Production structure and technical efficiency analysis of sericulture in Pakistani Punjab

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Production Structure and Technical Efficiency Analysis of Sericulture in Pakistani Punjab

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Abstract

The objectives of this paper are to study the sericulture production structure and the analysis of farm-level technical efficiency measures. The results show that most of the farmers involved in this enterprise are illiterate. This industry is further characterised by: inappropriate rearing sheds, complete lack of extension service, dependence on government forests for mulberry leaves – facing peak season shortage, supply of poor quality silkworm seed and improper processing and marketing facilities. Labour shares more than 70 percent of the total cost of production and, however, promises reasonably high return on investment. Stochastic production frontier analysis indicates that the sericulture enterprise faces increasing returns to scale. Average technical efficiency is found to be 0.88 with a minimum of 0.37 and a maximum of 0.98, leaving significant scope for improvement in productivity and thus profitability. The results further show that technical efficiency is positively associated with the size of the activity.

1.0 Introduction

Pakistan is basically an agricultural economy. It accounts for about 24 percent of the country's output, employs more than 50 percent of the total labour force and directly or indirectly supports about 75 percent of the population. Its contribution to the country's total foreign exchange earnings exceeds 70 percent (Pakistan, 1998). Presently there are about five million private farms in Pakistan: among those, about 50 percent have less than two hectares of land -- which is not an economical size and most of these farmers are even unable to earn their sustenance. Recent research results have shown that about one third of our rural population has been living under extreme poverty -- rural land-less communities are even more ill fated (Qureshi and Arif, 1999). The most striking concern is that the poverty index has increased over time. To deal with such a state of affairs, the farming community is practicing intensive and exhaustive agriculture, while the non-farming rural lot has nothing to endure against this rising destitution. There is no extra land to be put under cultivation, while the pressure on land

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continues to maximize output and employment for the fast growing population of the country. This plight calls for 'Integrated Agriculture' with livestock, poultry, forestry and cottage industry.

Among the cottage industries, sericulture is an important welfare-oriented village-based activity. One of the special features of this industry is that of the mulberry crop -- the sole source of silkworm feed -- can be grown under diverse environmental conditions by small and marginal farmers (Panda, 1995). Fortunately, Pakistan is a sub-tropical country and is suitable for growing mulberry and rearing silkworm (GUO, 1985).

Sericulture is a highly labour-intensive enterprise and has played a significant role in economic development of some of the now advanced nations, particularly Japan, in the early stages of modernisation (Otsuka, 1982). Due to high cost of labour input, Japan, China, Italy and France have diverted their resources from sericulture to electronics, transport, and heavy machinery industries. However, the silk production culture is getting popular in labour-abundant countries such as Vietnam, Thailand, some parts of China, India and Pakistan. Sabir (1997) argues that India and Pakistan among the Asian countries are in a better position to develop this sector. If adopted on modern lines backed by advanced technology and knowledge from countries such as Japan, China, Korea and Thailand etc, then this cottage industry could prove more remunerative than most of the cash crops (Hanumappa and Anatharaman, 1992).

As regards development of sericulture in Punjab, Pakistan, it was first introduced in Taxila locality in 1947. Subsequently, it expanded to forest localities where mulberry plantation was available in abundance to support sericulture farms. These forest localities are Changa-Manga, Daphor, Chichawatni, Kamalia, Khanewal, Bhagat, Kundian and Jauharabad, among others.

According to Sabir, in Punjab about 9000 households are engaged in this profession, about 18660 acres of land is under mulberry trees, and about 1053 acres of mulberry are as bush type plantation on government lands. Moreover, 225 acres of bush type mulberry is planted on private lands. As regards production of Sericulture, about 12500 packets are reared annually providing 375 metric tons of cocoons. On average, Pakistan does not produce more than 300 to 400 metric tons of raw silk annually, which is not enough to meet the domestic demand of the silk industry. An almost equal amount is being imported every year to meet the requirements of the silk industry.

