and $\gamma = \frac{\sigma^2}{\sigma_s^2}$ the technical efficiency of production for the i-th firm at the t-th observation is defined by equation (3)

$$TE_{it} = \exp(-D_{it}) = \exp(h_{it}\delta - g_{it}) \qquad (3)$$

The prediction of the technical efficiencies is based on its conditional expectation, given the model assumptions.

4. Data and Empirical Application of Model

The data was related to "Soone Valley" cauliflower production, where mostly off season vegetables are grown. There are three cauliflower crops. Cauliflower is mainly grown in winter season from Oct-Nov to Feb- March. Two off-season crops are grown in summer season. Off-season I is grown from March to July and off-season II is grown from May-June to Oct-Nov. Farmers prepare seasonal crop nursery at the end of off-season.

[1] Large part of this methodology was taken from Battese and Coelli (1995)

Two villages of "Soone Valley" named Anga and Khoura were selected for data collection being the most important in terms of area under cauliflower. Cauliflower growing villages were selected with the consultation of District Agriculture Department Khushab. A well structured, field pre-tested comprehensive interviewing schedule was used for collection of data. The cauliflower growing farmers were randomly selected from the list of farmers in selected villages. A sample of total of 100 farmers was taken 50 from each village. The same 100 farmers were approached in the three cropping seasons .The survey was conducted in 2007-08.

The survey data contained information on socio-economic characteristics of the farmers.
For this study, the Cobb-Douglas stochastic frontier production function was found to be an adequate model for the data. The model to be estimated is defined as:

$$\ln Q_{it} = \beta_0 + \sum_{i=1}^{6} \beta_i \ln M_{it} + C_{it} - D_{it}$$

$$i=1,2......,100 \quad t=1,2,3 \quad (4)$$

Where

Q_{it} is total value of output of ith farmer (per acre)

M_1 is tractor (hours per acre)

M_2 Quantity of seed (gram per acre)

M_3 is plant protection measures (Rs per acre)

M_4 is NPk nutrients (Kg per acre)

M_5 is Irrigation (inches per acre)

M_6 Labor (man days per acre)

C_i`s are random errors which are associated with measurement error in production and those stochastic factors which are not in control of farmer. $C_i$`s are assumed i.i.d and N $(0, \sigma_v{}^2)$ and independent of D_i. D_i`s capture technical inefficiency of production and are non-negative random variables. $D_i$`s are assumed to be independently distributed, such that D_i is obtained by truncation at zero of normal distribution with variance σ^2 and mean D_i, where the mean is define as:

$$D_{it} = \delta_0 + \delta_1 h_{1it} + \delta_2 h_{2it} + \delta_3 h_{3it} + \delta_4 h_{4it} + \delta_5 h_{5it} + g_{it}$$

Where;

h_1 is farmer`s education in years

h_2 is age (year)

h_3 is experience (year)

h_4 is a dummy of access to credit

h_5 is a dummy of distance between the farm house and the farms

5. Results and Discussion

Results of Stochastic frontier Production Function are reported in Table 1. OLS estimators of three variables out of six were significant at 1 percent level of significance, one variable significant at 5 percent level of significance and rest of the two were significant at 10 percent level of significance. In case of MLE estimators namely tractor hours, plant protection measures, irrigation and labor coefficients were statistically significant at 1 percent level of significance. The estimators namely seed and NPK nutrients coefficients were statistically significant at 10 percent level of significance.

These results recommended that the models provided the best fit for the data of cauliflower production. Since Cobb Douglas type production function was used, the estimator directly represents elasticity of independent variables.

Table 1: Results of Stochastic frontier Production Function

	OLS Coefficients		MLE Coefficients	
Variables	coefficient	t-ratio	coefficient	t-ratio
Constant	1.76***	3.01	1.614***	3.192
Tractor	0.21***	6.11	0.243***	5.128
Seed	0.14*	1.68	0.168*	1.793
PPM	0.17***	6.23	0.178***	6.335
NPK nutrients	0.06**	2.91	0.072*	1.65
Irrigation	0.06*	1.79	0.055***	2.667
Labor units	0.49***	8.79	0.52***	6.911

1 * indicate that the coefficient is significantly different from zero 10 percent level of significant;
2 ** indicate that the coefficient is significantly different from zero 5 percent level of significant;
3*** indicate that the coefficient is significantly different from zero 1 percent level of significant.

The tractor hours which were used for land preparation showed that yield of cauliflower tend to increase 0.24 percent after increasing one percent increase in tractor hours.The results revealed that seed also has positive impacts on cauliflower yield. The coefficient of the seed showed that one percent increase in seed quantity increased yield by 0.19 percent. These results were consistent with other studies Hassan, *et al*. (2005) and Ahmad, *et al*. (1999). The production elasticity of plant protection was positive and statistically highly significant at 1 percent level of significance. The result was showing that application of one percent increase in plant protection measures increased cauliflower yield by 0.18 percent. The production elasticity of NPK nutrients was 0.07. This indicated that one percent increase in the use of this variable tend to increase cauliflower yield by 0.07 percent. The coefficient of NPK was similar to Hassan (2004) study.

