FARM SPECIFIC DETERMINANTS OF FARM INCOME AND EFFICIENCY IN PAKISTAN: A PARAMETRIC ANALYSIS

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ABSTRACT

The study was conducted to estimate the major determinants of farm income and technical efficiency in the districts of Bahawalpur and Rahim Yar Khan, Punjab, Pakistan during 2011-12. Data were collected from 201 farm managers using random sampling technique. For the estimation purpose, Stochastic Frontier Cobb Douglas production function was employed. The estimated result of technical efficiency was approximately 65 percent. It showed that on average farm managers are 65 percent efficient in managing farm income and there is still a room for increasing 35 percent farm income by fetching improvement in efficiency. The key farm specific factor that had negative impact on the farm income and efficiency was low prices of farm output relative to the prices of inputs. On the other side of the picture, farm markets’ mechanism is quite poor and farmers are not getting due prices of farm output. There is mounting need of bringing development in the rural infrastructure by generating educational and technological facilities in rural areas, we can make farm manager more competitive in achieving new growth opportunities in agriculture sector.

KEYWORDS: Stochastic frontier analysis; cobb douglas; technical efficiency; farm income, Pakistan.

INTRODUCTION

Pakistan is blessed with four seasons, due to which its soil is rich in producing all kinds of crops, fruits and vegetables. Besides fruits and vegetables, major focus of Pakistani farmers conveys to the cash and food crops. These crops are major sources of farm household’s income. Hence, by enhancing productivity and efficiency, farmers can get in a position to acquire higher level of income.

In Pakistan, a large proportion of the rural population still depends on framing for diurnal nourishment. There is a need to focus on increasing farm productivity of staple food crops. This will fill the demand supply gap, avoid

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the food shortages and increase the farm household income for their survival intentions (29). All this can be possible by appropriate farm management, farm processing, use of high technological inputs, farm marketing. Major reasons of the depressed agricultural performance in Pakistan are the traditional farm practices and technical inefficiency in use of farm inputs that lowers the farm income. Although farm markets exist in Pakistan, but the functioning of these markets is very poor. Two types of markets typically are established in Pakistan, sales’ markets and retail markets. According to the estimates, there are 700 wholesale markets in the country. Out of these, 205 are regulated. Approximately 132 markets are in Punjab, 71 are in Sindh, 2 are in Baluchistan whereas zero regulated market exists in Khyber Pakhtun khwah (KPK) due to the absence of any legal framework. We mostly discuss the agricultural productivity; nevertheless, without market response productivity alone is nothing. The culture of market structure in Pakistan is widely diversified and a producer is less benefited relative to the intermediaries. This situation creates distortions in markets that render very low share to farmers. The arthies act as per the price maker in agricultural markets of Pakistan due to which farmers are under privileged in attaining the precise prices of farm merchandises (7).

Several previous studies reveal that major substance of rural income is based on farm income. In Pakistan, a larger proportion of the rural population relies on farm income. Consequently, farm household’s income depends much more on farm income relative to non-farm income. Earlier studies (5, 21, 27) disclose the input cost, farmers’ managerial abilities, availability of water, farm size and distance from main market, as the major factors that distress farm technical efficiency and income. Hence, improved and efficient farming will result in additional farm income as well as increasing the productivity of farm sector in Pakistan. The main objective of present study was to find out the farm specific factors that affect the productivity, technical efficiency and income of farm sector in Pakistan.

Measuring technical efficiency has a great significance in farm sector. Technical efficiency simply shows that how farm manager can be able to attain the maximum level of output from available inputs (17).

A number of studies (12, 2, 1, 33) have measured the technical efficiency and productivity of farm sector by using Stochastic Frontier Analysis (SFA) approach. They attempted to discover the key determinants that are disturbing the farm technical efficiency and productivity. Hyuha et al. (21) illustrated that as farm size increases, it positively affects the profitability of farm income and technical efficiency. Gomez and Neyra (18) and Abedullah

et al (1) employed SFA technique and observed that sowing area, land preparation hours, irrigation, labour hours and fertilizer application contribute positively to farm production.