The average yield of cocoons as this study indicates is 27 kg, which is considered very low as compared to the yields in Japan and Korea where production is more than 40 kg from the same quantity of seed. The productivity per packet of seed in the study area ranges from 9 kg to 45 kg. It is hypothesized that the main factor affecting this wide variation in yield is management efficiency, also called technical efficiency. The farm level technical efficiency measure carries immense importance in preparing development strategies. In cases where the most producing firms are found closer to the production frontier using the existing technology, then an increase in productivity requires the outward shift of the output frontier by applying new inputs and advanced technologies. On the other hand, if the farmers face significant inefficiencies, then productivity can easily be enhanced using the same resource base and technology more efficiently. What is needed is institutional and infrastructural development for better delivery of inputs, improvement in extension, education and farm management services, and execution of managerial skill development programmes.

The main objectives of the present study are to analyse the structure of sericulture farming and measure the farm-specific technical efficiencies. To our knowledge no study has yet been conducted analysing technical efficiency using Pakistani sericulture data.[4] The remaining paper is planned as follows. In section 2.0 we describe the methodological framework. Section 3.0 contains the results and Section 4.0 concludes the paper.

2.0 Methodological Framework

2.1 The data

Sericulture activity or silkworm rearing is spread over the large areas in the Punjab, especially around forest plantations. The present study is restricted to two localities, i.e., the Changa Manga and Chichawatni forests. These localities were selected on the basis of the concentration of sericulture activities. A list of sericulturists in and around the Changa-Manga and Chichawatni forests was obtained from the sericulture department of the Government of Punjab, Lahore. From each locality five villages were selected at random. From each village eight respondents were selected again at random. Consequently, 40 respondents were selected from each locality constituting 80 respondents in total. In order to get precise and detailed information, the personal interview method as a technique of data collection was adopted. A comprehensive interviewing schedule was designed, which was pre-tested in field conditions before starting the actual survey.

2.2 Measurement of technical efficiency and empirical model

Farrell (1957) was the first who introduced the concept of technical efficiency of a firm. He defined technical efficiency as the ratio of actual realised output to that of maximum achievable potential with the same quantities of inputs and technology. Farrell's original work was of a non-parametric type, which was later extended to parametric ones. These models could be divided into two groups – one deterministic, and the other, stochastic frontier. The former assumes that any deviation from the frontier is due to inefficiency, while the latter allows for statistical noise.

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4 The only exception is a study by Panda (1995) who used Indian sericulture data and analysed efficiency and productivity status by applying Ordinary Least-Squares procedure. Studies relating to sericulture enterprise of Pakistan include Jalal-ud-Din (1984), Siddique (1988) and Sabir (1997), who discussed the history, problems and future prospects of sericulture in Pakistan; and Namdar and Khan (1989), Ahmad and Khan (1993) focused their studies on cost and profitability analysis of sericulture farming.

The stochastic frontier approach was developed independently by Ainger, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The key advantage of this technique is that the error term in such models has two components – one is symmetric, capturing the effects of those factors which are not under the control of the firm and the other is one-sided, representing management inefficiency. Kalirajan (1981) proposed that the predicted technical inefficiency effects could be regressed on various observable explanatory variables involving farmer or farm-specific factors to examine the determinants of inefficiency: This two-step procedure has been used by various applied researchers. This procedure has been criticized on the ground that it violates one of the basic assumptions that of 'identically independently distributed technical inefficiency effects in the stochastic frontier' (Battese, Malik and Gill, 1996). Battese and Coelli (1993 and 1995) proposed a one-stage modelling approach in which the technical inefficiency effects are a function of various observable variables such as age, education, access to extension services etc.

The translog and the Cobb-Douglas forms of production functions are the most widely used in efficiency analysis of the agriculture sector. The translog is a flexible functional form, which does not require *a priori* restrictions on technology like constant returns to scale, Hicks' neutral technology, homogeneity, separability and constant elasticity of substitution. This functional form is a second-order Taylor series approximation requiring a large number of parameters to be estimated. Multicollinearity is often a problem while estimating the translog models. The problem of multicollinearity becomes more severe when a single equation production function is estimated and the present study is no exception.[5] Consequently, this study uses the Cobb-Douglas stochastic production frontier, which is written as

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(pack_i) + \beta_2 \ln(leav_i) + \beta_3 \ln(lab_i) + \beta_4(loc) + v_i - \mu_i \qquad (1)$$

