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Kiran Lata
Ph. D Scholar, Division of Agricultural Economics & ABM, SKUAST-J, Chatha, Jammu and Kashmir, India

Jyoti Kachroo
Professor & Head, Division of Agricultural Economics & ABM, SKUAST-J, Chatha, Jammu and Kashmir, India

Manish Kr Sharma
Professor & Head, Division of Statistics & Computer Science, SKUAST-J, Chatha, Jammu and Kashmir, India

SP Singh
Assistant Professor, Division of Agricultural Economics & ABM, Chatha, Jammu and Kashmir, India

Kamlesh Bali
Associate Professor, Division of Sericulture, SKUAST-J, Chatha, Jammu and Kashmir, India

Moni Gupta
Associate Professor, Division of Biochemistry, Chatha, Jammu and Kashmir, India

Arnab Roy
Ph. D Scholar, UAS, GKVK, Bangalore, Karnataka, India

Correspondence
Kiran Lata
Ph. D Scholar, Division of Agricultural Economics & ABM, SKUAST-J, Chatha, Jammu and Kashmir, India

Technical efficiency and factors influencing technical efficiency of sericulture production in Jammu region: A stochastic frontier approach

Kiran Lata, Jyoti Kachroo, Manish Kr Sharma, SP Singh, Kamlesh Bali, Moni Gupta and Arnab Roy

Abstract
This paper has assessed the level of technical efficiency and its determinants of sericulture production in Jammu region of J&K state. The study is based on cross-sectional data collected through primary survey during the year 2017-18 from 270 silkworm rearers through a multi-stage sampling technique. The paper has employed stochastic production frontier approach for the estimation of TE and simple linear regression model to analyze determinants of TE. The maximum likelihood estimates of the major inputs showed that saplings (+), FYM (-), human labour (+), DFLs (+) and disinfectant (-) in Kathua, disease free layings (+) in Rajouri, spalings (-), DFLs (+) and newspaper (+) in Udhampur and saplings (-), FYM (+) and DFLs (+) have contributed significantly to increase the cocoon yield. Mean technical efficiency of 62 per cent, 63 per cent, 62 per cent and 62 per cent was achieved by the silkworm rearers of Kathua, Rajouri, Udhampur and at overall level, respectively implying that the rearers can still enhance their technical efficiency by 38 per cent, 37 per cent, 38 per cent and 38 per cent in Kathua, Rajouri, Udhampur and at overall level, respectively with the given inputs and technology. Furthermore, the results have demonstrated that the cocoon crop is lucrative in Kathua, Udhampur and at overall level as the cocoon growers enjoyed increasing returns to scale ($\varepsilon_p > 1$), hence economies of scale exists while Rajouri encountered decreasing returns to scale ($\varepsilon_p > 1$). The variance parameter lambda (λ) and gamma (γ) both were significant and greater than 1 indicating the goodness of fitted model and inefficiency impact, respectively. The estimated value of gamma (γ) was 0.91, 1.00, 0.99 and 0.76 per cent in Kathua, Rajouri, Udhampur and at overall level which underscores that 91 per cent, 100 per cent, 99 per cent and 76 per cent variation in the production frontier was explained by technical inefficiency effect, respectively. Among major socio-economic factors influencing the technical efficiency, farm size in Kathua, household size and experience in Udhampur and household and farm size at overall level were found having significant effect on technical efficiency while in Rajouri none of the factor was found significantly influencing the technical efficiency. The study suggested for proper management of inputs which stresses the need for extension agents to make aware and train the silkworm rearers regarding cocoon crop management practices to enhance the production as the awareness about scientific techniques of cocoon production would play an important role in increasing the cocoon yield.

Keywords: Sericulture, cocoons, technical efficiency, stochastic production frontier

Introduction

In developing countries like India, agriculture and agro-based industries plays a very important role in the amelioration of rural economy as India is primarily an agrarian economy which is evident from the fact that half of India's population is directly or indirectly dependent on agriculture for their livelihood (Anonymous, 2016) [3]. With the rapid increase in population the size of agricultural holding has decreased and possession of these small sized holdings by a large proportion of farmers' in the absence of alternative sources of income has become one of the main factors of rural poverty and hindered agricultural growth. Also, confronted with a number of factors like limited land availability, limited cash returns and is confined to one or two seasons in a year, the agriculture sector has limited potential for generating new jobs in rural areas. Furthermore, reducing the rural poverty continues to be the ultimate goal of the developing countries like India, related to which various strategies have been pursued to address this concern and among the major ones is creation of rural employment. All this pushes villages to look for supporting and establishment of rural based industries like sericulture. It is one of the small scale rural based cottage industries that can be very effective tool in creating more employment opportunities for rural people.

