STOCHASTIC FRONTIER PRODUCTION ANALYSIS OF TOBACCO GROWERS IN DISTRICT MARDAN, PAKISTAN

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ABSTRACT:- The theme of this research was to analyze the stochastic frontier production of tobacco growers. This parametric approach was encompassed to investigate the technical efficiency of growers. The primary data was gleaned during 2014-15 from sampled population of three villages namely Takkar Kali, Garo Shah and Passand Kali of Takhtbhai Tehsil, Mardan district of Khyber Pakhtunkhwa province. The multi-stage sampling technique was utilized to obtain the desired sample size of 120 tobacco growers. The major findings of stochastic production frontier analysis indicate that all variables were statistically significant and have portrayed positive contribution to tobacco production except fertilizer which was found significant but has revealed inverse relation with tobacco production. The mean technical efficiency was estimated at 0.85 depicting that tobacco growers can further amplify efficiency by 15% with given level of inputs. The inefficiency model estimates demonstrate that only experience of tobacco growers in study area was significantly decreasing the inefficiency of the growers. The study has concluded that tobacco growers are operating in the second stage of production; therefore, tobacco production can still be enhanced. It is recommended that season long trainings for tobacco growers may be undertaken by the concerned authorities to enhance the crop management skills for rational use of input.

Key Words: Tobacco; Stochastic Frontier Production; Technical Efficiency; Yield; Pakistan.

INTRODUCTION

The agriculture sector of Pakistan requires a paradigm shift for substantial contribution in elevating the socio-economic condition of the escalating population. The major food crops of Pakistan include wheat, rice and maize. These grain crops not only address the concern of food security but also provide significant share in Gross Domestic Product (GDP) of Pakistan. However, cotton and tobacco are non-food cash crops and both generate notable revenue for Pakistan's economy (GoP, 2014).

Particularly, the share of Pakistan tobacco industry to overall GDP was estimated as 4.4%. This industry offers almost 312,500 job opportunities and employed almost 1.2 million people in Pakistan (PTC, 2010). The tobacco production of Pakistan was 108,000 tons in 2013 and 2014 (GoP, 2014). All the four provinces of Pakistan have vital contribution in tobacco production which adds significantly to Pakistan's economy. However, the lowest tobacco producing province is Sindh while the highest producing province is Khyber Pakhtunkhwa (KPK). In KPK the most producing area is Swabi and Mardan (GoP, 2014).

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Tobacco crop is one of the lucrative cash crops but still its per acre tobacco production in Pakistan is much less as compared to neighbouring countries such as China and India. Considering the significance of tobacco crop and constraints of the tobacco growers, this research study was carried out to analyze the stochastic frontier production of tobacco growers, estimate technical efficiency and identify the factors (if any) that explains variation in technical efficiency.

MATERIALS AND METHOD

Study Universe

In Khyber Pakhtunkhwa province, three districts namely; Swabi, Mardan and Charsadda are deemed as an icon districts for tobacco production. However, due to time and financial constraints this research endeavour was limited to three villages; Takkar Kali, Garo Shah and Passand Kali of Takhtbhai tehsil of Mardan district .

Sampling Design and Sample Size

Multistage sampling technique was adopted to select the sampled respondents who were tobacco growers. In the first stage, District Mardan was selected purposely as this district is famous for tobacco production and was easily accessible for data collection. The focus of this study was tobacco crop, therefore Takhtbhai Tehsil which is considered as more tobacco producing tehsil of Mardan was selected purposely in the second stage of the sampling. In the 3rd stage three tobacco producing villages were selected randomly. The proportional allocation sampling design was employed in the 4th stage of the to obtain desired sample size of 120 tobacco growers through following formula:

$n_i = (Ni/N)^* n$

where,

n_i = Number of sampled tobacco farmers in the i^{th} village

n = Total sample size

N_i = Total number of tobacco farmers in the i^{th} village.

