

Technical efficiency of dairy farmers in Tamil Nadu- an application of stochastic frontier production function

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ABSTRACT

The study was undertaken in Coimbatore and Tiruppur districts of Tamil Nadu state of India with the objective of estimating technical efficiency in milk production with respect to different milch animals. The primary data on socio-economic characteristics of milk production, expenditure incurred on feeds and fodder, imputed labour wage of family members, miscellaneous expenses and procurement price were collected from 180 milk producers from the study area. Stochastic frontier production function analysis was used to estimate the technical efficiency in milk production. The mean technical efficiency in milk production was estimated to be 86.32 per cent for crossbred, 77.41 per cent for local cows and 84.49 per cent for buffalos. The education level of famers had the positive impact on returns from milk production of crossbred cows while age negatively and significantly influenced the technical efficiency in crossbred and local cow farms; land holding size had the negative and significant influence. In case of the herd size it was found that the estimates for local cows were negative and significant.

Keywords: Milk production; technical efficiency; stochastic frontier function

INTRODUCTION

Animal husbandry and dairying play an important role in socio-economic development of the farming community in India. The Indian dairy sector gained substantial growth momentum from ninth plan onwards as a sequel of which the country had the pride of being world's largest milk producing nation registering an annual output of about 137.70 million tonnes of milk with the annual growth rate of 3.97

per cent during the year 2013-14 (Anon 2015). This growth is largely steered by the increased animal number rather than rise in productivity per animal. There has been only marginal improvement in the productivity of indigenous cows, crossbreds or buffaloes over the last two decades in India. The average daily milk production data stood at 6.52 kg for crossbreds, 2.10 kg for indigenous cattle and 4.44 kg for buffaloes in India suggesting that the productivity of these animals is far

below their genetic potential (Garg 2012). Low productivity of animals with higher genetic potential can be primarily attributed to the imbalanced and inadequate feeding.

Technical efficiency is a comparative measure of productivity and states as to how much gain in milk output could be realized without changing the level of input (efficiency parameter). It measures performance of a producer vis a vis peer group and it is considered to be one of the important factors of productivity growth. Estimation of the extent of inefficiency can also help in deciding how to raise dairy farm productivity whether by improving the farm efficiency or developing new technologies itself (Ali and Chaudhry 1990).

Literature holds strong evidence that farmers in developing countries fail to exploit full potential of a technology and make allocative errors. Thus increasing the efficiency in production assumes greater significance in attaining potential output at the farm level. Although some studies are available on analysis of technical efficiency in dairy farm production in the Indian context (Saravanakumar and Jain 2008, Bardhan and Sharma 2013, Al-Sharafat 2013) recent studies on efficiency in milk production in Tamil Nadu are hardly on surface. Thus the dairy farm households were evaluated in terms of efficiency of milk production using stochastic frontier production methods. Also analysis of factors causing (in) efficiency offers crucial insights into key variables that

might be worthy of consideration in policy making in order to ensure optimal capital and resource utilization.

METHODOLOGY

The study was carried out in Coimbatore and Tiruppur districts of Tamil Nadu which happen to be the progressive districts in dairy development in the state. Two Taluks from each district were randomly selected and three villages from each Taluk were drawn. From each selected village 15 milk producers were randomly selected for the detailed study. A total sample of 180 milk producers was selected for studying the technical efficiency of milk production and the determinants of it. The primary data on socio-economic characteristics and pertaining to milk production and quantity and price of feeds and fodders fed to individual animal, labour utilization pattern, miscellaneous expenses, quantity of milk produced and price realized were collected during 2014.

In order to provide a satisfactory measure of technical efficiency, Farrell (1957) gave the concept of production frontier which defines the maximization of physical production with given level of resources. But this deterministic framework did not include the statistical noise and other distributional assumptions. Aigner et al (1977) and Meeusen and van den Broeck (1977) independently proposed 'composed error' model ie the error term is composed of two

independent elements ($\varepsilon = v + u$) and its distributional assumptions were popularly known as stochastic frontier production function approach. The objective of the present work was to estimate the efficiency of farm household using an output-oriented

measure with respect to milk production for crossbred, local cow and buffalo.

