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Economic Efficiency of Dairy Farms in Bengaluru Rural Area : A Stochastic Frontier Production Approach

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ABSTRACT

A study carried out in northern parts of Bengaluru district revealed that only two percent of the 514 sampled dairy farms had a production efficiency score near to one as reported by stochastic frontier production analysis (SFP). The highest efficiency score was 0.93, lowest was 0.085 and the average score was 0.5867. About 30 per cent of the sampled dairy farms were operating at less than 0.50 efficiency levels. When taken as a group, these scores suggested that there is a considerable potential for improving production efficiency by increasing output and or reducing inputs. The maximum likelihood estimates of SFP depicts that increase in the herd size, roughage and concentrates by 1 per cent from their geometric mean level, the output will increase by 0.81, 0.09 and 0.05 per cent over and above the geometric mean level of milk yield, respectively. The γ parameter is used to show the proportion of total variance that is attributed to technical inefficiency in the estimated model. The value of γ is 0.86 and is significant at one per cent level. The magnitude of γ implies that out of total variance in milk production, 86 per cent of the variation can be attributed to the variation in output among the dairy farmers and is due to differences in production efficiency. All factors associated with variation in production efficiency were found statistically signiûcant. Increase in the herd size decreases the inefficiency of dairy by operation of economies of scale and fodder crop variable also showed a positive relationship with the efficiency of farms.

Keywords : Stochastic frontier production, Dairy farms, Production efficiency, Herd size

THE Indian dairy sector has become the backbone of Indian agriculture. The contribution of agriculture to the Gross Domestic Product (GDP) is decreasing over the years. On the other hand, the contribution of the livestock sector to the overall GDP has been consistent at 5 per cent during the last three decades and the livestock sector contributes over 25 per cent of the output of agriculture (Bhaskar, 2007).The Indian dairy sector has grown consistently ever since the White Revolution during 1970s, making India the world's largest producer of milk with 18.5 per cent of global share and with an annual production of 163.7 million tonnes of milk during 2016-17. It has increased by 19 per cent during 2016-17 in comparison to the year 2013-14. Per capita availability of milk has increased from 307 grams in 2013-14 to 351 grams in the year 2016-17.

A report by The International Farm Network Comparison showed that India is growing in its milk production at a faster pace of 4.7 per cent annual growth rate for the last 15 years. This growth was largely attributed to the increasing number of farms (Anon., 2015). India is having of 199.1 million cattle population, which includes 39.73 millions of crossbred. There was an increase of 34.78 per cent of exotic/ crossbred cattle from 14.4 million to 19.42 (Anon., 2012). The average daily milk yield for crossbred cattle is 7.1 kg per day, but still significantly lesser than those United Kingdom, United States and Israel which are at 25.6, 32.8 and 38.6 kg per day, respectively (Kapoor, 2014). Crossbreeding programme was started during 1950s in India between indigenous and exotic cattle mainly with Holstein Friesian (HF) and Jersey for increase in milk production (Rajesh *et al.,* 2015). There is wide variation of dairy farming practices which is reflected in the average milk yield. Therefore, to increase the competitiveness of India's dairy industry, the economic efficiency of dairy farmers has to be improved.

A key to increase the competitiveness of India's dairy industry is to improve the economic efficiency of dairy farmers. With this background an attempt was made to analyse the economic efficiency of crossbred dairy farms in Bengaluru district and to identify the factors associated with the variation in efficiency of crossbred dairy farms.

METHODOLOGY

The study was carried out in Bengaluru rural district as dairy farming is a common agricultural activity in the area. Simple random sampling procedure was employed for the selection of sample crossbred dairy farms. The Bengaluru was divided into two transects namely North of Bengaluru and South of Bengaluru taking the reference point as Vidhana Soudha to measure the distance. Thirty villages were selected randomly in the North and South regions. The primary data were collected through personal interviews from 300 crossbred dairy farmers in North and South regions, respectively, to constitute a total sample size of 600 crossbred dairy farms. But after data validation and trimming the outliers, there were 274 and 240 crossbred dairy farms in North and South regions, respectively, to constitute a total sample size of 514 crossbred dairy farms which were considered for analysis. Further the post stratification of dairy farmers was made as small, medium and large crossbred farmers standardizing the size of the crossbred cows owned by the farmers.

Efficiency Analysis

Efficiency analysis ranks decision-making units by comparing all farm resources employed to producing a given set of outputs and constructing a frontier based on the input-output space. The Cobb-Douglas Stochastic Frontier Production (SFP) approach was used for the assessing the economic efficiency of crossbred dairy farmers, following the Coelli (1996) model as follows

$$\ln Y_i = \beta_o + \sum_{j=1}^{4} \beta_j \ln X_{ji} + v_i - u_i \qquad (1)$$

where, ln denotes natural logarithm; Y_i is annual milk production of farm *i* measured in litres; X_{j1} is herd size; X_{2i} is annual consumption of roughage feed in kilograms (equals consumption of green fodder plus dry fodder, assuming a dry matter content of 30 per cent and 90 per cent respectively, (Binici *et al.*, 2006); X_3i is annual consumption of purchased dairy concentrate in kilograms; X_{4i} is human labour in man-days, v_i is a symmetric, identically and independently distributed $N(0,\sigma_v^2)$ error term. It represents random variation in production due to random exogenous factors, such as measurement errors, unobserved production inputs, and statistical noise. u_i is a non-negative error term. It reflects technical inefficiency relative to the stochastic frontier.