A study by Bravo-Ureta and Pinheiro (14) employed the Stochastic Frontier Analysis approach and measured the technical, allocative and economic efficiency in Dominican Republic economy. They concluded that lower age of the farmer and higher education help in enhancing technical efficiency. (19) and Battese and Coelli (12) highlighted that farm specific variables play significant and fundamental role in determining farm inefficiency hence negatively influence farm income and efficiency.

Kibaara (25) measured the technical efficiency in maize production for Kenya using the parametric approach. Results of the study indicate that the average technical efficiency is approximately 49 percent; though, efficient use of mechanical inputs and land preparation practices and education can help to increase the technical efficiency of maize farms.

Mainstream studies (23, 34, 20, 39, 37, 16, 38, 6) on technical efficiency analysis demonstrate that the farm specific factors are the major sources of variation in farm efficiency and income. In the earlier studies, Stochastic Frontier Analysis technique was the most oftener used technique to measure efficiency and productivity of farm sector. The present study also uses the Stochastic Frontier Analysis to find out farm specific factors affecting the farm technical efficiency and incomes in Pakistan.

**MATERIALS AND METHODS**

The present analysis is based on primary data which have been collected from various districts of Punjab, Pakistan through random sampling technique during the year 2011-12. Hence, major farm specific factors affecting the farm income and efficiency can be found out. The income of the framer is derived from the net revenues that farm manger attains by selling the field crops in markets. In total, 201 farm mangers were selected using random sampling technique.

Measurement of technical efficiency in management of farm resources plays a significant role in agricultural sector. The production frontier shows that how a farm manager can achieve maximum output from specified input at each level (4). The previous studies revealed that the definitions of efficiency, provided by Koopman (26) and Farrell (17) give the brief explanation of production frontier. According to Farrell (17), for attainment of economic
efficiency, it is required to calculate allocative and technical efficiencies. Summing up, we can say that there are three types of efficiencies involved in the production frontier efficiency analysis. Two approaches fundamentally are used for efficiency analysis, one is parametric approach based on Stochastic Frontier Analysis (SFA) which emphasizes that output of a farm is reliant upon the set of available inputs. In SFA approach, random error components exposed the farm inefficiency. Second, approach is non-parametric technique, well-known as Data Envelopment Analysis (DEA). DEA technique based on linear programming, free from functional form restrictions and does not take into account random shock.

According to Coelli (15), farm sector’s output is much dependent on meteorological conditions and natural disasters. So it’s judicious decision to espouse SFA approach that easily captures these inefficiencies and error components.

**Stochastic Production Frontier Model**

In the present study, the Stochastic Frontier Model has been used under the formulation of Cobb Douglas production function. General form of Stochastic Frontier Analysis model as follows:

\[ Y_i = X_i \beta + e_i \quad \ldots \quad (1) \]

Here \( e_i = (V_i - U_i) \) and \( i = 1, 2 \ldots N \)

Technical Efficiency Model specification:

\[ \ln Y_i \beta_0 + \ln \beta_1 X_1 + \ln \beta_2 X_2 + \ln \beta_3 X_3 + \ln \beta_4 X_4 + \ln \beta_5 X_5 + \ln \beta_6 X_6 + \varepsilon \quad \ldots \quad (2) \]

Here

- \( Y_i \) = income of the farm manager
- \( X_1 \) = farm output
- \( X_2 \) = Distance from main market
- \( X_3 \) = Farm size in acres
- \( X_4 \) = farm output price
- \( X_5 \) = water availability, water available for irrigation on time \( = 1 \), otherwise \( = 0 \)
- \( X_6 \) = total farm input cost
- \( e_i \) = Compound error term that captures error term and inefficiency component \((V_i, U_i)\).
Y_i signifies the production level of the i^{th} farm, X_i shows the input quantities available to i^{th} farm, ß reflects the vector of unknown parameters, e_i shows as error term that set aside two components. Where first component V_i comprised the factors such as measurement error, natural disasters and crop related diseases in farm output. It is independently and identically distributed (iid) with zero mean and variance as V_i ~ N (0; σ^2_v). On the other hand U_i is assumed to account for inefficiency factors in farm output and is positive and half normal, mainly associated with socio-economic and farm specific variables. These variables negatively impact technical efficiency. U_i it is also distributed independently and identically (iid) with zero mean and variance given as U_i ~ N (0; σ^2_u).

