Indian J Dairy Sci 78(1): 72-79
https://doi.org/10.33785/IJDS.2025.v78i01.011

RESEARCH ARTICLE

Measuring the technical efficiency of milk production in Punjab: Frontier production function approach

Jaspreet Singh, Parminder Kaur(✉) and Kashish Arora

Received: 04 October 2023 / Accepted: 22 March 2024 / Published online: 23 February 2025

Abstract: An effort has been made to examine the technical efficiency in milk production and the determinants thereof for 80 dairy farmers, selected from Ludhiana and Patiala districts of Punjab state. The total number of milch animals on small, medium, and large farms was 2.71, 4.73 and 12.79, respectively with an overall average of 5.12 milch animals. Overall, of the total costs, variable costs and fixed costs accounted for 85.0 and 15.0 percent respectively. The net returns were observed to be Rs 22568.9, Rs 81784.2 and Rs 340827.5 per farm in case of small, medium and large dairy units, respectively. The net returns per litre of milk were estimated to be Rs 3.65, Rs 7.50 and Rs 10.51, respectively on the respective farms with an overall average of Rs 7.92. The farmers intended to realize 77.30 percent of the technical abilities and potential for improvement in technical efficiency in milk production was 21.3 percent. This implies that dairy farmers could enhance the milk production by 21.30 percent with existing level of technology and resources. The technical efficiency of dairy farmers determined by age of farmers, land holding, price of milk received by the farmers and training were found to be positive and significant. The study indicated that dairy farmers should be trained on a regular basis for appropriate feeding practices, rearing optimal herd size with quality animals, and new technologies in milk production to attain maximum milk production and thus achieve more benefits. Besides, strong and effective linkage of farms to market could provide incentives towards increasing their efficiency in milk production. Dairy farmers can gain considerable higher profits by increasing the efficiency in their operations.

Department of Economics and Sociology, Punjab Agricultural University, Ludhiana-141004, India

Parminder Kaur (✉)

Email: parminderkaur-aes@pau.edu

Key words: Cost and returns, Dairying, Determinants, Technical efficiency, Tobit analysis

Introduction

Animal husbandry and dairying have been part of human life since the start of civilization. They have contributed not only in providing low cost and nutritious food to millions of people but also in providing animal power and maintaining ecological balance (Dhawan and Kashish 2016). There exists a close link between livestock and agriculture sector. In India, livestock sector produced 230.58 million tonnes of milk, 9.77 million tonnes of meat and 138.38 billion eggs in 2022-23. The share of Gross Value Added (GVA) of livestock sector to agriculture sector has increased to 30.19 percent during the year 2022-23 while its share in total GVA was 5.73 percent in the said year (Anonymous, 2023). Livestock sector in general and dairy sector in particular provides cushion to overall agricultural growth (Kashish et al. 2014; Dhawan and Kashish 2016; Dadhich 2017). Dairying is one of the oldest professions pursued by mankind. It came up as the complementary activity to agriculture and now become a full-fledged business. The dairy industry is a very important part of the global food system (Singh et al. 2022). India has been the leading producer and consumer of dairy products worldwide since 1998 with a sustained growth in the availability of milk and milk products (Kashish et al. 2016). Dairying has always been quoted as one of the means for poverty alleviation and improvement of nutritional security (Kumar and Shah, 2016; Kashish et al. 2017). It has been proud to be the largest milk producing country, accounting for 23.1 percent of world production with an annual output of 230.58 million tonnes at an annual growth rate of 3.83 percent achieved during 2022-23 (Anonymous, 2023).