The computer programme FRONTIER Version 4.1 was used to estimate the model and to obtain the maximum likelihood estimates of the SFP function. The calculation of MLE requires (Coelli, 1996) $\sigma^2 = \sigma_v^2 + \sigma_u^2$. This indicates total varianceis due to variance in error term (v) and non-negative random variable (u), wherein v and u assumed to be independent of each other. The error term v_i represents the influence of factors outside the control of the farmer, while u_i represents the technical inefficiency factors because of poor management practices which are under control of the farmer. This variance parameter in model is represented by Gamma value, calculated using the following equation

$$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$$

Factors Affecting the Technical Inefficiency Scores

In this section an attempt was made to estimate the factors associated with the technical inefficiency scores of respondents taking the degree of production efficiency or technical inefficiency scores as dependent variable. Regression analysis was used for the analysis. The empirical specification of the technical inefficiency model is given by (Bettese and Coelli, 1995)

$$u_i = \delta_0 + \sum_{m=1}^{5} (\delta_m Z_{mi}) \qquad (2)$$

Where as Z_{mi} are socio-economic characteristics, Z_{1i} is age of farmer. Z_{2i} *is* education attainment of farmer in years, Z_{3i} is a binary variable equal to one if the farmer is a dairy co-operative member and to zero otherwise, Z_{4i} is a binary variable equal to one if the farmer cultivates fodder crop and to zero otherwise and Z_{5i} is total number of cows in the herd.

Results and Discussion

The sampling parameters of dairy farms in North and South of Bengaluru are depicted in Table 1. It was observed that small, medium and large dairy farms account for 18.09 per cent, 68.48 per cent and 13.42 per cent, respectively. The small and medium dairy farms accounted for 86.57 per centof total dairy farmers sampled.

Table 1

Sampling Parameters of Dairy Farms in Bengaluru

Herd Size	Farmers Sampled (No.)	Distribution of Sampled farmers (%)
Small (1-2 dairy cows)	93	18.09
Medium (3-8 dairy cows)	352	68.48
Large (>8 dairy cows)	69	13.43
Total	514	

Descriptive statistics of the variables are presented in the Table 2. The average milk production small, medium and large crossbred farms in the study area were 3366.56, 9352.22 and 21853.33 litres per farm per year respectively. The average milk yield of all respondents per herd per year was 9947.37 litres with an average herd size of 5 lactating crossbred cows per herd. The average roughage feed was 6549.75 kilograms per farm per year, whereas, concentrates average was 1881.93 kilograms per farm per year. About 66.73 per cent of dairy farmers were members of the milk co-operative and producers' organization and 25 per cent of farmers were producing their own fodder.

Production efficiency of dairy farms

The Cobb-Douglas production function was estimated using the computer version FRONTIER 4.1 and frontier estimates are presented in Table 3. As expected, the major production inputs considered had positive coefficients, implying that amount of milk produced increases as the use of these input increases. Except for mandays, all other coefficients were significant at one per cent.

Results revealed that if the crossbred dairy farmer increases the herd size, roughage and concentrates by one per cent from their geometric mean level, the

Table 2

Characteristics of Dairy farmers

Variable	Small	Medium	Large	Overall
Annual Milk Production (Litres/Herd)	3366.56	9352.22	21853.33	9947.37
Herd Size (No.)	2	5	12	5
Roughage Feed(Kg/Herd)	2397.40	6207.75	13891.06	6549.75
Concentrate Feed (Kg/Herd)	813.00	1802.61	3727.29	1881.93
Human Labour (Man-Days/Herd)	309	360	535	374.20
Age of Farmer (Years)	51.12	48.98	49.88	49.50
Education Attainment (Years)	4.98	5.80	7.48	5.88
Milk Co-operative Member (%)	64.51	71.50	72.50	66.73
Fodder Crop (%)	19.25	27.40	33.33	25

TABLE 3

Maximum likelihood estimates of stochastic frontier production function

Variable	Parameters	Coefficients	t-ratio
Constant	β_0	6.62	21.46
ln(herd size)	β_1	0.81 *	18.47
ln(roughage feed)	β_2	0.09 *	4.02
ln(concentrate feed)	β_3	0.05 *	3.65
ln (man days)	β_4	0.10 **	2.96
Variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.76	7.82
$\gamma = \frac{\sigma_u^2}{\sigma^2}$		0.86	14.50
LR statistic	16.17		

Note: *,**significant at the 1 and 10 per cent level respectively

output will increase by 0.81, 0.09 and 0.05 per cent over and above the geometric mean level of milk yield, respectively.