Where:

i	indicates the i-th farmer in the sample;
Ln	is natural logarithm (i.e., logarithm to base e);
Y	represents the total output of cocoon for i-th farmer (in kg);
Pack	are the number of packets reared by the i-th farmer;
Leav	shows the total quantity of leaves used by the i-th farmer (in kg);
Lab	represents the amount of labour used by the i-th farmer (in man-days);
Loc	is dummy variable showing value of 1 if farmer belongs to Changa-Manga and 0 if belongs to Chichawatni;

[5] The translog production function was also estimated that resulted into various violations of regularity conditions. However, some of the empirical studies have shown that technical efficiency measures are unaffected by alternative functional forms (e.g., Ahmad and Bravo-Ureta, 1996).

β's are unknown parameters to be estimated;

v is a random variable which is assumed to be independent and identically distributed random error, having normal distribution with mean 0 and variance $\sigma^2 v$; and

μ is a non-negative random variable associated with the technical inefficiency of farmers assuming half normal distribution truncated at mean 0 and has a variance $\sigma^2 u$.

According to Battese and Coelli (1993), the technical inefficiency component μ_i is a function, i.e., $\mu_i = Z_i\delta + w_i$. Where Z_i is vector of explanatory variables, δ is a vector of unknown parameters to be estimated, and w_i is an unobservable random variable assuming truncated normal distribution with mean zero and variance σ^2, given that μ_i is non-negative (i.e., $w_i \geq . -Z_i\delta$). The model of technical inefficiency effects in our case is written as

$$\mu_i = \delta_0 + \delta_1 (loc) + \delta_2 (exp_i) + \delta_3 (edu_i) + w_i \quad (2)$$

Where:

Exp represents the experience of the i-th farmer in this occupation in years; and

edu indicates the number of years of formal education of the i-th farmer.

Given the specifications of the stochastic frontier and inefficiency models in Equations 1 and 2, technical efficiency measures for the i-th farm are estimated as $TE_i = \exp(-\mu_i)$. Various hypotheses are tested using generalised likelihood-ratio statistic, which is specified as

$$LR = -2[L(H_0) - L(H_1)] \quad (3)$$

Where $L(H_0)$ and $L(H_1)$ represent the values of the log likelihood functions under the null and alternate hypotheses, respectively. The LR test statistic has an asymptotic chi-square distribution with degrees of freedom equal to the difference between the number of parameters in the unrestricted and restricted models.

3.0 Results and Discussion

This section of the paper is divided into two subsections. The first summarizes the structure of sericulture production in Punjab, and the second explains the results of the frontier function analysis.

3.1 The structure of sericulture in Punjab

Education and Experience: The data show that about 58 percent of the sampled sericulture farmers to be illiterate. The remaining 42 percent are found to have some education ranging from one to 16 years of schooling. The average education of a sampled respondent is about four years of schooling. Experience, along with education, is very much essential for the sericulture profession, since it is a skilled-labour demanding activity from start to the end of the production process. About 30 percent of the farmers have 5-10 years of experience, 49 percent are in business for the last 11 to 20 years and about 21 percent have over 25 years of experience in sericulture farming. On average, a farmer is in this business for the last 17 years.

Type of Rearing Sheds: About 83 percent of the sampled farmers raise silkworms in buildings made of mud. The remaining 17 percent used brick-made buildings for rearing. Thus, most of the farmers are without proper rearing sheds, which could be the main source of low productivity in the area. The silkworms are very susceptible to various diseases and thus, require suitable rearing rooms to prevent entry of insects, etc. Besides, silkworms should be raised at a constant temperature and under good hygienic conditions for not only greater, but also, better quality production (Otsuka, 1982).

Technical Information: The survey indicated that there is virtually no technical guidance available to the farmers. Out of 80 sampled farmers, only one has a contact with the extension agent of the Sericulture Department, Government of Punjab. That is why almost all of the farmers are unaware of new techniques of production and are thus facing low productivity.

Sources of Seed and Leaves: The main source of silkworm seed is the Sericulture Department of the Government of Punjab. More than 90 percent of the farmers get silkworm seed from this source, while the others obtain from private dealers. As regards the quality of seed, about 90 percent of the farmers claimed that the seeds provided by all these sources is of extremely very poor quality and, thus, having a very low hatching percentage.