As Punjab is one of the major milk producing state with about 7 percent share in total milk production of India and ranked sixth with annual milk production of 13.34 million tonnes (Anonymous 2020). Dairy farming is one of the alternatives to the wheat-rice system in Punjab, which offers regular income and employment to families, particularly small and marginal (Elumalai and Pandey 2004; Kashish et al. 2017). To stimulate milk production in Punjab, an ambitious program has been set up to include the genetic

improvement of local bovine and buffalo breeds through breeding and crossbreeding. Despite the efforts of the Government, Punjab Dairy Development Board and the various cooperatives to improve milk production there are still high input costs for milk production compared with low milk prices, which together reduce profit margins. Productivity has to be increased in order to sustain milk production in Punjab. Productivity can be improved in two ways: technological progress and to improve technical efficiency (Gerber and Franks 2001; Karanja et al. 2012). In a developing country like India, it is important to know what policies and measures should be taken to improve productivity before investing scarce capital to achieve technological progress (Saha and Jain, 2004). In this context, the analysis of efficiency assumes fundamental importance, since the improvement of technical efficiency implies that inefficient farmers adopt technologies and practices and, therefore, save scarce capital to obtain better results (Nizam and Armagan 2006). Furthermore, the analysis of the factors that cause (in) efficiency provides important insights on key variables that could be worthy of consideration in the formulation of policies to ensure optimal use of capital and resources. Increasing efficiency is an important factor for productivity growth and can be increased by using better technologies together with better management of all essential inputs available to farmers (Gunden et al. 2006; Lovell 1993; Jaforullah and Whiteman 1999). Efficiency analysis in milk production becomes all the more important in underdeveloped production environments of developing countries like India which are basically low-input and low-output environments characterized by subsistence holdings, resource poor locations with milch animals of low production potential and having poor infrastructural support system.

Available studies have shown that farmers in developing countries fail to exploit full potential of technology and make allocative errors (Gelan et al. 2010; Otieno et al. 2012 and Rao 2012). Thus, increasing the efficiency in production assumes greater significance in attaining potential output at the farm level. The consequence of technical inefficiency is the increased production cost, which make dairy farms less competitive and the viability of dairy farming is questioned. A clear understanding of farm level inefficiency in milk production and identification of their determinants would provide the clue for making this sector competitive and viable. In view of the above, the present study was carried out to examine the technical efficiency in milk production along with influence of various factors on the efficiency in central plain region of Punjab state.

Materials and Methods

To achieve the stipulated objectives, the primary data pertaining to crop year 2017-18 were collected by using well-structured and pre-tested interview schedule. The central plain region of Punjab was purposively selected being developed and highest milk producing region of the state. Multistage simple random sampling technique was used for sample selection. In first stage two districts namely Patiala and Ludhiana having highest milk production above the state average were selected purposively. In next stages, one block from each chosen district and two villages from each chosen block were selected randomly. After the selection of villages, a list of all the dairy farmers with number of milch animals (cows and buffalos) maintained on each farm was prepared. Using Cube root frequency method of stratification, the size distribution of herds of these farms was then transformed to identify the size ranges of small (1-5 animals), medium (6-10 animals) and large (>10 animals) units. A sample of 20 respondents from each selected village was selected randomly, making a total sample of 80 farmers. The details of sample selection are presented in Table 1.

To calculate the cost and returns from milk production, primary data regarding quantity of dry fodder, green fodder and concentrates fed to the dairy animals per day and the purchase price per unit were collected from selected dairy farmers. Furthermore, the data on their expenditure on veterinary and health care services were also collected from the dairy farmers. To examine fixed cost per farm, data regarding value of dairy animals, value of equipments, dairy buildings and different machineries were also compiled. In order to evaluate the gross returns, data regarding amount of milk sold, quantity of dung sold and young stocks sold were also collected from different dairy farmers to know the exact picture of dairy farmers at a field level.

