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Determinants of Technical Efficiency of the Dairy Farmers in Ada'a District of Oromia State, Ethiopia

Research Article

L. Fita[1*], M.M. Trivedi[2], A.M. Patel[2], B. Tassew[1] and C.G. Joshi[2]

[1] Ambo University, Ambo, Ethiopia
[2] Anand Agricultural University, Anand, 388110, Gujarat State, India

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*Correspondence E-mail: yerulemma@gmail.com

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ABSTRACT

The study was conducted to indicate the determinants of technical efficiency of the dairy farmers in Ada'a district of Oromia state, Ethiopia. The study was arranged in four purposively selected peasant associations of the peri-urban and four kebeles of the urban dairy production sub-systems from which thirty dairy farmers were selected randomly. A total of two hundred forty respondents were personally interviewed using structured questionnaires to know the socio-economic characteristics of the respondents. The stochastic frontier production function of the Cobb-Douglas model was used to estimate the technical efficiency of milk production. The study revealed that mass media exposure of the dairy farmers, training on dairy farming, dry fodder and concentrate feeds were the significant determinants of technical efficiency of milk production in the study area. Organizational participation of the farmers, education level, labor and experience of the farmers in dairy farming had also positive effect on the technical efficiency of milk production. The results obtained with this study suggest that there is a need to strengthening the existing extension services to address the determinants of technical efficiency of the dairy farmers to bring about significant increase in milk production and a balance in demand and supply of milk production in the study area.

KEY WORDS dairy farmers, socio economic characteristics, stochastic production frontier, technical efficiency.

INTRODUCTION

In many studies of technical efficiency, the results are used to estimate the effects of various factors on inefficiency. These may be estimated using a two-step process in which the production frontier is first estimated and the technical efficiency of each farm, derived. These are subsequently regressed against a set of variables which are hypothesized to influence the farm's efficiency. This approach has been adopted in a range of studies (FAO, 2000). The analysis of efficiency estimates revealed that there were significant technical efficiency differences among the dairy farmers. The measurement of technical efficiency of a farm indicates that if a farm is successful in converting all the physical inputs into outputs and the efficiency of converting is equal to the frontier production function, then it is said to be an efficient farm and if a farm falls short of this requirement, then the farm is termed as technically inefficient farm (Reddy *et al*. 2008). A number of studies have suggested that efficiency of farmers is determined by various socio-economic and demographic factors (Kalirajan and Shand 1989; Boris and Laszlo 1991; Suzanne *et al.* 2000) and farm inputs (Saha and Jain 2004; Manoharan *et al*. 2004; Nega and Simeon 2006; Reddy *et al*. 2008).

Given a set of the existing technology and inputs, some farmers were able to achieve maximum technical efficiency in milk production while others were found inefficient. This divergence could be related to various factors. Therefore, it is important to identify the factors which influence the technical efficiency of the dairy farmers to further intervene and increase milk production in the study area.

MATERIALS AND METHODS

The study was conducted in Ada'a district of East Shoa Zone of Oromia state, Ethiopia. Ada'a district is located at about 45 km away from Addis Ababa, the capital city of the country. The district lies between longitudes of 38˚ 51' to 39˚ 04' East and latitudes 8˚ 46' to 8˚ 59' North covering a land area of 1750 km^2. The majority of the land (90%) is plain highland ranging between 1600 to 2000 meters above sea level.

The district has sub-tropical climate and receives 860 mm rainfall per annum. The overall mean minimum and maximum temperature of the area is 8 ˚C and 28 ˚C, respectively. The main rainy season occurs between mid June to mid September, followed by a dry season that might be interrupted by the short rainy season in February and March. The study was arranged in four purposively selected peasant associations (PAs) of the peri-urban and four kebeles (town administrative zones) of the urban dairy production sub-systems based on their better potential for milk production. Peri-urban and urban production sub-systems are the two different dairy production systems of the secondary towns in the country. Enumeration of all the households owing at least one crossbred milking cow and use stall feeding in each of the selected peasant association and kebele was made with the help of the development agents (DAs) in the respective selected areas. The number of crossbreds (BoranxHF) per household ranged from 1 to 5 cows. The parity of the cows ranged from 1 to 4 with an average milk yield of about 11.20 liters per cow per day. From each selected peasant association / kebele, thirty dairy farmers were selected randomly. A total of two hundred forty respondents were personally interviewed using structured questionnaires to know the socio-economic characteristics of the dairy farmers (age, education status, mass media exposure, extension contacts, organizational participation of the farmers, training on dairy farming and experience on dairy farming) in the study area. The amount of inputs used for milk production viz., green fodder, dry fodder, concentrate feed and output / milk yield were measured every fortnightly for three months. The averages of seven observations were taken as daily inputs and output (milk yield) to estimate the technical efficiency of milk production. Crop residues such as teff straw, wheat straw, maize stover, barley straw, chickpea straw and natural hay are the major dry fodders used for animal feeding in the area. Oats, vetch, elephant grass, maize and leguminous tree leaves like cajanus cajan and leuceania are some of the green fodders used for animal feeding in the area.

Average green and dry fodders consumed per cow per day were 4.92 and 6.33 kg, respectively.