Sericulture is both an art and science of raising silkworms for the production of cocoons which is the raw material for the production of silk. In India it has turned out to be a highly remunerative enterprise and promising rural industries because of its unique characteristics of being eco-friendly, agro-based, labour intensive, short gestation period and capacity to develop into a family enterprise with low capital investment, high output and reasonably good assured returns. It has gained a special place among the agro-based cottage industries of our country as it provides employment and income to the rural poor, especially, farmers with small land holding and marginalized sections of the society. Being a rural based industry, the production and weaving of silk are largely carried out by relatively poorer sections of the society and this aspect of sericulture has made it popular and sustainable in India. India is the second largest producer of silk in the world after China having a share of about 15.49 per cent in the global production (Bhat, 2014) [5]. India is the only country in the world that has the unique distinction of producing all the five commercially known varities of silk viz. Mulberry, Eri, Tropical Tasar, Oak Tasar and Muga. Due to the prevalence of favourable climatic conditions, mulberry is cultivated mainly in five states of the country namely, Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu and Kashmir called as traditional sericulture states which jointly account for about 97 per cent of mulberry silk production as well as area under mulberry cultivation (Bhat, 2014) [5].

In the state of Jammu and Kashmir it plays a very important role in rural development as it integrates well with the farming systems and is the subsidiary occupation of about 30455 families are practicing sericulture as a subsidiary occupation in the state by producing 973 MTs of cocoons and generating an income of about □ 2224 lakhs annually without any role of middleman (Anonymous, 2016) [3]. It is practiced in 20 districts of the state out of which major silk producing districts are Anantnag, Kupwara, Pulwama, Baramula, Ganderbal, Udhampur, Rajouri, Reasi and Kathua and has flourished well in the rain-fed areas of Rajouri, Udhampur and Kathua districts. With this background, the present study was undertaken with the following objectives:

- To study the technical efficiency of sericulture production.
- To identify the factors influencing the technical efficiency.

Study Area and Methodology

Multi-stage sampling technique was adopted for accomplishing the objectives of the study. At the first stage, three districts namely Kathua, Rajouri and Udhampur were purposively selected based on highest number of silkworm rearers and cocoon production as the sericulture has flourished well in these districts of Jammu region. Then, two development blocks from each selected district were selected purposively based on the same criteria. Further, three villages from each selected block were selected randomly and at the fourth/final stage, 270 silkworm rearers (15 from each village, 45 from each block and 90 from each selected district) were randomly selected and interviewed using pre-tested schedule during the year 2017-18.

Analytical Framework

Stochastic Frontier Production Function

The stochastic frontier production function proposed independently by Aigner *et al.* (1977) [1], Meeusen and Van den Broeck (1977) [7] was used and the function is specified as:

$$Y_i = f(x_i; \beta) + e_i$$

Where

$i = 1, 2, \ldots\ldots N$

$e_i = v_i - u_i$

Y_i is output level of ith farm; $f(x_i; \beta)$ is a suitable function such as Cobb Douglas or Translog production function of vector, x_i, of inputs for the ith farm and a vector, β, of unknown parameters. e_i is an error term made up of two components v_i and u_i. v_i is a random error and u_i is associated with technical inefficiency of the farm and ranges between zero and one. N represents the number of farms involved in the cross-sectional survey of the farms.