N = Total number of tobacco farmers in the area

n_1(Takkar Kali) =215/655*120= 39

n_2(Gharo Shah)=140/655*120= 26

n_3(Passand Kali) =300/655*120= 55

After estimating the proportional allocation sampling technique, in the last and 5th stage 39, 26, 55 tobacco growers were selected from Takkar Kali, Gharo Shah and Passand Kali, respectively, on random sampling basis.

Data Collection and Analysis

The prescribed questionnaire was used to collect the primary data from tobacco growers through face to face interview method. The collected data was analyzed by using computer software Frontier 4.1 and STATA. The econometric and descriptive statistics techniques were exercised to gauge the major findings of this research endeavor.

Stochastic Frontier Production Function

The foundation of stochastic frontier production function was laid down by Farrell (1957) which was followed by the additional underpinning of Aigner et al. (1977) and Meeusen and Van den Broeck (1977). The general form of the model can be expressed as:

$$\ln(q_i) = \beta' x_i + v_i\ u_i$$

where,

- i = 1,2,.........,N
- q = Represents the output of the i^{th} firm
- x_i = K x 1 vector containing the logarithms of inputs
- β = Vector of unknown parameters to be estimated
- ν_i = Systematic random error which account for statistical noise
- μ_i = Non-negative random variable associated with technical inefficiency

Moreover, a Cobb-Douglas type stochastic frontier model takes the form as illustrated by Coelli et al. (2005):

$$\ln q_i = \beta_0 + \beta_1 \ln x_i + v_i + u_i$$
$$q_i = \exp(\beta_0 + \beta_1 \ln x_i + v_i + u_i)$$
$$q_i = \exp(\beta_0 + \beta_1 \ln x_i) \text{ x } \exp(vi) \text{ x } \exp(-u_i)$$

Underpinning of Technical Efficiency Model

The farm specific technical efficiency is defined as the ratio between observed outputs to the corresponding stochastic frontier output as stated by Coelli et al. (2005) and can be expressed mathematically as under:

$$TE_i = \frac{q_i}{\exp(x_i\beta+v_i)} = \frac{\exp(x_i\beta+v_i-u_i)}{\exp(x_i\beta+v_i)} = \exp(-u_i)$$

Model Specification

The model specification is given as follow:

$$\ln Y = \ln\beta_0 + \beta_1 \ln TH + \beta_2 \ln SED + \beta_3 \ln LD + \beta_4 \ln IR + \beta_5 \ln PM + \beta_6 \ln FERT + \beta_7 \ln CH + DTAKKAR + DPASSAND + (V_i - U_i)$$

where,

- ln = Natural log
- Y = Production of tobacco in maunds acre^{-1}
- βi = Coefficient to be estimated
- TH = log transformed tractor hours acre^{-1}
- SED = log transformed seed used in mg acre^{-1}
- LD = log transformed labor days acre^{-1}
- IR = log transformed irrigation used in time acre^{-1}
- PM = log transformed poultry manure in trolley acre^{-1}
- FERT = log transformed fertilizer used in kg acre^{-1} (urea, DAP,NPK)
- CH = log transformed chemical used in liter acre^{-1} (pesticide, weedicide)
- DTAKKAR = Dummy variable = 1 if farmer of the village Takkar and 0 otherwise
- DPASSAND = Dummy variable=1 if farmer of the village Passand and 0 otherwise
- V_i = Stochastic effect which are outside the farmer control
- U_i = Technical inefficiency or short fall of output from its maximum possible output.

Determinants of Inefficiency

The following model was used to decide the various aspects contributing to inefficiency of the tobacco producing farmers:

$$U_i = \delta_0 + \delta_1 (EDU) + \delta_2 (AGE) + \delta_3 (EXP) \ldots\ldots\ldots\ldots (3.10)$$

where,

- U_i = Inefficiency effect
- δ_i = Unknown parameters to be estimated

EDU = Educational level of the farmer (years of schooling)
AGE = Age of the farmer (years)
EXP = Farming experience (years)

Statistical Diagnosis

This study has used the primary data which was collected from tobacco farmers using a well-structured questionnaire. So the model was checked for the problem of multicollinearity and heteroscedasticity because primary data collection may create these problems.