Technical efficiency in milk production

Of the various approaches to the estimation of technical efficiency, the parametric Stochastic Frontier Production function (SFP) (Aigner et al. 1977, Meeusen and van den Broeck 1977), and non-parametric Data envelopment analysis (DEA) (Charnes et al. 1978) are the two most popular approaches. Each approach has its own advantages and disadvantages. Although the advantage of DEA lies in its general nonparametric limit, its limitations are due to the fact that, using the DEA model, the efficiency values are contaminated by omitted variables, measurement errors, and other sources of statistical noise. On the other hand, the strength of SFP lies in its ability to separate the term error into two components, namely, inefficiency and random noise can only be implemented by introducing a specific functional form, and therefore the resulting efficiency indicators can be sensitive to the selected functional form his (Gelan and Muriithi 2010). The frontier production function defines the potential output that can be produced by a farm/firm with the given level of inputs and technology.

The stochastic frontier production function was used in this study to estimate the technical efficiency in milk production. In the general form the stochastic frontier production function can be written as:

$Y_k = f(X_{ik}) \exp(v_k - u_k)$

Where, Y_k is the output of the k^{th} farm, X_i's are the inputs in the production process, v_k is a random variable representing statistical noise and other stochastic shocks entering into the definition of the frontier. It is almost universal to specify this random term as independent normally distributed with zero mean and constant unknown variance σ_v^2, and independent of X_i, i.e., $v_k \sim N(0, \sigma_v^2)$. u_k is a non-negative random variable representing technical inefficiency and is assumed to be distributed independently of v_k and X_i. It can be measured by the difference between maximum output Y* (estimated through the stochastic frontier production function) and observed output, Y_i. Thus, farm-specific inefficiency is the distance below the frontier ($Y_i - Y^*$). The above stochastic frontier production function can be estimated by maximum likelihood once a density function for u_k is specified.

The stochastic frontier production function of Cobb-Douglas type has been specified for this study:

$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + (v_i - u_i)$

Where

Subscript i, denotes the i^{th} farmer in the sample

ln = the natural logarithm (i.e., to base e)

Y_i = Returns from milk (in Rs)

$\beta_0 \ldots\ldots\ldots \beta_6$ = parameters to be estimated

X_1 = Expenditure on green fodder

X_2 = Expenditure on dry fodder

X_3 = Expenditure on concentrates

X_4 = Veterinary expenses

X_5 = Value of labour

X_6 = Fixed cost

$v_i - u_i$ = random error term

The model is estimated by using stochastic production function and the Maximum Likelihood Estimates (MLE) . The model was estimated using the computer program FRONTIER 4.1 (Coelli, 1996) to estimate simultaneously the parameters of the stochastic production frontier and the technical inefficiency effects.

Potential for increasing milk production

The average potential to measure milk production was determined using the following formula.

$$= \left(1 - \frac{mean\ technical\ efficiency}{\text{maximum technical efficiency}}\right) * 100$$

Determinants of technical efficiency

The observed differences in technical efficiency may be due to numerous factors including the degree of sample homogeneity, the methods employed and differences in farm specific characteristics. The present study analyzed the variation in technical efficiency in milk production due to farm specific characteristics such as age of farmer, herd size, proportion of milk sold, price received and dairy training of farmer. In order to know the contribution of each factor, the level of technical efficiency of the milk producers considered was regressed in these factors. Tobit model, also known as censored regression model or limited dependent variable regression proposed by Tobin, 1958 was used to examine the determinants of technical efficiency. A censored sample is a sample in which information on dependent variable is available for only some observations. If we use OLS on censored data set, estimates obtained will be inconsistent meaning coefficients will not necessarily approach the true population parameters as sample size increases (Gujarati, 2003). In such cases, Tobit model is used for analyzing censored sample.