The maximum likelihood estimates (MLE) of the parameters of the model defined by equation:

$$Y = f(X_i \beta) \exp(V_i - U_i)$$

Where,

Y_i is the production of the ith farm (i=1, 2, 3,……….n),

X_i is a (1xk) vector of functions of inputs quantities applied by ith farm; β is a (1xk) vector of unknown parameters to be estimated. V_i are random variables assumed to be independent as N (0, δ^2v) and independent of U_i. U_i are the non-negative random variables associated with technical inefficiency in production, assumed to be independently and identically distributed and truncated (at zero) of the normal distribution with mean $Z_i\delta$ and variance σ^2u expressed as N ($Z_i\delta$, σ^2u); Z_i is a (1xm) vector of farm specific variables associated with technical inefficiency, and δ is a (mx1) vector of unknown parameters to be estimated (Battese and Coelli, 1995) [4]. In the process, the variance parameters σ^2u and σ^2v are expressed in terms of the parameterization:

$\sigma^2 = (\sigma^2 u + \sigma^2 v)$ and

$\gamma = (\sigma^2 u / \sigma^2 v + \sigma^2 v)$ or

$\gamma = \sigma^2 u / \sigma^2$

Where, σ^2 is the variance parameter which denotes total deviation from the frontier, σ^2_u is the deviation from the frontier due to inefficiency and σ^2_v is the deviation from the frontier due to stochastic noise. Gamma (γ) is an indicator of relative variability of U_i and V_i that differentiates the actual yield from the frontier. It can take values from 0 to 1, where 0 implies that the random component of model due to noise whereas γ equals to 1 implies that the random component of model is entirely due to inefficiency.

Specification of the model

The stochastic frontier production function of the Cobb-Douglas type under half normal distribution of u_i was employed to assess the technical efficiency and estimated by using Maximum Likelihood Method. The estimates (MLE) are computed using the computer programme Frontier 4.1. The model used is specified as:

$$\ln Y_{ij} = \alpha_0 + \alpha_1 \ln X_{1ij} + \alpha_2 \ln X_{2ij} + \alpha_3 \ln X_{3ij} + \alpha_4 \ln X_{4ij} + \alpha_5 \ln X_{5ij} + \alpha_6 \ln X_{6ij} + \alpha_7 \ln X_{7ij} + \alpha_8 \ln X_{8ij} + \alpha_9 \ln X_{9ij} + \alpha_{10} \ln X_{10ij} + \alpha_{11} \ln X_{11ij} + V_{ij} - U_{ij} \quad (i = 1, 2, \ldots\ldots, n)$$

The subscripts i and j refer to the ith farmers and jth observation respectively,

Where;

Y = Cocoon yield (kg/ounce), X_1 = Saplings (Number), X_2 = Machine labour (hours/acre), X_3 = Farm yard manure (Tonnes/acre), X_4 = Fertilizers (Kgs/acre), X_5 = Human labour (Days/acre), X_6 = Disease free layings (DFLs) (ounce/farm), X_7 = Leaves (kgs/ounce), X_8 = Human labour (Days/ounce), X_9 = Disinfectants (kgs/ounce), X_{10} = Newspaper (kgs/ounce), X_{11} = Coal (kgs/ounce), α_0-α_{11} are the parameters to be estimated, V_{ij} - U_{ij} = Random error term, ln = the natural logarithm (i.e. to base e)

The technical efficiency of individual farm was worked out using formula:

$$TE_i\hat{} = Y_i / Y_i^*$$

Where,

Y_i = Observed output and Y_i^* = Frontier's output

The technical inefficiency was worked out as:

Technical inefficiency = 1- $TE_i\hat{}$

Determinants of Technical Efficiency

For assessing the socio-economic factors influencing technical efficiency at the farm level linear regression model was used. Maximum likelihood estimates (MLE) of technical efficiency, regressed on age and education of the head of the family, family members involved, farm size, experience of rearers. As the technical efficiency variable varies between 0 and 1, the variable will be transformed into ln [TE/1-TE] so that the latter transformed variable now varies between - ∞ to + ∞, which will facilitate estimation of the parameters by using MLE technique.

The following linear regression model was used:

$$L_n\,[TE/(1-TE)] = \beta_0 + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \beta_3 X_{3ij} + \beta_4 X_{4ij} + \beta_5 X_{5ij} + U_i$$

Where,

TE_{ij} = Technical efficiency for i^{th} crop on j^{th} farm, β_0 = Intercept/constant, β_i = regression coefficients, X_1 = age of the head of family, X_2 = education of the head, X_3 = farm size, X_4 = experience of rearers, X_5 = family members involved in silkworm rearing, U_i = error term