RESULTS AND DISCUSSION

Statistical Diagnosis

Detection of Heteroscedasticity

Of the several assumption of classical linear model, one assumption is "homoscedasticity" where homo mean equal or same and scedasticity mean variance. Homoscedasticity thus refers to as equal or same variance. In case δ^2 is not constant then there is a problem referred to as heteroscedasticity. There are several reason of variances difference, i.e., inappropriate data collection technique, presence of outlier and error learning model. The problem of heteroscedasticity is mostly common in cross sectional then time series data. This research study has employed Koenker Basset (K.B) Test to detect the problem of heteroscedasticity.

K.B test revealed that independent variable (PRE-2) are insignificant with P-value of 0.349, which confirms that results are homoscedastic and there in no problem of heteroscedasticity (Table 1).

Table 1. Koenker Basset (K.B) test estimates for detecting heteroscedasticity

Independent variable	Co-efficient (β)	S.E	T-ratio	Sig
Constant	0.00240	0.00200	1.12	0.264
PRE_2	-0.00014	0.00015	-0.94	0.349

Source: Survey Data, 2014, Dependent variable: RES_2

Detection of Multicollinearity

The phenomenon which has a moderate of perfect relationship between the predictor variables is called multicolinearity. In the presence of exact relationship between the predictor (explanatory) variables it is difficult to get the estimates of their individual coefficients accurately. This leads to incorrect conclusions about the dependent and explanatory variables. If the purpose of the regression analysis is only forecasting then multicolinearity is not a problem because it gives the high value for R^2 i.e., higher the value of R^2, better will be the forecasting but if one is interested to estimate the value of β and to interpret it then it will cause serious problem. This problem occurs because of inappropriate data collection method, model specification, an over determined method, etc. As the data used in the study was cross sectional data, therefore, it has the possibility of presence of multicolinearity. To detect the multicollinearity problem, the variance inflation factor (VIF) was used in this research study. In general, existence of multicollinearity is considered as high, if the estimated value of VIF is greater than 5 (Table 2). The computed results depict that variance inflation factors for major variables are suitable and are less than 5, therefore, there is no existence of multicollinearity in the data collected.

Stochastic Frontier Analysis

The maximum likelihood estimates of Cobb-Douglas type stochastic

Table 2. Variance inflation factor (VIF) estimates for detecting multicollinearity

Variable	VIF	1/VIF
Tractor hour	3.33	0.300
Labor	3.07	0.325
Irrigation	2.94	0.340
D Takkar	1.79	0.557
D Pasand	1.78	0.561
FYM	1.58	0.632
Seed	1.48	0.674
Chemical	1.41	0.709
Fertilizer	1.19	0.843
Mean VIF	2.06	

Source: Survey Data, 2014

production function revealed that the signs of majority coefficient were according to the expectation except fertilizer which is negative. That implies that 1% increase in fertilizer will decrease tobacco production by 0.020%. Thus due to overuse of fertilizer, tobacco growers are facing with diminishing return scale. The result is corroborated with those of Hasnain et al. (2015), Saddozai et al. (2013) and Islam et al. (2004) who argued that the coefficient of fertilizer with negative and statistically significant illustrate that the farmers are facing diminishing return to scale. The estimation further explain that the coefficient of labor days have great elasticity among the explanatory variable to tobacco yield. This illustrates that a 1% increase in labor days will increase 0.31% production of tobacco. By summing overall elasticity of all inputs, the coefficient of elasticity was estimated at 0.954 (Ep<1), these results are similar with previous study of Ali et al. (2013). Three villages of the study area were taken as dummy variable to compare the production level of tobacco among these villages. Village Gharo Shah was taken as a bench-mark village and the other two villages Takkar Kali and Passand Kali were compared with benchmark village. The estimated dummy variables for both Takkar Kali and Passand Kali were statistically significant at 1% level which implies that tobacco production level among three villages was different from each other.

