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Research Article

A stochastic production frontier approach in the estimation of technical efficiency of cocoon production in Doda district of Jammu

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SUMMARY : This paper presents measures of the technical efficiency and factors influencing technical efficiency in cocoon production in Bhaderwah Block of Doda district in Jammu & Kashmir State by using frontier production model. The results revealed that the mean technical efficiency was 68.48 per cent and the study implied that the average output could be increased by 31.52 per cent by adopting proper technology. The stochastic frontier analysis also showed that 76 per cent of the observed inefficiency was due to the farmer's decision making and 24 per cent of inefficiency was due to the random factor outside the control of the farmers. So for increasing the productivity of cocoon in this area, it is very important that the existing technologies should be properly utilized.

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KEY WORDS :
Technical efficiency, Production, Cocoon, Stochastic

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BACKGROUND AND OBJECTIVES

Sericulture, a labour intensive, export oriented, eco-friendly, employment creating and income generating activity, play a vital role in the improvement of rural and semi-urban economies of developing countries like India. It is estimated that sericulture can generate employment @ 11 man days per kg of raw silk production (in on-farm and off-farm activities) throughout the year. India is the second largest producer of silk in the world (production-125805 MT, 2004), next to China (81.7 % of the world production) and has a 12.00 per cent share in global raw silk production. While India produces around 18,475 MTs of raw silk annually (2006-07), total annual consumption of silk in the country, per annum is around 26,000 MTs. The additional requirement of 8,000 MTs of silk (particularly, bivoltine mulberry silk of international quality) is imported mainly from China (Anonymous, 2007). Therefore, there is scope for production of additional quantity of silk in the country to meet the domestic demand. The raw silk production which was around 16,319 MTs during the year 2002-03 has increased to 18,475 MTs during the year 2006-07, showing an increase of around 13.21 per cent in-spite various constraints like drought in traditional sericultural areas of southern peninsula during the year 2002-03 and 2003-04. This apart, the prices of sericultural commodities had come down during the same period due to large scale dumping of Chinese silk (yarn and fabrics) into the country during same period. However, the situation has now improved and the prices of sericultural commodities have improved because of the imposition of anti-dumping duty on the low grade silk yarn and fabrics imported from China. The stakeholders of the silk industry are now showing keen interest to take-up sericulture on a large scale due to the favourable conditions. The earnings from silk exports during the year 2006-07 has been 3338.35 crores *i.e.*, an increase of 141.58 per cent from 2001-02 to 2006-07, so much so, the estimated target for 2007-08 was 3500 crores (Anonymous, 2007).

India's silk exports are likely to surpass the target set for fiscal 2006-07 on the back of rising demand for Indian silk products in foreign countries, the US and UK in particular. Cultivation of sericulture is not very widespread being practiced regularly in contiguous districts in the three southern states of Karnataka (producing about 61 % of country's silk), Andhra Pradesh and Tamil Nadu; in the NER; in the tribal areas of Jharkhand, Chhattisgarh, Andhra Pradesh, Orissa and in Jammu & Kashmir and West Bengal. In these states, the silkworms are reared four to six times in a year except for the state of Jammu and Kashmir where rearing is practiced in spring season only. Among the various states of India, Jammu and Kashmir is the oldest silk rearing areas producing multivaline and biovoltine silk and covers an area of about 5000 acres under its plantation. Strategically situated at Northern most extremity of India, the state of Jammu and Kashmir has twelve districts out of twenty two districts under sericulture leaving aside Kargil and Leh. Despite having received a serious set back, sericulture is practiced in 3,159 villages out of 6,758 villages in J&K, which account for 46.74 per cent of the total number of villages and industry continues to provide part time employment to 33,300 families (Kachroo and Kachroo, 2006). The state is having four distinct seasons with a suitable diverse agro- climatic conditions favourable for mulberry cultivation and bivoltine silk. The state houses two large silk factories in Srinagar and Jammu. Jammu and Kashmir state produce quality silk by rearing univoltine/bivoltine straws which fetches higher returns as compared to multivoline races. However, the major constraint with univoltine and bivoltine strains is that they lay kurodane eggs in spring (main rearing) season as results of which no second or third rearing takes place and the growth trend in production and yield of cocoon per mulberry tree had been -1.18 and -7.13 per cent per annum, respectively between the period 1974-75 to 2003-04 (Kachroo and Kachroo, 2006). These negative trends in production and yield means more risk and hence can be a discouraging factor for the producers to invest in this venture, which poses great concern for the policy makers and economists. It is essential to trap the potential yield in state of Jammu and Kashmir by applying and rearranging the existing level of input use. This would lead to enhancing economic efficiency of silk production. Inefficiencies in the use of various resources not only affect the productivities of crops but their cost and return structure and producer incentive as well. Technical inefficiency may be attributed to be one of the factors responsible for it, because changes in productivity occur due to changes in technology. Available evidence in the last few years reveal that technological package via efficient utilization of scarce resources which have alternative uses may accelerate the pace of silk production. In this regard, it is necessary to quantify current levels of technical efficiency so as to estimate losses in production that could be attributed to inefficiencies due to differences in socio-economic characteristics and management practices. So it also calls for a detailed examination of the farm efficiency in terms of technical efficiency for increasing productivity in a resource poor state like Jammu and Kashmir. The measurement of economic efficiency is not complete without a study of technical efficiency and it is the frontier production function that enables the measurement of technical efficiency of farmers (Battese and Coelli, 1995). Thus, the identification of the factors responsible for enhancing cocoon productivity, therefore, demands considerable attention. Apart from its manifold uses in terms of households and industries its production per unit input use per unit time and area needs to be increased. Thus, present study will examine various aspects of technical efficiency of cocoon production which ultimately leads to silk production in Bhaderwah block of district Doda (J&K), so that suitable policy option for enhancing silk production and productivity can be implicated. Keeping in view of this background, it was proposed to undertake this study with the following objectives (a) to examine the technical efficiency of silk via cocoon and (b) to identify the factors influencing technical efficiency in cocoon production.