Specification of Inefficiency Model

Stochastic production frontier model is extended by Battese and Corra (1977) by changing σ^2_v and σ^2_u with δ^2 = σ^2_v + σ^2_u, where δ^2 captures total variation that is due to σ^2_v (random error) and σ^2_u (inefficiency) in the production frontier model. γ captures the total variability which incorporates the variability in total variation. Its values remains in range of zero and one. If value of γ is zero it demonstrates that all the variability in output is due to statistical noise and if its value is one it reflects that variability in farm output is entirely due to inefficiency factors. It can be calculated as γ = σ^2_u / σ^2_v + σ^2_u.

The inefficiency modal used in present study is as follows:

\[ U_i = (\alpha, Z) + W \quad \ldots \quad (3) \]

\[ U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + W \ldots \quad (4) \]

Here

- \( Z_1 \) = Farm manager experience in years
- \( Z_2 \) = farm manger education in years
- \( Z_3 \) = farm output sale to intermediary =1 other otherwise zero
- \( Z_4 \) = family size (number of family members)
- \( W_i \) = Random term

RESULTS AND DISCUSSION

The Maximum Likelihood Estimation technique has been used to find out the major factors that influence farm income and technical efficiency in Pakistan. The results of stochastic frontier Cobb Douglas production function presented in (Table 1), in total 14 parameters are estimated under Cobb Douglas
production function and inefficiency model. The estimated result of variance parameter of gamma reveals its value around 0.91. As mentioned before, the value of gamma ranges between 0 and 1. Subsequently present result of gamma is consistent with theory and explains that 91 percent of variation in farmer income is due to technical inefficiency and remaining part is due to random error. Hence, the present result clearly shows that inefficiency in farm sector is one of the major reason that is negatively affecting the farm income and productivity.

Table 1. Cobb - Douglas Stochastic Frontier Production Function.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>Coefficient</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>$\beta_0$</td>
<td>-561.67</td>
<td>-3.39</td>
</tr>
<tr>
<td>Ln output</td>
<td>$\beta_1$</td>
<td>1.3453</td>
<td>6.21</td>
</tr>
<tr>
<td>Ln DMM</td>
<td>$\beta_2$</td>
<td>-0.0736</td>
<td>-6.00</td>
</tr>
<tr>
<td>Ln Farm size</td>
<td>$\beta_3$</td>
<td>0.8755</td>
<td>13.59</td>
</tr>
<tr>
<td>Ln output price</td>
<td>$\beta_4$</td>
<td>0.3351</td>
<td>12.10</td>
</tr>
<tr>
<td>Ln water availability</td>
<td>$\beta_5$</td>
<td>0.4311</td>
<td>10.00</td>
</tr>
<tr>
<td>Ln total input cost</td>
<td>$\beta_6$</td>
<td>0.2003</td>
<td>4.43</td>
</tr>
<tr>
<td>Variance Parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma$</td>
<td></td>
<td>0.2712</td>
<td>10.001</td>
</tr>
<tr>
<td>$\gamma$</td>
<td></td>
<td>0.9109</td>
<td>61.44</td>
</tr>
<tr>
<td>Log likelihood function</td>
<td></td>
<td></td>
<td>38.54</td>
</tr>
</tbody>
</table>

Source: self-calculation and estimation

To estimate the effect of farm output on farm income, on field crop variable is used as an independent variable. The coefficient of farm output is positive and statistically significant at 1 percent level. It shows that one percent increase in farm output result in 1.34 percent increase in farm income.