Along with the stochastic production frontier estimates, numerical values of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ (total variance, 0.76) and gamma (γ) parameter of the model are also given in Table 3. The γ parameter is used to show the proportion of total variance that is attributed to technical inefficiency in the estimated model. The value of γ is 0.86 and is significant at one per cent. The magnitude of γ implies out of total variance in milk production, 86 per cent of the variation in milk production is attributed to the variation in output among the dairy farmers and is due to differences in production efficiency. The significance of γ indicates that technical inefficiency effects are significant in determining the level and variability of milk production. Further, the estimated value indicates that only 14 per cent of variation in milk production is attributed to random shocks that are out of the control of the farmers.

The distribution of production efficiency scores are presented in Table 4. Based on the estimated production efficiency frontier it was observed that, only two per cent of the 514 sampled dairy farms had a production efficiency score near to one. This indicates that only two crossbred dairy farms were efficient in milk production. The highest score was 0.93, lowest score was 0.085 and the average score was 0.5867. Nearly 30 per cent of the sampled dairy farms were operating at less than 0.50 efficiency score. When taken as a group, these scores suggested that, there is considerable potential for improving production efficiency by increasing output and/or reducing inputs. For example, if a farmer with average efficiency increases the farm's efficiency to that of the most efficient farm in the sample, then this dairy farmer could increase his efficiency score by 37.25 per cent of the total efficiency (*i.e.,* 1- (0.5857/0.935). The increasing efficiency of dairy farmers with average efficiency to that of most efficient farm is in line with the results of Turkey dairy farmers as reported by Binici *et. al.* (2006).

TABLE 4

Distribution and summary statistics for production efficiency scores of dairy farmers

Production Efficiency Score	Number of Dairy Farms	Percent of Dairy Farms
≤0.5	152	29.57
>0.50 ≤0.60	98	19.07
>0.60 ≤0.70	91	17.70
>0.70 ≤0.80	121	23.54
>0.80≤0.90	50	9.73
>0.90	2	0.39
Mean	0.5867	
Minimum	0.085	
Maximum	0.93	

Analysis of Technical Inefficiency

In the technical inefficiency model, technical inefficiency score (*U*i) was taken as dependent variable and the explanatory variables were specific socio-economic and herd size (*Zi*) variables. A variable that has a positive parameter estimate will have an increasing effect on farm technical inefficiency. The implication is that the variable that has an increasing effect on technical inefficiency will have a decreasing effect on technical efficiency and *vice versa*. The estimated coefficients and probability results for the

TABLE 5

Maximum Likelihood estimation results of technical inefficiency model variables

Variable	Parameters	Coefficients	t-ratio	Probability
Constant	δ_0	0.001318 **	2.17	0.03
Age	δ_1	-0.00253 *	-1.59	0.11
Education	δ_2	-0.10533 ***	-6.32	0.00
Co-operative Member	δ_3	-0.04161 **	-2.29	0.02
Fodder Crop	δ_4	-0.00089	-0.39	0.69
Herd size	δ_5	-0.001318 **	-2.17	0.03

Note: *** = Significant at 1 per cent, ** = Significant at 5 per cent, * = Significant at 10 per cent

technical inefficiency model are given in Table 5. The results showed that efficient farmers are mostly older dairy farmers. The study found that, age was positively related with production efficiency and is statistically significant at 5 per cent level of significance. This finding is in line with the Binici *et al.* (2006). Sorsie *et al.* (2015) who reported out that older maize farmers were more efficient than the younger maize farmers in Ethiopia.

Education was also positively related with the efficiency, which was highly significant at 1 per cent level and the value of regression coefficient for education was -0.10533 indicating that if, there is one year increase in the level of education of dairy farmers, inefficiency score decreases by 0.1053.

Member farmers of milk cooperative and producer organizations along with the farmers who cultivate fodder crops showed a positive relationship with the production efficiency. This could be attributed to the training received by farmers on advanced cattle rearing practices, higher price realisation by dairy farmers and regular payments as also supported by (Rajani *et al.*, 2015).

It was interesting to note in the Table 5 that, herd size had a positive relationship with the production efficiency and was significant at 5 per cent level. It was found that, as the size of the herd increases the production efficiency increases. The decreasing effect of herd size on technical inefficiency is attributed to the operation of economies of scale. Shalini (2017) reported that net income realized by all types of farms varied positively with size of the dairy unit. Thus, large sized dairy units reaped the benefit of scale economies.

The study revealed that, farms had an average efficiency score of 0.5867. Further, the analysis revealed that 86 percent of the variation in output among the sampled farmers due to differences in their production efficiency. These findings imply that the average dairy farmer in this sample has the potential to substantially increase their efficiency without changing their production frontier because these variations were under the control of farmers which can be reduced by proper management practices by adopting the balanced feed supply norms and attaining the training programmes conducted by dairy co-operative. The analysis identified factors associated with the variation in production efficiency and estimates were statistically significant. Increasing the herd size decreases the inefficiency of dairy by operation of economies of scale. The variable fodder crop also has the positive relationship with the efficiency of farms. Both factors are potentially attainable but both add to the variable cost. There is a need for creating awareness about the success of co-operative operations among the dairy farmers as efficiency level of trained farmers was much higher than those who did not receive any kind of training either from milk cooperative society or from other organisations.

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