The general production function (Battese and Coelli 1995) with inefficiency effects used in this study are defined as:

$$Y_i = f(x_i; \beta) \exp(v_i - u_i) \quad i = 1, 2, 3, \dots, n \quad (1)$$

where Y_i denotes the output quantity of the i^{th} farm, x_i is a $(1 \times J)$ vector of input quantities and β is a $(J \times 1)$ vector of unknown parameters to be estimated. The v_i are two-sided random variables associated with measurement errors in output and other noise in the data which are beyond the control of firms. v_i are assumed to be independently and identically

distributed $N(0, \sigma_{v_2})$ and independent of u_i . In the absence of stochastic term u_i , the model in equation (1) reduces to purely deterministic (mean) production function. The u_i are defined as non-negative random variables which account for technical inefficiency effects in production and are independently distributed as truncations at zero of the $N(\mu_i, \sigma_{u_2})$ distribution where:

$$\mu_i = \delta_0 + \sum_{k=1}^K \delta_k z_{ik} + \omega_i \quad (2)$$

Here z_i is a $(1 \times K)$ vector of farm characteristics that affects efficiency and δ is a $(K \times 1)$ vector of parameters to be estimated. The ω_i 's are random variables generally defined by the normal distribution with zero mean and variance

σ^2 , with point of truncation as $\omega_i - \delta z_i$. Maximum likelihood estimation (MLE) methods were used to estimate the stochastic frontier. For the likelihood function the variance terms are parameterized as:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \text{ and } \gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2), \text{ with } 0 \leq \gamma \leq 1 \text{ (Battese and Coelli 1995)}$$

The technical inefficiency for the i^{th} firm is estimated as the expectation of u_i

conditional on the observed value ($v_i - u_i$):

$$TE_i = E[\exp(-u_i) | v_i - u_i] = E[\exp(-\delta_0 - \sum_{k=1}^K \delta_k z_{ik} - \omega_i | v_i - u_i)]$$

Cobb-Douglas production function was employed to study the technical efficiency among milk

producing farmers across the animal breeds which is of the following form:

$$\ln Y = \ln \beta_0 + \sum_{i=1}^5 \beta_i \ln X_i + v_i - u_i$$

where Y= Value of milk production (Rs/day/animal), X_2 = Cost of green fodder (Rs/day/animal), X_3 = Cost of dry fodder (Rs/day/animal), X_4 = Cost of labour (Rs/day/animal), X_5 = Veterinary and miscellaneous cost (Rs/day/animal), v_i = Measurement error, weather, breed etc, u_i = Technical inefficiencies, β 's= Parameters to be estimated.

In order to understand and estimate the determinants of technical efficiency of milk production for crossbreds, local cows and buffaloes, farm specific technical efficiency scores were regressed on the farm specific characteristics by using OLS technique which is of the following form:

$$TE = \theta_0 + \sum_{i=1}^4 \theta_i F_i + \varepsilon_i$$

where TE= Farm specific technical efficiency scores, F_1 = Education (years), F_2 = Age (years), F_3 = Land holding size (ha), F_4 = Herd size (SAU), θ 's= Parameters to be estimated, ε_i = Random error

RESULTS and DISCUSSION

Socio-economic profile of respondent households

Among 180 dairy farming households, majority of farmers were from marginal and small category. The average operational land holding of the sample households in the study area was 1.79 ha. About 77 per cent of the sample

households had male as head of the family and further it was observed that dairy farmers with graduation were very few. Agriculture was the main occupation for 49.44 per cent of households and dairy farming was the subsidiary occupation for 53.33 per cent of the sample households. Crossbred formed larger percentage in the total herd size (around 60%). Average herd size of crossbred was 3.07 whereas it was 1.17 of local cow and 0.80 of buffalo.

Estimates of frontier milk production function of crossbred cows

Technical efficiency estimates were generated for 180 crossbred rearing dairy farms in Coimbatore and Tiruppur districts

of Tamil Nadu and are presented in Table 1. It could be observed that cost of concentrates and green fodder had positive influence and were statistically significant at 0.001 level showing direct influence on the value of crossbred milk production. This implies that one per cent increase in feed intake of concentrate and green fodder would increase the value of milk production by 0.2112 and 0.2283 per cent for each of these variables respectively. Similarly Sarvanakumar and Jain (2008) found that the green fodder and concentrate were the dominant factors in determining the milk output from crossbred in Tamil Nadu.