The coefficient of irrigation was positive and statistically highly significant according to the expectation. This indicated that one percent increase in water lead to increase the cauliflower yield by 0.06 percent. The results were also consistent with those of Ahmad, *et al*. (1999), Ahmad *et al*, (2002) and Bakhsh, *et al*. (2007). The cauliflower was mainly a labor intensive vegetable. The cauliflower cultivation requires more labor force for various farm management practices such as sowing, weeding, and harvesting. The expected sign of labor was positive and highly significant at 1 percent level of significance. This showed that one percent increase in labor enhance cauliflower yield by 0.52 percent. The result was consistent with Bakhsh, *et al*. (2006) and Bakhsh, *et al*. (2007). Tractor hours and labor were the major contribution in the production of cauliflower. The results were also consistent with Olarinde, *et al*. (2008).

In order to investigate the determinants of inefficiency, the technical inefficiency model was evaluated; results are presented in Table 2. The estimated coefficients in the inefficiency model are of exacting interest to this study. The coefficient of years of schooling was statistically significant at 10 percent level of significance and has negative relationship with inefficiency. Its implies that farmers having more years of schooling are technically less inefficient as compared to illiterate farmers due to technological information and good farm management practices. The results of the study were consistent with Kumbhakar, *et al*. (1991), Ahmad, *et al*. (2002), Dhungana, (2004), Abeduallah (2006).

Table 2: Results of Technical Inefficiency

Technical Inefficiency Model		
Variable	Coefficient	t-ratio
Education	-0.063*	-1.827
Age	0.095*	1.69
Experience	-0.089**	-2.471
Credit Dummy	-0.113*	-1.765
Distance Dummy	0.019	0.298
sigma-squared	0.178***	7.2
Gamma	0.938	9.67
Mean Efficiency		0.51

1 * indicate that the coefficient is significantly different from zero 10 percent level of significant;
2 ** indicate that the coefficient is significantly different from zero 5 percent level of significant;

3*** indicate that the coefficient is significantly different from zero 1 percent level of significant.

Age of cauliflower grower also affected the level of technical inefficiency. It was significant at 10 percent level of significance, and its coefficients showed that it has positive relationship with technically inefficiency. Parikh, *et al*. (1995) and Olarinde, *et al*. (2008) also showed in their studies that age was positively related to technically inefficiency, the older cauliflower growers were technically more inefficient being traditional and less willing to adopt new production technology than younger ones. Younger farmers are likely to have some education and have more access to information and extension services. The parameter estimate of experience variable showed that as numbers of years spent in cauliflower production increase, the technical inefficiency decrease in cauliflower production. The coefficient of experience was negative and significant at 5 percent level of significance. In case of credit dummy had negative sign, which showed that access to credit dummy variable had a significant negative impact on technical inefficiency. This implies that farmers with better access to credit are technically less inefficient than those having no access to credit in sample area.

The distance dummy variable was a positive but not significantly correlated with the technical inefficiency of farms. The farmers who live on farm were technically less inefficient than the farmer who's live on in village. The mean technical efficiency was 0.51 showing that there was greater chance to increase per acre yield of cauliflower production provided technical efficiency was improved. The variance parameters sigma-squared and gamma estimators are significantly different from zero and play a role in explaining variation in the dependent variable. This finding was consistent with the theory that the true value of the gamma should be greater than zero and less than one. The share of one-sided error in total gamma was 94 percent. These results showed that the technical inefficiency effects were significantly affecting on the production of cauliflower. The ranges of technical efficiency in seasonal crop were 0.27 to 0.94. The mean technical efficiency of period 1 was 0.59 showing that there was greater chance to increase per acre yield of cauliflower production provided technical efficiency was improved.

6. Conclusion and Recommendations

Cauliflower is one of the most popular vegetable cultivated in Punjab. Cauliflower is a winter season crop and grows best in a relatively cool temperature with a wet atmosphere. The farmers having surplus family labor with small land holdings earn large profit by growing this vegetable. The result showed that labor was the more important variable in cauliflower production. The coefficient of all inputs was positive showing positive impact on cauliflower production. The low magnitude of production elasticities of all variables except labor showed that these resources were scarce. The use of these resources was sub optimal. There is a need to improve the resource use efficiently of these inputs to increase the productivity of these inputs. The mean technical efficiency was 51 percent. This shows that per acre yield of the cauliflower could be improved by better using of available resources efficiently. The technical efficiency could be improved by educating the cauliflower growers. Policies designed to educate cauliflower growers through proper agricultural extension services may have a great impact in increasing the level of technical efficiency and hence cauliflower productivity, as they can utilize given resources efficiently by using latest techniques. Seed play a major role in improvement in cauliflower production. No organization work in "Soone Valley". Thus there is need to give cauliflower seed to cauliflower growers. Private sector initiative may to be taken to provide seed. Fertilizer and plant protection measure such as pesticides, weedicides spray can increase cauliflower production. Government should ensure proper supply of this input coupled with credit facilities especially for small farmers. The government should proved road and transport facilities and also encourages farmers market to ensure better return to vegetables producers.

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