Table 1: Sample selection of dairy farmers in Ludhiana and Patiala districts of Punjab

Districts	Blocks	Villages Selected	Herd size group			Overall
			Small	Medium	Large	
Ludhiana	Raikot	Kalsiyan	11[#]	5	4	20
		Lohatbadi	8	7	5	20
Sub-total (a)			19	12	9	40
Patiala	Nabha	Laloda	12	6	2	20
		Sangatpura	9	8	3	20
Sub-total (b)			21	14	5	40
Grand Total (a+b)			40	26	14	80

[#]*Number selected*

$$Y = \beta X + \mu \ if \ \beta' X + \mu > 0;$$

= 0 otherwise

Such that $\mu \sim N(0, \sigma^2)$

Thus, Tobit's analysis of factors influencing the technical efficiency of selected farms is specified as:

$$TE_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e_i$$

Where

TE_i = Technical Efficiency

X_1 = Herd size

X_2 = Land holding

X_3 =Age of farmer

X_4 =Square of age

X_5 = Price received

X_6 = Proportion of milk sold

X_7 = Training in dairy sector

e_i = Error term

Results and Discussion

The purpose of this section is to study the crucial characteristics of the sample dairy farmers that may have an impact on the decision-making process, efficiency and profitability of the dairy enterprise. In the present section, the study has focused on the demographic profile of sample farmers, variable and fixed cost incurred in milk production and technical efficiency of sample farmers and determinants thereof in the study area.

Socio-economic profile of selected dairy farmers

The socio economic profile of surveyed households is presented in Table 2. The average age of households was 53.1 years. The family size varied among different categories of households. The average size of family on small, medium and large size categories was 5.33, 5.77 and 7.00 respectively (Table 2). Overall, the family size came out to be 5.76 members. The herd strength and the number of milch animals in the households affect the economic position of milk producers. The total number of milch animals on small, medium and large dairy units was 2.71, 4.73 and 12.79 respectively. The proportion of buffaloes was found evidently higher on all size categories as compared to crossbred cows and indigenous cows collectively. On an average, out of total milch animals the percentage of buffaloes was 69.14. The proportion of crossbred cows (26.36 %) and indigenous cows (4.50 %) were found to be the highest in case of large farms.

Cost structure in dairy farming

To understand milk production from its economic perspectives, it is vital to examine the costs, explicit or implicit being used into its production. The cost structure in dairy farming on different categories of dairy units is presented in Table 3. The different costs endured on rearing the milch animals were categorized as fixed and variable costs. A perusal of table reveals that overall per farm total cost of rearing the milch animals was estimated to be Rs 438285.4 and total cost was found increased with the increase in herd size which ranged from Rs 257847.2 on small and Rs1013700.8 on large dairy units. Overall, the fixed and variable costs accounted for 14.53 percent and 85.4 percent respectively. Further, breakup of the variable costs revealed that a sizeable portion of variable costs i.e. 79.5 percent was accounted by the feed cost component as also found by Kumawat et al. 2014; Kashish et al. 2016. Amongst the feed and fodders, concentrates like oil cakes, cotton seeds, gram husk and wheat bran, etc. together constituted 48.5 percent while across the different categories 49.8, 46.5 and 48.9 percent of the total variable costs was incurred on small, medium and large dairy farms, respectively. Labour being the second highest component of cost accounted

Table 2: Socio-economic profile of sample households in Punjab, 2017-18

Particulars	Small	Medium	Large	Overall
Average age (years)	52.9	54.5	50.8	53.1
Average family size (No.)	5.33	5.77	7.00	5.76
Operational Land-holding (acres)	8.72	12.39	20.07	11.90
Land used for dairying (acres)	0.32	0.39	1.13	0.48
Total Herd size	3.44	6.28	17.35	6.80
Total Milch Animals	2.71	4.73	12.79	5.12
Buffalo	*2.10*	*3.35*	*8.00*	*3.54*
Crossbred cattle	*0.53*	*1.26*	*3.86*	*1.35*
Indigenous cattle	*0.08*	*0.12*	*0.93*	*0.23*

for 17.6, 17.1 and 18.0 percent of the total variable costs in the case of small, medium and large sized dairy units respectively. It is pertinent to mention here that the proportion of expenditure on hired labour was increasing with the increase in herd size and the share of family labour was higher on small sized dairy units in comparison to other categories. Overall, the contribution of veterinary charges, transportation charges, electricity charges and interest on working capital accounted for 0.8 percent 0.7 percent, 0.3 percent and 1.2 percent, respectively of the total variable costs. Amongst the fixed costs, interest on fixed capital was the major item of fixed cost and overall accounted for 50.7 percent of the total fixed costs followed by depreciation on milch animals (37%). The examination of Table 3 revealed that the highest proportion of fixed costs in total costs were found on small sized dairy farms (15.4%) and that of variable costs were observed on large dairy farms (87.1%).