Al-Sharafat (2013) in his study reported that herd size, feed intake and value of veterinary services coefficients had positive signs and were statistically significant at 0.01 level showing direct relationship with milk production in Jordan. Contrary to that the coefficient of veterinary and miscellaneous cost had negative sign and statistically significant at 0.001 level showing perverse relationship with the value of milk production. The coefficients of remaining variables like cost of dry fodder and cost of labour were positive but did not significantly influence the value of milk production from crossbred cows.

The value of the estimate of log likelihood ratio 115.17 which followed chi-square distribution indicated goodness of fit of the model. The variance parameters σ^2 and γ were positive and significant at

0.001 level showing that the farm specific variability contributed more to the variation in the milk yield among the crossbred sample households which implied that the total variation in milk production from the frontier was attributable to technical inefficiency. A value of 0.9317 for γ suggested that about 93 per cent of the differences in farmers' milk production level were related to farm specific technical efficiency and the remaining differences were due to random error. The results of estimates of technical efficiency were comparable with the findings of Kumar and Singh (2004) and Sharif (2014).

Estimates of frontier milk production function of local cows

Table 1 shows the estimates of technical efficiency of milk production from 37 local cow dairy farms in the study area and it was found that the explanatory variables like the cost of green fodder and dry fodder were positive and statistically significant at 0.001 level. One per cent increase in the expenditure on green fodder and dry fodder would increase the returns from local cow's milk production by 0.51 per cent and 0.19 per cent respectively. The coefficient of cost of labour was negative sign and significant at 0.001 level inferring that on one per cent increase in labour hours would decrease the milk output by 0.1 per cent. The local cows were sent for grazing and amounted to high imputed (family) labour hours than for crossbred cows. Hence the over utilization of labour

Table 1. Maximum likelihood estimates of the Cobb-Douglas production function for milch animals

Variable	Crossbred cows				Local cows				Buffalos			
	Coefficient	SE	t-ratio		Coefficient	SE	t-ratio		Coefficient	SE		t-ratio
Constant	4.0132	0.1985	20.2132		2.04	0.21	9.73		1.8360	0.2052		8.9485
Cost of concentrate (Rs/day/animal)	0.2112	0.0400	5.2795*		0.22	0.11	1.93		0.6213	0.0669		9.2842*
Cost of green fodder (Rs/day/animal)	0.2283	0.0292	7.8202*		0.51	0.06	8.08*		0.0258	0.0976		0.2649
Cost of dry fodder (Rs/day/animal)	0.0822	0.0463	1.7743		0.19	0.03	6.75*		0.3089	0.0513		6.0169*
Cost of labour (Rs/day/animal)	0.0724	0.0383	1.8911		-0.10	0.01	-10.64*		-0.0400	0.0381		-1.0499
Veterinary and miscellaneous costs (Rs/day/animal)	-0.1712	0.0393	-4.3547*		-0.06	0.04	-1.50		-0.0703	0.0316		-2.2291*
σ^2	0.0692	0.0229	3.0287*		0.03	0.00	7.14*		0.0016	0.0004		4.0655
Γ	0.9317	0.0384	24.2628*		0.98	0.01	142.81*		1.0000	1.5849		0.6310

*Significant at 0.001 level

Log likelihood function	Crossbred cows		Local cows		Buffaloss	
	115.17		25.83		59.79	

resources led to negative impact on milk output of local cow. The coefficient of veterinary and miscellaneous expenses was negative but statistically insignificant.

The estimates of log-likelihood function (25.83) followed chi-square distribution indicating goodness of fit of the model. The variance parameters σ^2 and γ were positive and significant at 0.001 level showing that the farm specific variability contributed more to the variation in the milk yield among the local cow sample households. The value of gamma (γ) was 0.98 implying that 98 per cent of the differences in the milk output of local cow farms were due to farm specific technical efficiency and the remaining two per cent differences were due to random errors. The results of estimates of technical efficiency were in conformity with the results of Kumar and Singh (2004) and Sharif (2014).