Results and Discussion

Technical Efficiency Estimates

The estimated technical efficiency of sericulture production in Kathua district is furnished in Table 1. The maximum likelihood estimates of parameters in the Cobb-Douglas production function model revealed that the coefficients saplings, farm yard manure, human labour (planting), disease free layings (DFLs) and disinfectants contributed significantly to increase cocoon production. The elasticity sum of all inputs was worked out as 1.0712 (ε_p >1) which suggests increasing returns to scale in Kathua. The estimated variance parameter, gamma (γ) was 0.91 which implies that about 91 per cent of the variation in cocoon output was due to technical inefficiency rather than random variability. The computed value of lambda (λ) was 3.2054 which is greater than 1 indicating that the employed stochastic production model was a good fit and correctly measured the composite error term. The estimated values of σ^2_v and σ^2_u turned as 0.0030 and 0.0311, respectively showing differences between the observed and frontier output due to inefficiency and not chance alone (Coelli *et al.,* 1998) [6]. Log likelihood function turned out as 131.356 which was large and significantly different from zero, indicating a good fit and the correctness of the specific distributional assumption. The rearers achieved mean technical efficiency of 62 per cent which means that on an average 38 per cent of the technical potential of the sample district was not realized in raising the cocoon output.

Table 1: Maximum Likelihood estimates (MLE) for parameters of Cobb-Douglas stochastic frontier production function for Kathua district

N = 90					
Variables	**Parameter**	**Coefficients**	**Standard Error**	**Z**	**P-value**
Frontier production function					
Constant	α_0	2.5226***	0.1235	20.42	0.000
Log Saplings	α_1	0.0417*	0.0252	1.65	0.099
Log Tractor hours	α_2	-0.0001	0.0024	-0.28	0.781
Log FYM	α_3	-0.0765*	0.0431	-1.77	0.076
Log Human labour	α_4	0.0686***	0.0235	2.91	0.004
Log DFLs	α_5	1.1288***	0.0243	46.38	0.000
Log Human labour	α_6	-0.0403	0.0334	-1.21	0.228
Log Disinfectant	α_7	-0.0503***	0.0196	-2.57	0.010
Sum of elasticity of inputs	ε_p	1.0712			
Diagnostic statistics					
σ^2_v		0.0030			
σ^2_u		0.0311			
σ_v		0.0550			
σ_u		0.1763			
σ^2		0.0341			
σ		0.1847			
Lambda (λ)		3.2054			
Gamma (γ)		0.91			
Log likelihood function		131.356			
Wald chi² (χ^2)		4754.14***			
Mean Technical efficiency		0.6198			

Note: *,** and *** Significant at 10 per cent, 5 per cent and 1 per cent level of significance, respectively

The Maximum likelihood estimates for Rajouri district are furnished in Table 2 which indicates that only disease free layings (DFLs) contributed significantly in increasing cocoon production. The elasticity sum of all inputs worked out to be 0.99 (ε_p <1) indicating decreasing returns to scale in Rajouri. Gamma (γ) turned out to be 1.00 implying 100 per cent of variation in output due to technical inefficiency rather than random error. λ (38.9122) and likelihood function (240.6902) were greater than 1 indicating a good fit. The estimated values of σ^2_v and σ^2_u are 0.0000 and 0.0492, respectively indicating differences between the observed and frontier output solely due to inefficiency and not chance. The mean technical efficiency of 63 per cent was attained by the rearers indicating that on an average 37 per cent of the technical potential of the sample district was not realized in raising the cocoon output.

Table 2: Maximum Likelihood estimates (MLE) for parameters of Cobb-Douglas stochastic frontier production function for Rajouri district

N = 90					
Variables	**Parameter**	**Coefficients**	**Standard Error**	**Z**	**P-value**
Frontier production function					
Constant	α_0	2.4414***	0.0345	70.75	0.000
Log Saplings	α_1	0.0047	0.0066	0.71	0.479
Log Tractor hours	α_2	0.0004	0.0008	0.49	0.627
Log FYM	α_3	-0.0068	0.0103	-0.66	0.509
Log Human labour	α_4	-0.0012	0.0013	-0.92	0.359
Log DFLs	α_5	1.0012***	0.0107	93.89	0.000
Log Human labour	α_6	0.0054	0.0088	0.61	0.541
Log Disinfectant	α_7	-0.0065	0.0079	-0.81	0.417
Sum of elasticity of inputs	ε_p	0.9972			
Diagnostic statistics					
σ^2_v		0.0000			
σ^2_u		0.0492			
σ_v		0.0057			
σ_u		0.2218			
σ^2		0.0492			
σ		0.2218			
Lambda (λ)		38.9122			
Gamma (γ)		1.00			
Log likelihood function		240.6902			
Wald chi^2 (χ^2)		52608.77***			
Mean Technical efficiency		0.6299			