About 94 percent of the sampled sericulturists purchase mulberry leaves from the government forests. The other six percent of the farmers got mulberry leaves from private sources, as well as from government forest resources. Being a single source of mulberry leaves, it creates various problems for the farmers such as, shortage of leaves, when these are most needed as reported by about 68 percent of the respondents; and non-availability of leave permits was reported by 10 percent of the farmers.

Sericulture as Occupation and Labour Use: Sericulture is still being considered as a secondary occupation in Pakistan. Only two percent of the sampled farmers have been practicing it as their sole occupation. About 28 percent are ordinary labourers engaged in this occupation to supplement their income. About 26 percent are the ordinary farmers growing crops and raising livestock, 27 percent are either government or private sector employees and the rest are shopkeepers/traders and students having sericulture farming activity as a side business. Most of the sericulture farming is family based: about 55 percent of the farmers rely on family labour only, and the remaining 45 percent use hired labour in addition to their own family labour. The use of hired labour is found to be positively associated with the size of the activity.

Cost Structure: The cost comparison of the surveyed localities indicates that the production cost per kg of output is higher in Chichawatni as compared with Changa-Manga, mainly because of low productivity. The labour input dominated by sharing about 70 percent of the total variable cost incurred in the production of cocoons in both the localities. The second major input item is silkworm seed costing about 10 to 12 percent of the total. The third major variable cost item is that of mulberry leaves sharing about seven percent of the total. The remaining costs were incurred on other miscellaneous items.

Profitability of the Sericulture Business: Per packet production of cocoons is greater in Changa-Manga as compared to that of in Chichawatni (Table-1). Average income per kg of cocoons is Rs. 27.33 in Chichawatni, while it is Rs. 35.91 per kg in Changa-Manga. Moreover, the average rate of net returns per rupee of investment is higher in Changa-Manga, i.e., Rs. 0.56 as compared to Chichawatni where it is only Rs. 0.38.

Table-1: Production per Packet of Seed, Average Income per Kilogram of Cocoon Produced

Locality	*Prod. (kg)*	*Price/ kg (Rs)*	*G.incom (Rs)*	*Cost (Rs)*	*N.incom Rs (Rs)*	*N.incomper Kg (Rs)*	*Rate of Return*
Chichawanti	24	100	2400	1743.88	656.12	27.33	0.38
Changa Manga	31.50	100	3150	2018.74	1131.26	35.91	0.56

The results given in Table-2 show that the cost of production per packet declines as the size of the activity increases, while the net returns are positively associated with the size. Moreover, rate of returns per rupee of investment also improves with the increase in the size of the enterprise.

Thus it appears that the sericulture is a very profitable business. It could further prosper on a larger scale if supported by a better marketing system. About 64 percent of the respondents are not satisfied with existing marketing facilities and the prices paid for cocoons.

Table-2: Average Profit Per Packet of Cocoon Production by the Size of Activity

Packet(No)	*TC production (RS)*	*Prod/pack (Kg)*	*Price per packet (kg)*	*Gr. Income per packet (Rs)*	*Profit per packet (Rs)*	*Rate of Return*
Chichawatni						
1	2078.94	22.00	100	2200.00	121	0.06
2	1668.60	23.00	100	2300.00	631	0.38
3	1564.58	35.66	100	3566.00	2001	1.28
Changa Manga						
1	2648.45	21.00	100	2100.00	-548	-0.21
2	2347.88	30.00	100	3000.00	652	0.28
3	1691.19	30.47	100	3047.73	1357	0.80
4	1642.10	32.43	100	3243.00	1601	0.97

3.2 Technical Efficiency Analysis

Three versions of the Cobb-Douglas stochastic frontier production function given in Equations 1 and 2 were estimated using the computer programme "FRONTIER 4.1" written by Tim Coelli of the University of New England, Armidale, Australia. The results are reported in Table-3. The first, Mod I, is the unrestricted model specified in Equation 1. In this model the location variable is used both in the production frontier and a factor affecting the inefficiency term. The sign of the location variable in frontier is found to be negative and statistically non-significant. This indicates that there is no productivity differential between two localities. To test its significant contribution, the Likelihood Ratio (LR) test is also used (Equation 3). The null hypothesis, i.e. H_0: $\beta_4=0$, that there is no contribution of the location variable in frontier cannot be rejected (Table 4).