Returns structure in dairy farming

The perusal of Table 4 shows that per farm gross returns on small, medium and large farms were to the tune of Rs 280416.1, Rs 487791.7 and Rs 1354528.6 respectively. Overall, the gross returns were found to be Rs 535782.9 out of which the returns from sale of milk, dung and young stock were estimated to be Rs 497086.5 (92.8%), Rs 23911.6 (4.5%) and Rs 14784.8 (2.8%) respectively.

The returns to fixed farm resources (RFFR) indicate the level of profitability resulting from the existing use of variable resources

Table 3: Cost structure in dairy farming on different size categories of dairy units in Punjab, 2017-18

Particulars	Small		Medium		Large		Overall	
	Rs/farm	%	Rs/farm	%	Rs/farm	%	Rs/farm	%
A. Variable Cost								
Feed and Fodder								
Green Fodder	26745.4	12.3	50012.0	14.6	113938.7	12.9	49565.9	13.2
Dry Fodder	37435.3	17.2	64498.0	18.9	154196.2	17.5	66663.8	17.8
Concentrates	108678.8	49.8	158775.0	46.5	431742.9	48.9	181496.3	48.5
Total Feed Costs	172859.5	79.2	273285.0	80.0	699877.8	79.3	297726.0	79.5
Human Labour								
Hired Labour	4200.0	1.9	12646.2	3.7	90428.6	10.2	22035.0	5.9
Family labour	34218.8	15.7	45625.0	13.4	68437.5	7.8	43914.1	11.7
Total labour	38418.8	17.6	58271.2	17.1	158866.1	18.0	65949.1	17.6
Veterinary & insemination charges	1572.5	0.7	2746.2	0.8	7692.9	0.9	3025.0	0.8
Electricity	2000.0	0.9	2500.0	0.7	4519.0	0.5	2603.3	0.7
Transportation charges	800.0	0.4	900.0	0.3	1500.0	0.2	955.0	0.3
Interest on working capital	2515.9	1.2	3939.9	1.2	10178.7	1.2	4319.7	1.2
Total Variable Cost	218166.7	100.0	341642.2	100.0	882634.3	100.0	374578.1	100.0
B. Fixed Cost								
Depreciation								
on milch animals	12636.0	31.8	23413.5	36.4	55252.8	42.2	23596.6	37.0
on dairy buildings	2466.7	6.2	3569.2	5.5	4628.6	3.5	3203.3	5.0
on equipments	3863.1	9.7	4241.5	6.6	7585.7	5.8	4637.5	7.3
Interest on fixed capital	*20714.8*	*52.2*	*33177.0*	*51.5*	*63599.4*	*48.5*	*32269.8*	*50.7*
Total fixed cost	39680.5	100.0	64401.3	100.0	131066.5	100.0	63707.3	100.0
Total Cost (A+B)	257847.2		406043.5		1013700.8		438285.4	

in dairy business. It was calculated by deducting the total variable costs from gross returns. The perusal of Table 4 shows that per farm RFFR were Rs 62249.4, Rs 146149.5 and Rs 471894.3 on small, medium and large size of dairy farms respectively while per farm net returns were estimated to be Rs 22568.9, Rs 81748.2 and Rs 340827.8 on above said farm categories respectively. This revealed that RFFR and net returns increased with increase in herd size. On an average, RFFR and net returns were Rs 161204.8 and Rs 97497.5 respectively. The gross returns per litre of milk produced were estimated highest on small farms (Rs 45.38) followed by medium (Rs 44.71) and large (Rs 41.75) dairy units. The cost per litre of milk production was estimated to be Rs 41.73, Rs 37.21 and Rs 31.24 on the respective farm categories. It revealed that cost per litre of producing milk decreased with increase in herd size indicating prevalence of economies of scale on large farms. This might be due to fact that large dairy farmers were rearing better milch animals and following better management practices as compared to small and medium dairy owners.