Estimates of frontier milk production function of buffaloes

A perusal of Table 1 reveals that the variables namely concentrates and dry fodder were statistically significant while remaining variables green fodder and labour were not significant in the milk production from buffaloes. A one per cent increase in value of concentrate and dry fodder would increase the milk output by 0.6213 and 0.3089 per cent respectively indicating the importance in milk production. The coefficient of veterinary and miscellaneous expenses was negative but statistically

significant implying that one per cent increase in the cost of veterinary expenses would decrease the value of milk output in buffalo farms.

The value of the estimate of log likelihood ratio (59.79) which followed chi-square distribution was indicating goodness of fit of the model. The variance parameter σ^2 was positive and significant at 0.001 level showing that the farm specific variability contributed more to the variation in the milk yield among the buffalo sample households. A value of 1.00 for γ suggested that about cent per cent of the differences in farmers' milk production level were related to farm specific technical efficiency. The results of estimates of technical efficiency were akin to the findings of Sarvanakumar and Jain (2008) and Sharif (2014).

Distribution of technical efficiency of milk production

The farm specific technical efficiency (TE) was estimated for all the three categories of milch animals and the distribution of technical efficiency scores for the sample dairy farmers of the study area are presented in Table 2.

Crossbred cows

The Table 2 shows majority (48%) of the farmers were technically efficient with more than 90 per cent TE. Around 23 per cent of farmers were with TE of less than 80 per cent and 29 per cent of the farmers were technically efficient with 81-90 per cent TE.

Table 2. Frequency distribution and descriptive statistics of technical efficiency of different breeds

Technical efficiency (%)	Crossbred cows	Local cows	Buffalos
41 to 50	-	2.70	-
51 to 60	6.11	8.11	-
61 to 70	7.78	29.73	-
71 to 80	8.89	13.51	18.18
81 to 90	28.89	27.03	78.79
> 90	48.33	18.92	3.03
# observations	180	37	33
Mean technical efficiency	86.32	77.41	84.49
Minimum	51.08	48.40	77.19
Maximum	97.90	99.99	94.37

Productivity enhancement in crossbred cows is one of the most important goals of Indian dairying (Saravanakumar and Jain 2008). Based on the technical efficiency of the most efficient farm the average potential to increase milk production of the crossbred cows was determined using the formula:

Potential for increasing milk production per milch animal =

$$\left[1 - \frac{\text{Mean TE}}{\text{Maximum TE}} \right] \times 100$$

The average potential for increasing milk production through technical efficiency improvement in the case of crossbred cow dairy farmers was 12 per cent which implied that if average farmer in the sample was to achieve the technical efficiency level of its most efficiency counterpart then average farmer would be able to increase his milk

output by 12 per cent. A similar calculation for the least technically efficient farmer revealed an increase in milk output by $[1 - (51.80/97.90)] \times 100 = 47$, ie 47 per cent. The results of estimates of technical efficiency were comparable with the reported results of Al-Sharafat (2013) and Sharif (2014).

Local cows

Table 2 further reveals that the estimated technical efficiency of local cow ranged from 48.40 to 99.99 per cent with a mean technical efficiency of 77.41 per cent indicating that on an average the sample dairy farms in the study area tended to realize approximately 77 per cent of the technical potentialities. This implied that approximately 23 per cent of technical abilities were not realized in the production of milk from local cow. Only 19 per cent of the farms achieved more than 90 per cent of their output potential and remaining

81 per cent of the farms lost more than 10 per cent of their output under the existing resources and technology.

Based on the technical efficiency of the most local cows the average potential to increase milk production was determined by the formula $[1 - (77.41/99.99)] \times 100 = 23$, ie 23 per cent. This suggested that if the average farmer in the sample was to achieve a technical efficiency level of its most efficient counterpart then the average farm can increase its milk production by 23 per cent. Likewise the least efficient farm would be able to increase the milk production by 52 per cent by following the practices of most efficient farm in the sample. The results of estimates of technical efficiency are in conformity with the study of Al-Sharafat (2013) and Sharif (2014).