Based on the LR test, the second model, Mod II, is estimated excluding the location variable from the frontier and the results are reported in Column 3 of Table-3. Given that Mod II is now the preferred model, the presence of the inefficiency effect was tested by assuming the null hypothesis 'H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$'. This means that the variance of the inefficiency term, i.e., σ^2_u is equal to zero. This implies that technical inefficiency effects are absent from the model. These restrictions suggest that the stochastic frontier production function defined by Equations 1 and 2 does not differ from a traditional average production function. The results given in Table 4 show that this null hypothesis is rejected by the data.

Table-3: Maximum Likelihood Estimates of the Cobb-Douglas Stochastic Frontier Production Models

Variable	*Parameter*	*Mod I*	*Mod II*	*Mod III*
Stochastic Frontier Model				
Constant	β_0	0.289***	0.285***	0.288***
		(0.037)	(0.031)	(0.032)
Packets	β_1	0.3128***	0.318***	0.321***
		(0.48)	(0.051)	(0.048)
Leaves	B_2	0.765***	0.754***	0.756***
		(0.054)	(0.047)	(0.044)
Labour	β_3	0.00024	.0049	0.0009
		(0.066)	(0.051)	(0.059)
Location	β_4	-0.0139	--	--
		(0.0222)		
Inefficiency Model				
Constant	δ_0	0.128	0.0093	0.162*
		(0.280)	(0.280)	(0.160)
Location	δ_1	-2.55**	-2.68*	-2.51**
		(1.11)	(1.66)	(0.620)
Experience	δ_2	-0.0566**	-0.052*	-0.059**
		(0.025)	(0.034)	(0.028)
Education	δ_3	0.006	0.003	--
		(0.140)	(0.012)	
	σ^2_s	0.260**	0.269*	0.261**
		(0.110)	(0.160)	(0.110)
	γ	0.996***	0.996***	0.997***
		(0.003)	(0.003)	(0.003)
Log Likelihood Function		68.51	68.23	68.19

***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table-4: Results of the Generalised Likelihood Ratio Tests

Hypotheses	*Log Lik. Function*	*Test Statistics*	*Critical value*	*Decision*
General Model – Mod I	68.51			
H_0: β_4=0	68.23	0.56	3.84	Do not reject H_o
General Model – Mod II	68.23			
H_0: $\gamma_0=\delta_0=\delta_1=\delta_2=\delta_3=0$	33.44	69.58	11.07	Reject H_0
H_0: $\delta_1=\delta_2=\delta_3=0$	59.79	16.88	7.81	Reject H_0
H_0:$=\delta_3=0$	68.19	0.08	3.84	Do not reject H_0

The second null hypothesis tested in Mod II is that of H_0: $\delta_1 = \delta_2 = \delta_3 = 0$, which specifies that the explanatory variables present in the technical inefficiency model have zero coefficients. This null hypothesis is again rejected.

The parameter estimate of the education variable in the inefficiency model has a positive sign showing that technical inefficiency increases as the manager has a greater number of years of schooling. This is an unexpected outcome and could be the result of high collinearity between experience and education – the correlation coefficient comes out to be very high (i.e., 0.60), given the cross-sectional nature of the data. To resolve the issue whether the education variable has any significant independent influence in explaining technical inefficiency, the LR-test is again performed. The null hypothesis, H_0: $\delta_3 = 0$ – that education or years of schooling has no influence on technical inefficiency, cannot be rejected.

Given the above statistical test result, the education variable was excluded from the inefficiency model. Finally, Mod III is considered to be the most preferred model for further analysis. The results of this model are given in the last column of Table 3. The signs of the parameter estimates are as expected. The sigma-square is found to be statistically significant at the 5 percent level pointing to the existence of firm level technical inefficiencies. The estimate of γ is found to be 0.997. This implies that the firms' productivity differentials mainly relate to variance in management. The high magnitude of γ suggests that the stochastic frontier production function does not significantly differ from the deterministic production frontier. This result is similar to that of the finding of a study by Ngwenya, Battese and Flemming (1997).