RESOURCES AND METHODS

The present study was carried out in Bhaderwah block of Doda district. 50 cocoon producers were selected by using multistage sampling. For selection of sample three stages were adopted (a) selection of block (b) selection of villages and (c) selection of silkworm rearers. There are 36 villages beneficial in which seed distributed by the department of agriculture J&K State Govt. for Sericulture. Four villages namely Chinta, Balote, Manowaha and Sanai were selected randomly. The lists of all the silkworm rearers in selected villages were obtained from the block office of sericulture department. The list of silkworm rearers prepared and classified on the basis of silkworm seed distribution *viz.*, small, medium and large. Small groups having seed 15 g, medium size groups having seed 30 gms and large size groups having seed 45 g. The total silkworm rearers in the selected villages were 110. Out of which 50 rearers were selected randomly from the 4 villages.

Estimation of technical efficiency :

The stochastic frontier production function is widely used to estimate technical efficiency (Russel and Young, 1983). The stochastic frontier production is presented as:

$$Y_i = f(x_i, b_i) \exp(v_i - u_i)$$

where, Y_i - possible production level of the ith farm, f (x_i , b_i) is the suitable functional form of the vector of inputs (x_i) and vector of unknown parameters (b_i) e.g. Cobb – Douglas, CES or Translog.

v_i - distributed randomly and a symmetrical two sided error-term as v ~N (0, s_v^2), which captures the effects of random shocks outside the farmers control, *i.e.* observation and measurement error and other statistical noise. Thus, v allows the frontier to vary across farms, or over time for the same farm and therefore, the frontier is stochastic.

u_i - distributed half- normal one-sided error term as u ~ N (0, s_u^2) that captures deviations from the frontier due to inequality. Both u_i and v_i are independent of each other.

The technical efficiency of an individual farm is defined as the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used on farm.

Specification of the model :

The stochastic frontier production function was specified for the present study. Due to its advantage over the other functional forms, it is widely used for the estimation of technical efficiency as well as resource use efficiency in the frontier production studies (Hazarika and Suramanian, 1993).

The model will be used as:

$$\ln y_i = \beta_{i0} + \beta_{i1} \ln L + \beta_{i2} \ln F + \beta_{i3} \ln S + v_i - u_{i\,(i=1,2,.......,n)}$$

where,

Y_i= Yield of cocoon in the ith farm (q/ha)
L =Human labour use in cocoon production (man days/ ha)
F= Quantity of feed used
S= Quantity of seed used in g
v_i-u_i =Random error-term

Determinants of technical efficiency :

The technical efficiency of the i-th sample farm, denoted by TE_i is given by:

$$TE_i = \exp(-U_i) = Y_i / f(X_i \beta) \exp(V_i) = Y_i / Y_i^*$$

where,

Y_i* = f (X_i β) exp (V_i) is the farm specific stochastic frontier. If Y_i is equal to Yi* then TE_i =1, reflects 100 per cent efficiency. The difference between Y_i and Y_i* is embedded in U_i (Coelli and Battese, 1996). If U_i=0, implying that production lies on the stochastic frontier, the farm obtains its maximum attainable output given its level of input. If U_i>0, production lies below the frontier an indication of inefficiency.