The variance parameter (λ) showed the good fitness of the frontier stochastic production model and also correctness of the composed error term which are beyond or under the control of farmer. The computed result of λ was 2.101 which is significantly different from zero suggests that the frontier stochastic production model was good fit and correctly measured the composed error term. The variance parameter (Γ) is the inefficiency effect. The Γ parameter obtained from result is 0.82 which employs that inefficiency factors that are unexplained by the production function result in 82% variation in stochastic production model (Table 3).

Technical Inefficiency Estimates

The inefficiency parameter with negative sign implies improvement in technical efficiency while the positive shows the inverse relation of the parameter to efficiency. The estimated results of this research study revealed that experience was the only parameter that contributes significantly in reducing the inefficiency of the tobacco growers (Table 4). This means that experience of the farmers can increase the efficiency of tobacco grower. Experienced farmers can adopt new technology and have link

Table 3. Maximum likelihood estimates of stochastic production frontier of tobacco crop

Independent variables	Coefficient	S.E.	t-ratio	Significance
Constant	1.356	0.172	7.90	0.000
Tractor	0.120	0.030	4.00	0.000
Seed	0.106	0.027	3.87	0.000
Labor	0.313	0.052	5.99	0.000
Irrigation	0.208	0.034	6.19	0.000
Poultry manure	0.093	0.029	3.19	0.001
Fertilizer	-0.020	0.008	-2.63	0.009
Chemical	0.133	0.057	2.92	0.003
Sum of elasticity	0.954			
Dummy for Takkar Kali	-0.012	0.004	-2.61	0.009
Dummy for Passand Kali	-0.010	0.003	-2.56	0.010
Variance parameters				
Sigma-v	0.099	0.020		
Sigma-u	0.208	0.034		
Sigma2	0.053	0.012		
$\lambda=\sigma u/\sigma v$	2.101	0.051		
$\Gamma= \lambda^2/1+ \lambda^2$	0.82			

Source: Survey Data, 2014

with extension workers to update themselves from new studies and technique. This result is persistent with the previous study of Douglas (2008) and Simwaka et al. (2013) while opposite to the previous results of Fernandez and Nuthal (2009) and Ali and Khan (2014). However, the estimates further unearthed the insignificant contribution of age of the farmers and education towards inefficiency which depicts no effect of age of tobacco farmers and education on inefficiency.

Table 4. Major factors affecting technical inefficiency

Variables	Coefficient	S.E	t-ratio	P-value
Constant	13.0766	5.1454150	2.54	0.011
Education	-00.1676	0.1406550	-1.19	0.233
Age	00.0528	0.0496342	1.06	0.287
Experience	-00.7703	0.1997559	-3.86	0.000

Source: Survey Data, 2014

Technical Efficiencies Indices

The mean technical efficiency score of tobacco growers was estimated as 85% in the study area. However the technical efficiency score ranges from 59% to 97%. The mentioned mean value of technical efficiency score (85 $\pm$ 9) demonstrates that the tobacco growers can enhance their efficiency for production by further 12% to attain the maximum technical efficiency.

CONCLUSION AND RECOMMENDATIONS

This research study concludes that labour followed by irrigation were identified as two substantial significant factors as compared to other inputs which can enhance the tobacco production by 31% and 20%, respectively subject to 1% increase in each variable. The research findings have further underpinned the irrational use of fertilizer, as its coefficient is negative, which implies that fertilizer has inverse relation with tobacco production. It is recommended on the basis of major findings that government and other input supplying agencies make efforts to ensure timely availability of crop inputs because majority of inputs are significantly contributing in tobacco yield. To enhance the efficiency of tobacco growers, the season long trainings should be undertaken by the concerned authorities to uplift the farmers crop managerial skills to avoid the irrational use of inputs. A special package of composite information along with technical assistance must be provided through the existing extension services system. Institutional arrangements in this perspective would be highly effective for reasonable production of tobacco on sustainable basis.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Dr. Khurram Nawaz Saddozai	Conceived the idea, Management of overall article.
2.	Mr. Muhammad Nasrullah	Review of literature, Data collection and analysis, Abstract development
3.	Dr. Noor P. Khan	Results and discussion, Conclusion and recommendation

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