The estimated production elasticity coefficient for packets for the most preferred model is 0.32 and is significant at the one percent probability level. This implies that a 10 percent increase in the number of rearing seed packets results in a 3.2 percent increase in the production of cocoons. The coefficient of leaves variable is significant at the one percent probability level and is equal to 0.76 showing a 7.6 percent increase in cocoon production with a 10 percent increase in the use of leaves. The estimated coefficient for labour is 0.0009, which is not only small in magnitude but also statistically not significant at any reasonable probability level.

The sum of all production elasticities, which is called the Function Coefficient (FC) is equal to 1.08 and the corresponding estimated standard error [Se(FC)] is equal to 0.045. The Se(FC) is computed as

$$Se(E) = \sqrt{Var(\beta_1) + Var(\beta_2) + Var(\beta_3) + 2Cov(\beta_1\beta_2) + 2Cov(\beta_1\beta_3) + 2Cov(\beta_2\beta_3)}$$

The hypothesis of constant returns to scale (H_0: FC = 1, H_1: FC>1) is tested using t-statistic. The null hypothesis, H_0: FC = 1, is rejected implying that there exists increasing returns to scale in sericulture farming. The magnitude of the FC implies that the production of cocoons increases by about 11 percent by increasing all inputs by 10 percent.

The signs of the explanatory variables for the technical inefficiency effects are as expected. The estimated coefficient for location is negative, which indicates that Changa-Manga farmers are technically more efficient than the farmers in Chichawatni. The parameter estimate of the experience variable is negative in sign implying greater years of experience with better education tends to reduce technical inefficiency. Performing the same task over and over again leaves lesser chances of error. Moreover, the previous management mistakes and flaws are usually covered up during the next production period (Kalirajan, 1981).

The distribution of technical efficiency over the sample given in Table 5 shows that about 83 percent of the farmers have a technical efficiency of 81 percent or higher. The remaining 17 percent of the farmers show a technical efficiency of less than 80 percent. Table 5 further indicates that farmers rearing four packets are more efficient than the farmers rearing three, two or one packet of seed – showing a positive association between size of the enterprise and technical efficiency.

Table-5: Technical Efficiency Index

Sample Distribution of Tech. Efficiency		*Technical Efficiency By Size of Activity*	
Range of TE	*% of Farmers*	*# of Packets*	*Technical Eff.*
Less than 70	7.50	1	0.773
71-80	10.00	2	0.884
81-90	23.75	3	0.932
91-100	58.75	4	0.945

Source: Appendix A.

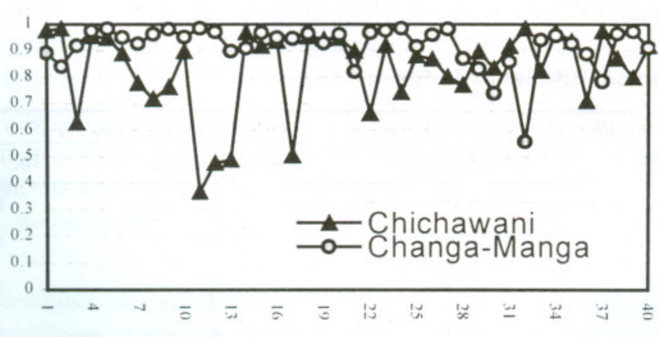
The results given in Table 6 show a wide variation in the levels of technical efficiencies. On average, farmers are 88 percent technically efficient with a minimum of 37 percent and a maximum of 98 percent. This result leaves considerable scope for improving technical efficiency and thus productivity, by using the same level of resources. The measures of technical efficiency further show that the farmers in Changa-Manga are technically more efficient with a mean of 0.92 -- varying from 0.56 to 0.98 and standard deviation of 0.08 -- than the farmers in Chichawatni having an average of 0.83 -- extending from 0.37 to 0.98 and standard deviation of 0.16. Figure 1 displays a very clear difference in variations of technical efficiency measures in both of these localities. The lesser variation in Changa-Manga could be attributable to better marketing and other facilities like availability of reeling machines. The data further show that the Changa-Manga farmers have a greater number of years experience than the farmers of Chichawatni. Above all, Mulberry leaves are easily available in Changa-Manga in the peak season as compared with its availability in Chichawatni.