Note: *,** and *** Significant at 10 per cent, 5 per cent and 1 per cent level of significance, respectively

The maximum likelihood estimates for Udhampur district are presented in the Table 3 which reveals that saplings, disease free layings and newspaper contributed significantly to the cocoon production. The sum of elasticity of all inputs was 1.04 (ε_p >1) indicating increasing returns to scale in Udhampur. Gamma (γ) turned out to be 0.99 implying 99 per cent of difference between the observed and frontier output due to technical inefficiency. Lambda (13.58) and log likelihood function (214.609) were greater than 1 depicting a good fit of the model employed and correct measurement of composite error term. The values for σ^2_v and σ^2_u turned out to be 0.0002 and 0.0372, respectively showing differences between the observed and frontier output due to inefficiency and not chance alone. The mean technical efficiency of 62 per cent indicates that on an average 38 per cent of the technical potential was not realized in raising the cocoon output in the sample district.

Table 3: Maximum Likelihood estimates (MLE) for parameters of Cobb-Douglas stochastic frontier production function for Udhampur district

frontier production function for Udhampur district					
N = 90					
Variables	**Parameter**	**Coefficients**	**Standard Error**	**Z**	**P-value**
Frontier production function					
Constant	α_0	2.4533***	0.0279	87.88	0.000
Log Saplings	α_1	-0.0010**	0.0005	-1.98	0.047
Log Human labour	α_2	-0.0012	0.0013	-0.92	0.359
Log DFLs	α_3	1.0248***	0.0061	168.72	0.000
Log Human labour	α_4	-0.0064	0.0112	-0.57	0.571
Log Disinfectant	α_5	0.0015	0.0044	0.34	0.734
Log Newspaper	α_6	0.0156**	0.0078	1.99	0.046
Log Coal	α_7	-0.0003	0.0006	-0.56	0.572
Sum of elasticity of inputs	ε_p	1.0419			
Diagnostic statistics					
σ^2_v		0.0002			
σ^2_u		0.0372			
σ_v		0.0142			
σ_u		0.1929			
σ^2		0.0374			
σ		0.6115			
Lambda (λ)		13.58			
Gamma (γ)		0.99			
Log likelihood function		214.6090			
Wald chi^2 (χ^2)		44034.45***			
Mean Technical efficiency		0.6181			

Note: *,** and *** Significant at 10 per cent, 5 per cent and 1 per cent level of significance, respectively

MLEs of the parameters at overall level (Table 4) revealed that saplings, farm yard manure and disease free layings contributed significantly to cocoon production. Elasticity sum of all inputs was 1.034 ($\varepsilon_p > 1$) indicating increasing returns to scale in the study area. Gamma (γ) turned out as 0.76 implying 76 per cent of variation in output due to technical inefficiency rather than random error. Lambda (1.80) and log likelihood function (352.97) turned greater than 1 thus depicts that the employed model was a good fit. The values of σ^2_v (0.0020) and σ^2_u (0.0064) revealed differences between observed and frontier output due to inefficiency and not chance alone. Mean technical efficiency of 62 per cent at overall level indicated that on an average 38 per cent of the technical potential was not realized in raising the cocoon output in the study area.