Overall, net returns per litre of milk produced came out to be Rs 7.92 while these were estimated to be Rs 3.65, Rs 7.50 and Rs 10.51 on small, medium and large size dairy farms, respectively. This revealed that net returns per litre were highest on large farms and lowest on small sized dairy farms.

Technical efficiency in milk production

The level of technical efficiency of a particular farm is characterized by the relationship between observed production and ideal or potential production. The measurement of the specific technical efficiency of the operation is based on the deviation of the observed production from the best production or the efficient production frontier. If the actual production point of a farm is at the frontier, it is completely efficient. If it is below the frontier, it is technically inefficient, with the ratio of actual production to potential determining the efficiency of each farm.

The results of the maximum likelihood estimates of the parameters in the stochastic production frontier for milk producers are presented in Table 5. The comprehensive likelihood ratio (LR) statistic for testing the null hypothesis for the absence of inefficiency effects in the Cobb-Douglas stochastic frontier production was 7.06. The calculated LR statistics were statistically significant, suggesting that the null hypothesis i.e. there were no technical inefficiency effects in the Cobb-Douglas stochastic production function was rejected. The estimated gamma parameter (γ) for production function was 0.982, indicating that about 98.2 percent of the variation in the output of milk among the farmers was due to differences in their technical efficiencies and remaining 1.8 percent variation is due to random errors. Saha and Jain (2004) reported a relatively lower gamma value (0.723) from their study on milk production efficiently in Haryana.

The concentrates proved to be a significant factor that positively influenced milk production in the MLE model, which means that there is potential to enhance the profitability through this input. One percent increase in the value of concentrates would raise the milk production by 0.90 percent. The estimates of dry fodder (-0.20) found significant and negative indicating excessive use of this input suggesting in its reduction in order to increase the

Table 4: Returns structure in dairy farming on different size categories of dairy units in Punjab, 2017-18

Particulars	Small	Medium	Large	Overall
Returns				
(i) Per farm				
Milk	*259830.5 (92.7)*	*438628.8 (89.9)*	*1283525.0 (94.8)*	*497086.5 (92.8)*
Dung	*12560.0 (4.5)*	*31036.5 (6.4)*	*43112.6 (3.2)*	*23911.6 (4.5)*
Young Stock	*8025.6 (2.9)*	*18126.4 (3.7)*	*27891.0 (2.1)*	*14784.8 (2.8)*
Gross Returns	280416.1	487791.7	1354528.6	535782.9
RFFR	62249.4	146149.5	471894.3	161204.8
Net Returns	22568.9	81748.2	340827.8	97497.5
(ii) Per litre of milk				
Gross returns	45.38	44.71	41.75	43.51
Total variable cost	35.31	31.31	27.20	30.42
Total fixed cost	6.42	5.90	4.04	5.17
Total cost	41.73	37.21	31.24	35.59
Net returns	3.65	7.50	10.51	7.92

Figures in parentheses indicate percentage to the gross returns

technical efficiency of milk production on the selected farms. Human labour was significant variable and the effect was was positive implying that there is scope devoting more labour hours for taking care of animals.

Distribution of dairy farms on the basis of technical efficiency level

To determine the technical efficiency of the dairy households the mean technical efficiency indices of milk production were established and are presented in Table 6. Considering the entire sample of 80 farmers, the mean technical efficiency was observed to be 77.30, ranged between as high as 98.22 to as low as 27.39. Farmers still had a room to increase the efficiency in their farming activities by 21.30 percent to fill the efficiency gap. They could substantially improve their income levels through better farming practices. It is pertinent to mention here that more than one fourth of the respondents were operating in technical efficiency range of more than 90 percent while 20 percent of the selected respondents were operating within the technical efficiency range of 60-70 percent.