Table-6: Statistics of Technical Efficiency Measures

	Chichawatni	*Changa-Manga*	*Sample Average*
Mean	0.83	0.92	0.88
Minimum	0.37	0.56	0.37
Maximum	0.98	0.98	0.98
S.Deviation	0.16	0.08	0.13

Source: Appendix A.

Figure 1. Showing Technical Efficiency Indices



Source: Appendix A.

4.0 Concluding Remarks

The present research is aimed at studying the structure of the sericulture enterprise as well as undertaking a technical efficiency analysis of this type of farming in the Punjab province. The results of the study show that about 58 percent of the farmers are illiterate. On average, a sericulturist is in business for the last 17 years - farmers in Changa-Manga have more experience than that of in Chichawatni. About 80 percent of the farmers were without proper rearing places.

As regards the cost of production, labour shares the main portion of total cost of production that is about 70 percent both in Chichawatni and Changa-Manga. However, the hiring of labour increases as the size of activity increases. Moreover, there is an inverse relationship between the size of activity and the average cost of production. The cost of production per packet is found to be higher in Chichawatni than in Changa-Manga mainly due to lower yield in the former -- average production per packet in Changa-Manga is about 32 kg and in Chichawatni is 24 kg. The results also show that the production of cocoons per packet of seed is positively associated with the size of activity. Moreover, the net rate of returns per rupee of investment is higher in Changa-Manga (Rs 0.56) than that in Chichawatni (Rs. 0.38).

The production frontier analysis shows the existence of increasing returns to scale in sericulture enterprise. The results of the technical inefficiency model show that the farmers of Changa-Manga are technically more efficient than those located in Chichawatni, mainly due to having better access to input and output markets in the former. Experienced and educated farmers tend to have lower levels of technical inefficiency. The average technical efficiency is found to be 0.88 with a minimum of 0.37 and a maximum of 0.98. The results further show that technical efficiencies of the larger-scale farmers are higher than that of the farmers with small sized activity.

The major problems reported by the farmers relate to: low quality seed, non-availability of leaves at peak season, low price of cocoon, sub-standard marketing facilities along with cocoon diseases. In order to popularise the sericulture industry in Pakistan, these problems have to be taken care of. For this cottage industry to be viable and more productive, some other measures are also suggested, including:

- provision of local cocoon drying facilities,
- exclusive development in the source of mulberry foliage for silkworm – presently leaves are available only in the autumn season making silkworm rearing impossible in spring, which could be done encouraging area under bush type mulberry plants at the farm lands,
- the existing sericulture extension directorates should be made more effective and accountable,

- co-operatives should be encouraged for marketing of output and inputs, building of incubation centres and rearing places equipped with temperature and humidity controlled devices, and
- pilot projects relating to sericulture with community participation and involvement of local and foreign experts should be started in areas having silk production potential – such type of projects are in operation in some parts of China and Vietnam and proved very successful, see Yoshida (1997).

Appendix A

Predicted Technical Efficiencies of Sample Farmers

Farm No.	*Chichawatani*	*Changa-Manga*
1	0.977	0.893
2	0.984	0.839
3	0.630	0.919
4	0.955	0.975
5	0.948	0.984
6	0.889	0.951
7	0.778	0.927
8	0.718	0.963
9	0.763	0.981
10	0.898	0.952
11	0.368	0.985
12	0.477	0.970
13	0.489	0.899
14	0.970	0.910
15	0.917	0.968
16	0.938	0.949
17	0.504	0.947
18	0.954	0.966
19	0.945	0.929
20	0.948	0.962
21	0.899	0.821
22	0.663	0.969
23	0.921	0.977
24	0.742	0.985
25	0.882	0.915
26	0.869	0.959
27	0.802	0.982
28	0.771	0.870
29	0.896	0.832
30	0.835	0.740
31	0.917	0.860
32	0.984	0.557
33	0.824	0.942
34	0.972	0.958
35	0.937	0.927
36	0.710	0.888
37	0.974	0.785
38	0.870	0.965
39	0.800	0.973
40	0.918	0.913

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