Buffalos

The estimates of technical efficiency of farms ranged from 77.19 to 94.37 per cent with an average of 84.49 per cent indicating that on an average the sample buffalo dairy farms in the selected study area tended to realize only 85 per cent of the technical abilities. It means that 15 per cent of technical potentialities were not realized by farmers approximately. The result found that only 3 per cent of the farms were technically efficient with more than 90 per cent and majority (79 per cent) of the farms fell under the technical efficiency in between 81 to 90

per cent. No farm was found to be below 70 per cent technical efficient in the study area. The average potential to increase buffalo milk production was found to be 11 per cent by using the formula. Following similar calculation 18 per cent of the milk production could be increased by least technically efficient farmer with the available level of inputs. The results of estimates of technical efficiency were comparable with findings of Saravanakumar and Jain (2008), Al-Sharafat (2013) and Sharif (2014).

Analysis of determinants of technical efficiency

Table 3 shows the determinants which were associated with technical efficiency in case of sample dairy farmers. The regression was analyzed with the technical efficiency of individual farmer as dependent variable and the main four factors like education, age, land holding size and livestock inventory as dependent variables.

From the data it is found that one per cent increase in the education level will lead to an increase of almost 0.02 per cent in technical efficiency of crossbred farms whereas it was negative and not significant in local cow and positive in the case of buffalo farms but not giving significant influence on technical efficiency. The crossbred milk production was economically beneficial to the farmers and the result describes that the well educated farmer will perform better and follow

modern production practices as compared to the less educated one. It opined that education improves the skill and entrepreneurial ability of the farmer to organize inputs to bring maximum efficiency.

The above data also depict that an increase in one per cent of age in years would decrease the technical efficiency marginally (0.005%) in the case of crossbred farms whereas it was 0.007 per cent decrease in local cow farms. However it shows positive but not significant impact on buffalo farms. This describes that the young farmers actively participated and were more efficient than older ones.

The variable land holding size, the estimated determinants of technical efficiency of the crossbred and local cow farms show that as the land holding size increases by 1 per cent the technical efficiency would decrease equal by 0.02 per cent whereas in the case of buffalo it was negative but not significant. From this

it could be interpreted that the small farmers were more technically using the resources than larger farmers attaining maximum efficiency. Concerning the last variable which is the herd size, the study found that the estimates of local cow and buffalo were negative and significant in local cow only whereas in crossbred farms it was positive but not significant. This increase in TE due to increase in farm size could be attributed to the economies of size which implies that the lesser costs per production unit was attained in crossbred cow farms and the better distribution of resources was achieved. The results of estimates of technical efficiency are in consonance with the work of Al-Sharafat (2013) and Sharif (2014).

CONCLUSION

Technical efficiency was estimated for crossbred, local cow and buffalo dairy farms in Tamil Nadu. The results of this study indicated that technical efficiency of

Table 3. Maximum likelihood estimates of variables associated with technical efficiency of different breeds

Factor	Crossbred cows	Local cows	Buffalos
Constant	1.0131 (19.9692)	1.290834 (9.5729)	0.886599 (34.82771)
Education (years)	0.0181** (10.5743)	-0.00185 (-0.56103)	0.000049 (0.06941)
Age (years)	-0.005** (-7.1046)	-0.00719* (-2.35585)	0.00256** (2.325227)
Land holding size (ha)	-0.0188** (-3.2047)	-0.02266* (-2.07691)	-0.00656 (-0.80014)
Livestock inventory (in animal units)	0.0027 (1.7232)	-0.0009 (-0.06579)	-0.04666** (-2.78996)
Adjusted R square	0.8318	0.8718	0.882343

**Significant at 0.0001 level, *Significant at 0.001 level

milk production by most of dairy farms in Tamil Nadu was moderate. The mean technical efficiency was estimated at 86.32 per cent for crossbred, 77.41 per cent for local cow and 84.49 per cent for buffalo. The available resources were apparently not utilized efficiently as the majority of the animals in these farms were fed imbalanced rations resulting in milk yields below their genetic potential. The increased demand for milk owing to rising population, urbanization and purchasing capacity has to be met by enhancing productivity of dairy animals coupled with greater efficiency of use of the available feed resources. Since feeding alone accounts for more than 60 per cent of the total cost of milk production, balanced feeding of dairy animals can play a pivotal role in a successful dairy development programme.

ACKNOWLEDGEMENTS

The financial support through institutional scholarship for completion for this study provided by the ICAR-National Dairy Research Institute, Karnal is gratefully acknowledged.

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Received: 10.12.2015

Accepted: 27.2.2016