Factors influencing technical efficiency in milk production

Given a particular technology to transform the physical inputs into output, some farmers are highly efficient while others are inefficient. The efficiency of the farmers is determined by various socio-economic and demographic factors. The perusal of Table 7 shows the results of tobit regression model performed to see the factors that affect the technical efficiency of dairy farms. The variable herd size was found to be significant but negative which clearly indicating that the larger herd size containing more number of unproductive animals will decrease the technical efficiency of dairy farms. The land holding variable has positive and significant effect ($p<0.05$) on technical efficiency which clearly indicating that farmers having more land are technically more efficient in comparison to the other categories of dairy farms. The age variable has a significant ($p<0.05$) influence on technical efficiency of dairy farmers in the study area. This may be attributed to the fact that more experienced farmers would have come across more problems and found their solutions through their skills and knowledge. Price received was found to be a significant and positive determinant of technical efficiency due to increased investment on improved breeds of milch animals and improved cash flow. The proportion of milk sold had significant and positive influence on milk production efficiently implying that farmers with high degree of intensity of market participation were more efficient in milk production.

Table 6: Distribution of dairy households according to technical efficiency level

Technical efficiency levels	Overall
<60	8 (10.0)
60-70	20 (25.0)
70-80	14 (17.5)
80-90	15 (18.7)
90-100	23 (28.8)
Number of observations	80
Minimum	27.39
Maximum	98.22
Mean Technical efficiency	77.30
Average Potential to increase in efficiency	21.30

Figures in the parentheses are the percentages to the total

Table 5: Maximum likelihood estimates of parameters for milk production frontier functions

Variables	Overall
Constant	3.51** (0.80)
Green Fodder	-0.14 (0.11)
Dry Fodder	-0.20** (0.08)
Concentrates	0.90** (0.08)
Veterinary expenses	0.08 (0.07)
Human Labor	0.32** (0.13)
Depreciation	-0.18** (0.06)
σ^2	0.13** (0.02)
γ	0.982** (0.02)
LR test of one-sided error	16.28**
Log likelihood function	7.06
Number of observations	80

*** indicates significant at 5% level*

Conclusions

It is concluded that feed and fodder cost become an important component of variable cost and accounted for about 80 percent of the total variable cost. Among all the components of dairy sector, sale of milk accounted for more than 90 percent of the gross returns from milk production. Further, the results brought out that the presence of technical inefficiencies significantly affected milk

Table 7: Factors influencing technical efficiency of milk production in selected farms, 2017-18

Variables	Overall
Intercept	-0.9076 (0.4251)
Herd size	-0.0080* (0.0028)
Land holding	0.0035** (0.0016)
Age	0.0245** (0.0090)
Square of age	-0.0002** (0.0001)
Price received	0.0223*** (0.0063)
Proportion of milk sold	0.0019** (0.0006)
Training	0.1406*** (0.0305)
Log Likelihood	65.92
Pseudo R^2	-0.608

*Significant at *1%, **5% and ***10% level of significance.*

production. The estimated gamma parameters for production function was 0.982 indicating that about 98.2 percent of the variation in the output of milk among the farmers was due to differences in their technical efficiencies and remaining 1.8 percent variation is due to random errors. The mean technical efficiency of the dairy farms was estimated to be 77.3 percent. The average potential for improvement in technical efficiency in milk production was 21.3 percent which implies that dairy farmers could enhance the milk production by 21.3 percent with existing level of technology and resources. The factors such as age of farmers, land holding, price of milk received by the farmers and training were found to be positive and significant. The results of technical efficiency indicated that dairy farmers can gain significantly higher profits by increasing their efficiency as there is a room to increase the efficiency to fill the gap. Strong and effective linkage of farms to the market could provide incentives towards increasing their efficiency in milk production and thus greater returns.

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