Table 4: Maximum Likelihood estimates (MLE) for parameters of Cobb-Douglas stochastic frontier production function at overall level

N = 270					
Variables	**Parameter**	**Coefficients**	**Standard Error**	**Z**	**P-value**
Frontier production function					
Constant	α_0	2.6034	0.0683	38.14	0.000
Log Saplings	α_1	-0.0227*	0.0131	-1.73	0.083
Log Machine labour	α_2	-0.0023	0.0018	-1.29	0.196
Log FYM	α_3	0.0386*	0.0209	1.85	0.065
Log Human labour	α_4	0.0016	0.0026	0.62	0.534
Log DFLs	α_5	1.0216***	0.0121	84.55	0.000
Log Human labour	α_6	-0.0089	0.0164	-0.54	0.588
Log Disinfectant	α_7	-0.0089	0.0156	-0.57	0.567
Log Newspaper	α_8	0.0149	0.0097	1.53	0.127
Log Coal	α_9	0.0001	0.0014	0.04	0.966
Sum of elasticity of inputs	ε_p	1.0340			
Diagnostic statistics/Variance parameters					
σ^2_v		0.0020			
σ^2_u		0.0064			
σ_v		0.0444			
σ_u		0.08			
σ^2		0.0084			
σ		0.0916			
Lambda (λ)		1.8018			
Gamma (γ)		0.76			
Log likelihood function		352.970			
Wald chi² (χ^2)		16465.470***			
Mean Technical efficiency		0.6226			

Note: *,** and *** Significant at 10 per cent, 5 per cent and 1 per cent level of significance, respectively

Frequency Distribution of Efficiency Estimates

The decile range of frequency distribution based on technical efficiency estimates is displayed in the Table 5 which depicts that most of the rearers (23.33) in Kathua were operating in the efficiency score of 41-50 per cent and lowest (3.33 per cent) up to 40 per cent. Similarly, in Rajouri highest percentage of rearers (24.44 per cent) was found in the efficiency range of 71-80 per cent and lowest (3.33 per cent) up to 40 per cent efficiency level. In Udhampur as well majority of rearers (23.33 per cent) were found in the efficiency score of 41-50 and lowest (2.22 per cent) up to 40 per cent efficiency score. At overall level also most of the rearers (22.59 per cent) were found in the efficiency range of 41-50 per cent and lowest (2.96 per cent) up to 40 per cent efficiency level.

Table 5: Frequency distribution of silkworm rearers of sample districts and at overall level based on technical efficiency

Technical Efficiency Score Range (%)	Kathua		Rajouri		Udhampur		Overall	
	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Upto 40	3	3.33	3	3.33	2	2.22	8	2.96
41-50	21	23.33	19	21.11	21	23.33	61	22.59
51-60	20	22.22	18	20.00	21	23.33	59	21.85
61-70	20	22.22	18	20.00	19	21.11	57	21.11
71-80	16	17.78	22	24.44	20	22.22	58	21.48
Upto 90	10	11.11	10	11.11	7	7.78	27	10.00
Total	90	100.00	90	100.00	90	100.00	270	100.00

Determinants of Technical Efficiency

Regression analysis results for the Kathua district (Table 6) revealed that education, household size, age and experience were statistically insignificant but positively related with the technical efficiency depicting that a unit increase in these variables results in improving technical efficiency of silkworm rearers. Farm size was found having positive and highly significant effect on technical efficiency meaning that the rearers with more land under mulberry are technically efficient. Value of coefficient of determination (R square) as 0.14 indicates that 14 per cent of variation in technical efficiency was explained by variation in independent variables included in the model. Significant f value indicates that these variables contributed significantly towards the technical efficiency in Kathua.

In Rajouri district (Table 7) farm size, experience and age were found positively related with the technical efficiency while education and household size were having inverse relationship. Coefficient of determination was 0.04 indicating 4 per cent of variation in technical efficiency due to independent variables included in the model. Insignificant f value indicated that none of these variables contributed significantly towards the technical efficiency.

Table 6: Determinants of Technical Efficiency of Kathua district

Variables	Coefficients	Parameter	Standard Error	t- Stat	P-value
Intercept	7.5471	β_0	5.3875	1.4008	0.1649
Education of head	1.5450	β_1	1.5641	0.9878	0.3261
Household size	0.3378	β_2	1.5801	0.2138	0.8312
Farm size	3.4240***	β_3	1.0204	3.3554	0.0012
Age of head	0.0223	β_4	0.0564	0.3955	0.6934
Experience	0.0866	β_5	0.1172	0.7393	0.4617
R Square	0.1451				
F-value	2.852**				

Note: ** and *** Significant at 5 per cent and 1 per cent level of significance, respectively