To examine the impact of distance from main market on farm income, the variable of farm distance from the main market, has been taken. The coefficient of distance from main market is negative and statistically significant at 1 percent level. It simply depicts that one percent increase in farm distance from main market results in -0.0736 percent decline in farm income. This result is in line with the findings of Javed et al., (22); Narala and Zala (31).

Coefficient of farm size is positive and significant at 1 percent level. The value of coefficient is around 0.87 that indicates that 1 percent increase in farm size results in 0.87 percent increase in farm income. Earlier studies, Basnayake and Gunaratne (11); Barnes (10); Abedullah et al. (1); Narala and
Zala (31); Alam et al. (4) also found the positive and significant relationship of farm size with farm productivity and efficiency.

To evaluate the influence of farm output prices that farm manager receives after selling off his/her crop, the output prices' variable has been used as an independent variable. The result of output prices on farm income is positive and significant at 1 percent level. The coefficient of farm output price is positive and significant. It indicates that a 1 percent increase in output price will increase farm income approximately by 0.33 percent.

To find out the impact of water availability timing for irrigation, the dummy variable for water availability on time has been incorporated. This variable takes the value of 1, if water was available on time for irrigation and otherwise, zero. The result of this parameter is positive and significant having coefficient of 0.41 which indicates that if the timely availability of irrigation water increased by 1 percent the farm income will increase 0.41 percent.

The coefficient of input cost is positive and significant at 1 percent level. By applying proper high technological inputs for on field crops, farmers are able to attain higher level of output; resultantly farm mangers are able to manage higher level of output. The coefficient value of input cost is 0.20, which depicts that a 1 percent increase in input cost will increase the farm income by 0.20 percent.

**Inefficiency Model**

To find out the major factors that stimulate the inefficiency in farm income, an inefficiency model is estimated in this study. The result of inefficiency model by using maximum likelihood estimation is presented in (Table 2).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameters</th>
<th>Coefficient</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>α₁</td>
<td>-0.1502</td>
<td>-5.50</td>
</tr>
<tr>
<td>Education</td>
<td>α₂</td>
<td>-0.0111</td>
<td>-3.70</td>
</tr>
<tr>
<td>Selling agency</td>
<td>α₃</td>
<td>0.1370</td>
<td>3.30</td>
</tr>
<tr>
<td>Family size</td>
<td>α₄</td>
<td>0.069</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Source: Self calculation and estimation

The coefficient of years of farm manager experience is negative and statistically significant at 1 percent level. This result specifies that
experienced farmer is more proficient and capable to assign the particular resources more competently. The negative sign of experience solely shows the negative relationship between the inefficiency and experience. The value of coefficient is -0.15, which shows that a 1 percent increase in farm manager experience will decrease the inefficiency in farmer income by 0.15 percent (Table 2). Previous studies, such as [Hallam and Machado (20); Dhungana (16); Okoye et al. (32); Abedullah et al. (1); Alam et al. (4)].

The coefficient of education is negative but insignificant; the coefficient of education shows the negative relationship between education and technical inefficiency. Generally we presume that as the farm managers' number of years in education increase, the inefficiency decreases. The educated farmers take the decisions regarding input application more wisely as compared to uneducated farmers. But in the present study, this variable has no significance.

To see the impact of intermediaries (Commission agents) on farm income inefficiencies, we take the variable of farm output selling agency as dummy variable. The value of dummy variable is =1, if crop sale to intermediaries, otherwise zero. The coefficient of selling agency is positive and statistically significant. The result simply indicates the significance of marketing system for judicious farm output prices for farm managers. Due to inefficiencies in marketing system, the major share of farm income goes into the pocket of intermediaries. The coefficient of selling agency is 0.13, which means that 1 percent increase in selling of farm output to intermediaries contributes 0.13 percent increase in farm income inefficiencies (Table 2).

The coefficient of family size is positive and statistically significant at 1 percent level. The value of coefficient is approximately 0.069 which depicts that a 1 percent increase in farmer family size leads to 0.069 percent increase the inefficiency in farm manager income. Hence farm manager's family size is one of the major factors that contribute positively towards inefficiency.