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

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

where,

Y_i = is the production of the i-th farm (i=1, 2, 3------n), Xi is a (1x k) vector of functions of input quantities applied by the i-th farm; β is a (1x k) vector of unknown parameters to be estimated. V_is is random variables assumed to be independently. N(O,δ^2v) and independent of U_is are the non-negative random variables, associated with technical inefficiency in production assumed to be independently and identically distributed and truncations (at zero) of the normal distribution with mean $Z_i\delta$ and variance σ^2_u (/N (Zi δ , σ^2_u (/); Zi is a (1xm) vector of farm specific variables associated with technical inefficiency and δ is a (mx1) vector of unknown parameters to be estimated. In the process, the variance parameters σ^2_u and σ^2_v are expressed in terms of the parameterization :

$\sigma^2 = (\sigma^2_u + \sigma^2_v)$ and
$\gamma = (\sigma^2_u / \sigma^2_u + \sigma^2_v)$ or
$\gamma = \sigma^2_u / \sigma^2$

In the terms of its value and significance, γ is an important parameter in determining the existence of a stochastic frontier. The value of γ ranges between 0 and 1 with the values close to 1 indicating the random component of the inefficiency effects makes a significant contribution to the analysis of the production system. Similarly, γ = 1 implies that all the deviations from the frontier are entirely due to technical inefficiency.

It is proposed to identify the socio-economic factors influencing the technical efficiency at the farm level. MLE (Maximum likelihood estimators) estimates of technical efficiency will be regressed on rental value of per gross cropped area (Proxy for land quality), proportion of females in total agricultural workers in the family, proportion of children in the family, education dummy for the household having family adult member with education above primary level and farm size. As the technical efficiency variable varies between 0 and 1, the variable will be transformed into In [TE/ (1- TE)] so that the later transformed variable now varies between – ∞∞ ,which will facilitate estimation of the parameters by using the OLS technique.

The following linear regression model will be used to identify the socio-economic factors that condition technical efficiency of sample farms.

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

where,

TE_{ij} = Technical efficiency for ith crop on j-th farm,
β_0= Intercept/constant
β_i = Regression co-efficients,
X_1= Area under mulberry trees,

X_2 = Proportion of female workers in total workers in the family,

X_3 = Proportion of children in the family,

X_4 = Dummy for adult members/ having education above primary level and,

X_5 = Age of the head of the family

u_i = Error term.

OBSERVATIONS AND ANALYSIS

The experimental findings obtained from the present study have been discussed in following heads:

Estimates of OLS and frontier production function :

Sample of 50 farms were considered to estimate the technical efficiency. The dependent variable included in the model was out put of cocoon. The inputs included human labour, feed, seed, and area under mulberry trees. The estimate of λ was 1.143 and σ was 0.591, which were significantly different from zero indicating a good fit and the correctness of the distributional assumptions specified. The value of λ was more than one, implying the dominance of one sided component U_i in E_i and thus indicated high degree of technical inefficiency. In other words the inefficiency component was not dominated by the random factors. The variance ratio γ showed that the farm specific variability contributed more to the variation in yield, which means that variation in output from frontier is attributed to technical inefficiency. The value of γ was 0.767 (Table 1). This means that about 76 per cent of the differences between the observed and the maximum production frontier outputs were due to the factors, which were under farmer's control. The stochastic frontier analysis further showed that 76 per cent of the observed inefficiency was due to farmer's inefficiency in decision making and only 24 per cent of it was due to random factors outside their control.