Table 7: Determinants of Technical Efficiency of Rajouri district

Variables	Coefficients	Parameter	Standard Error	t- Stat	P-value
Intercept	9.7522	β_0	2.4860	3.9228	0.0001
Education of head	-0.0229	β_1	1.0883	-0.0210	0.9832
Household size	-0.0701	β_2	0.3461	-0.2025	0.8400
Farm size	1.0438	β_3	0.6351	1.6435	0.1040
Age of head	0.0069	β_4	0.0465	0.1483	0.8824
Experience	0.0326	β_5	0.0384	0.8495	0.3980
R Square	0.0391				
F-value	0.683^{NS}				

Note: ** and *** Significant at 5 per cent and 1 per cent level of significance, respectively; NS- Non-significant

For Udhampur district the regression results (Table 8) depicted that household size and experience were having significant influence on technical efficiency. The association between technical efficiency and experience was found positive and highly significant indicating that rearers having more years of experience in silkworm rearing are comparatively more efficient. Further the coefficients for education, farm size and age were non-significant though positive. Coefficient of determination turned out to be 0.28 indicating 28 per cent of variation in technical efficiency due to variables included in the model. Highly significant f value indicated that the variables included contributed significantly towards the technical efficiency.

Regression analysis at the overall level (Table 9) depicted that household size and farm size turned highly significant in influencing the technical efficiency. Coefficient of determination worked out to be 0.13 indicating that 13 per cent of variation in technical efficiency due to variation in the independent variables included in the model. Highly significant f value indicated that these variables contributed significantly towards the technical efficiency.

Table 8: Determinants of Technical Efficiency of Udhampur district

Variables	Coefficients	Parameter	Standard Error	t- Stat	P-value
Intercept	10.5356	β_0	2.9123	3.6176	0.0005
Education of head	0.4761	β_1	1.3257	0.3591	0.7204
Household size	-1.5142***	β_2	0.4282	-3.5364	0.0006
Farm size	1.3963	β_3	0.9846	1.4182	0.1598
Age of head	0.0090	β_4	0.0525	0.1714	0.8642
Experience	0.1341***	β_5	0.0458	2.9260	0.0044
R Square	0.2830				
F-value	6.633***				

Note: ** and *** Significant at 5 per cent and 1 per cent level of significance, respectively

Table 9: Determinants of Technical Efficiency at overall level

Variables	Coefficients	Parameter	Standard Error	t- Stat	P-value
Intercept	9.9121	β_0	1.7576	5.6396	4.3808
Education of head	0.2841	β_1	0.7479	0.3798	0.7044
Household size	-0.7981***	β_2	0.2941	-2.7137	0.0071
Farm size	2.1554***	β_3	0.4983	4.3253	2.1605
Age of head	0.0293	β_4	0.0299	0.9796	0.3282
Experience	0.0166	β_5	0.0255	0.6516	0.5152
R Square	0.1276				
F-value	7.721***				

Note: ** and *** Significant at 5 per cent and 1 per cent level of significance, respectively

Conclusions

The study has revealed that there is potential for increasing the cocoon production in Kathua by increasing the levels of saplings, labour and DFLs, in Rajouri by increase in saplings, DFLs and labour, in Udhampur by increasing DFLs, disinfectants and newspaper while at overall level by increasing the use of farm yard manure, labour, DFLs, newspaper and coal. Of all the inputs in the districts selected DFLs was the major contributing factor in the cocoon production. Frontier production function analysis further revealed that mean technical efficiency was 62, 63, 62 and 62 per cent in Kathua, Rajouri, Udhampur and at overall level, respectively which indicates that still there is potential to improve the production by 38, 37, 38 and 38 per cent, respectively with the given inputs and technology. The computed gamma was 0.91, 1.00, 0.99 and 0.76 per cent which underscores that 91, 100, 99 and 76 per cent variations in the cocoon production was explained by technical inefficiency factors. The realized production frontier is lower than that of potential production frontier (frontier obtained by adopting scientific recommendations), as none of the rearer was found following the recommended practices. Education, household size, farm size, age and experience in Kathua, farm size, age and experience in Rajouri, education, farm size, age and experience in Udhampur and education, farm size, age and experience at overall level are the important determinants of technical efficiency. To overcome these issues study has suggested that extension agents should aware and train the silkworm rearers regarding cocoon crop management practices to enhance the production as the awareness about scientific techniques of cocoon production would play an important role in increasing the cocoon yield.

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