**Analysis of Technical Efficiencies**

Maximum likelihood estimation method was used to estimate the level of efficiency for farm income in Pakistan. Results of technical efficiency of farm income are given in (Table 3).
Table 3. Frequency Distribution of Technical Efficiency.

<table>
<thead>
<tr>
<th>Efficiency Level</th>
<th>Frequency</th>
<th>Percentage change in Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;30</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td>0.31-0.40</td>
<td>9.00</td>
<td>4.48</td>
</tr>
<tr>
<td>0.41-0.50</td>
<td>22.00</td>
<td>10.95</td>
</tr>
<tr>
<td>0.51-0.60</td>
<td>45.00</td>
<td>22.39</td>
</tr>
<tr>
<td>0.61-0.70</td>
<td>47.00</td>
<td>23.38</td>
</tr>
<tr>
<td>0.71-0.80</td>
<td>42.00</td>
<td>20.90</td>
</tr>
<tr>
<td>0.81-0.90</td>
<td>27.00</td>
<td>13.43</td>
</tr>
<tr>
<td>&lt;90</td>
<td>7.00</td>
<td>3.48</td>
</tr>
<tr>
<td>Total</td>
<td>201.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Mean</td>
<td>0.65</td>
<td>Maximum 0.97</td>
</tr>
<tr>
<td>SD</td>
<td>0.15</td>
<td>Minimum 0.27</td>
</tr>
<tr>
<td>OTIE%</td>
<td>34.71</td>
<td></td>
</tr>
</tbody>
</table>

In the present study, the minimum level of technical efficiency is about 0.27 percent and maximum is around 0.97 percent. It is also observed, about 10.9 percent farm manager's income ranges between 41 to 50 percent level, around 22.3 and 23.3 percent of the farm manager technical efficiency lies in range of 0.51-0.60 and 61-70 level, respectively. Out of 201 farm managers, 42 have technical efficiency between 0.71 and 0.80 which is approximately 20.90 percent. 27 farm managers operated between 0.81-0.90 which is around 13.43 percent. It has also been noticed that only 3.48 percent of the total farmers are operating above the 90% of the technical efficiency.

The result of technical efficiency analysis evidently shows the great deal of inefficiencies in farm income in Pakistan. The estimated result of stochastic frontier analysis demonstrates that the average technical efficiency in obtaining farm income is about 65 percent. The results reveal that about 35 percent Overall Technical Inefficiency (OTIE) is found in farm income. Hence the farmers can increase their income by removing this inefficiency in their incomes.

CONCLUSION

Being a country highly dependent on agriculture sector, attaining higher level of efficiency is imperative for Pakistan's sustainable development. In the present study, the results of Stochastic Frontier Cobb Douglas production function indicate 91 percent of inefficiency. The estimated technical efficiency results demonstrate that the average technical efficiency in obtaining farm income is about 65 percent; nearly 35 percent inefficiency is present in farm sector. Hence technical inefficiency harmfully impacts farm income. To fulfill the growing demand for food and fiber there is need to triumph over major farm specific factor that negatively impact farm income and efficiency. These
major factors like low prices of farm output as compared to high prices of inputs depressingly impact farm income. Farm markets’ mechanism is quite poor in Pakistan as there is no true representation for farm grower. It is a kind of market imperfection where farmers are not getting due prices of farm output. There is mounting need to bring development in rural areas’ infrastructure. Due to poor infrastructure, farmer faces an additional cost in terms of distance from roads and main markets. Most of the farmers in the rural areas sell their farm output to village Arthi/middle man to avoid the transportation cost. Resultantly he is not able to obtain the due prices of farm commodities that prevail in market. Farmers are badly suffering due to low level of efficiencies in the current market structure. It widens the income gap between poor and rich farmers. On the other hand, by generating educational and technological facilities in rural areas, farm manager can, be made more competitive and better achieve new growth opportunities in agriculture sector.

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Hina Fatima : Planned and conducted the research, collected data and prepared writeup
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Nouman Badar : Managed the literature search