Table 1 : Estimates of Cobb-Douglas and frontier functions

Variable	Cobb-Douglas Production function estimates(OLS)	Frontier production Function estimates (MLE)
Constant	4496.76(3.95)	5144.25 (3.39)
Labour	48.67 (.20)	76.26 (.32)
Feed	-4.07(.241)	-4.85 (.39)
Seed	56.818(3.39)*	69.43(1.14)**
Area	958.36 (1.06)**	1049.65 (1.35)**
		Variances
		σ^2_u = 0.69
		σ^2_v = 0 .21
		σ^2 = 0.90
		λ = 1.14
		σ = 0 .59
		γ = 0.76

* and ** Indicate significance of value at P=0.05 and 0.01, respectively

The estimates of the stochastic frontier show that the estimated values of the co-efficients of the seed and area were positive, therefore, seed and land were productive inputs for successive production of cocoon production. The estimated value of the co-efficient of feed was negative but significant indicating over use of the factors in producing the cocoon. Statistically significant and positive values of estimated co-efficients indicated that farmers could increase per hectare yield by implying more units of these inputs.

Distribution of cocoon rearers under different levels of technical efficiency :

Technical efficiency of sample farms :

The farm specific technical efficiencies were estimated and the frequency distribution is given in the Table 2 and Fig. 1. The mean technical efficiency was found 68.48 per cent. The maximum number of farms came under the category of 80-100 per cent technical efficiency.

Table 2 : Efficiency level and number of farms of cocoon rearers

Efficiency levels (%)	Number of farms	Per cent of total
Up to 40	18	36
40-80	11	22
80-100	21	42

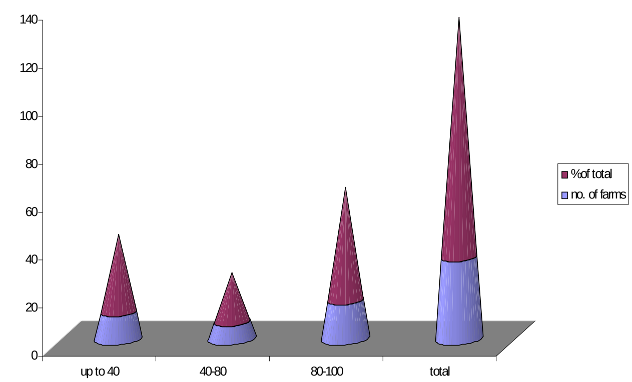

Fig. 1 : Different levels of technical efficiency

The study implied that the cocoon out put of the average farmer could be increased by 31.52 per cent by adopting proper technology by the rearers.

A linear regression model was used to identify the socio-economic factors that condition technical efficiency of sample farms (Table 3). Area has a positive influence on technical efficiency, the association between technical efficiency and area under mulberry is positive and highly significant *i.e.*, more area under mulberry is comparatively more efficient. This indicates that the farmers with more land under mulberry are technically efficient. Observations made on the study area show that the proportion of female workers in total agricultural workers in the family had a negative value of co-efficient but significant indicating that females are carrying out most of the activities on the farm and female headed household would have better opportunities to carry out frequent follow up and supervision of the farm activities on their plot, thus decrease technical inefficiency. The technical efficiency was not much influenced by the proportion of children in the family and dummy for adult members having education above primary level because they have not any significant co-efficient.

Table 3 : Technical efficiency

Variables	Co-efficient
Constant	67.99 (0.01)
Area	13.27*(3.94)
Edu	3.27 (0.008)
Female	-12.86*(3.91)
Child	-2.49 (0.005)
Age	-.0476 (0.00)

* Indicate significance value at P=0.05

The yield variability of cocoon was the highest in study area as well as in J&K state, which implies that the study has assumed importance in its attempt to decipher the various determinants of technical and its implications in the state. In this study, the technical efficiency of individual farms has been estimated using farm level data of cocoon production in Doda district of Jammu region. The mean technical efficiency has been found 68.48 per cent among the sample farms and across regions, which indicates that on average, the realized output can be raised by 31.52 per cent without any additional resources in the cocoon growing regions. Various socio-economic, biophysical and technological factors may be responsible for the observed difference in efficiency in the farms. The results showed that even under the existing technology, potentials exists for improving the productivity with proper allocation of the existing resources. Hence, proper extension strategies need to be taken to educate the estate owners about rational use of inputs. The technical efficiency of the cocoon producers in the study area of Jammu region can be improved by increasing the adoption level of the improved package of practices. This can be made possible by providing good quality of seeds and easy and cheap credit for the purchase of critical inputs like insecticides, plant protection chemicals etc. Except of this an assured market facility for their output through forward linkage with silk processing industries will indirectly reduce the price volatility in silk produce and increase the socio-economic status of these farmers.

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