The commonly used concentrate feed in the areas was a mixture of wheat bran, wheat middling and oil seed cakes (Noug and linseed cakes). Average concentrate consumed per cow per day was about 5.41 kg.

The following stochastic frontier production function of the Cobb-Douglas model (Battese and Coelli, 1988) was used to estimate the technical efficiency of milk production.

$$\ln Y_i = \beta o + \beta 1 \ln X_1 + \beta 2 \ln X_2 + \beta 3 \ln X_3 + \beta 4 \ln X_4 + \beta 5 \ln X_5 + V_i - U_i$$

Where:
ln: represents the natural logarithm.
i: 1, 2, 3……..n.
Y_i: total milk production in liters per cow per day.
βo: the constant term.
β1-β5: parameters to be estimated.
X_1: green fodder consumed per cow per day (kg).
X_2: dry fodder consumed per cow per day (kg).
X_3: concentrate feed consumed per cow per day (kg).
X_4: expenses for AI, Treatment and medicine (Birr).
X_5: labor spent per cow per day (man hour).
V_i: a symmetric random error.
U_i: half-normal error term.

The output oriented technical efficiency of the i^{th} farm, denoted by TE_i, can be estimated as the ratio of the observed output (y_i) and maximum potential output (y*):

$$TE_i = y_i / y^* = f(x_{ij}; \beta) \times \exp(v_i - u_i) / f(x_{ij}; \beta) \times \exp(v_i) = \exp(-u_i)$$

Where:
i, j: denote the farm and input respectively.
TE_i: technical efficiency of the i^{th} farm.
TI_i: technical inefficiency of the i^{th} farm.
exp $(-u_i)$: expected value of $-u_i$.

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

After the socio-economic characteristics of the farmers and technical efficiency of milk production were determined, the socio-economic characteristics viz., age, education level, extension contacts, organizational participation, mass media exposure, training on dairy farming, experience on dairy farming and farm input variables viz., green and dry fodder, concentrate feeds, labor and expenses for AI, treatment and medicine that are anticipated to cause variation in milk production efficiency were tested as the determinants of the technical efficiency.

The factors (independent variables) were chosen on the basis of intuition or past empirical studies. In order to find out the contribution made by each factor, the level of technical efficiency of the farmers was regressed on these factors.

The following simple linear multiple regression model was used to estimate the determinants of technical efficiency.

$$TE_i = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + b_{11} X_{11} + b_{12} X_{12} + e_i$$

Where:
TE_i: technical efficiency of the i^{th} farm.
X_1: age of the dairy farmer (years).
X_2: education level of the farmer.
X_3: extension contacts of the farmer.
X_4: organizational participation.
X_5: mass media exposure.
X_6: training on dairy farming.
X_7: experience on dairy farming (years).
X_8: green fodder consumed per cow per day (kg).
X_9: dry fodder consumed per cow per day (kg).
X_{10}: concentrate feeds consumed per cow per day (kg).
X_{11}: expenses on AI, treatment and medicine (ETB-Ethiopian birr).
X_{12}: labor spent per cow per day (man hour).
b_0: intercept term.
$b_1 \ldots b_{12}$: coefficients of the respective factors influencing the technical efficiency.
e_i: random error term.

RESULTS AND DISCUSSION

Maximum Likelihood Estimates (MLE) of stochastic frontier production function

The maximum likelihood estimates (MLE) of the Cobb-Douglas stochastic frontier production for peri-urban and urban production sub-systems are depicted in Table 1.

Though the estimated coefficient of green fodder was positive, it was found to be statistically insignificant in both the production systems which could be due to better availability of green fodder during the study period and therefore contributing less to the variation in milk yield.

The estimated coefficient of dry fodder was statistically significant in both the production systems which implies greater bearing of dry fodder on milk production. Concentrate feed had positive and highly significant ($P<0.01$) bearing on cow milk production in the urban area while it had positive and insignificant contribution on cow milk production in periurban area.

This could be attributed to better availability of green and dry fodders in the peri-urban area during the study period which could result in the reduction of concentrate supplementation.

In the present study since the log-linear model was employed, the coefficients represent elasticities of milk production with regard to respective inputs. Therefore, dry fodder which had the greatest overall coefficient (0.1899) had the greatest contribution to milk production in the study area (Table 1).

It is also interesting to note that concentrate feed had the greatest coefficient (0.3618) in urban area and hence greatly contributed to milk production. A high value (0.9325) of gamma (γ) estimate indicates the presence of significant inefficiencies in milk production. That means about 93 percent of the differences between the observed and maximum production frontier outputs were due to farmers' inefficiencies which are in the control of the farmers and can be reduced to enhance technical efficiency of the farmers in the study areas. Only about 7 percent of the variation was attributed to random error outside the control of the farmers.

The mean technical efficiencies of milk production of the peri-urban and urban dairy farmers were found to be about 67.47 and 63.06 percent, respectively. The overall mean technical efficiency of milk production of the dairy farmers in the study area was about 65 percent.

The low technical efficiency obtained in the present study suggests that farmers in the study area were not using the available resources (resources used for milk production such as green fodder, dry fodder, concentrate feed, labor and expenses for AI, treatment and medicine) efficiently / judiciously as evident from about 35 percent inefficiency level of the farmers. This necessitates reallocation of inputs to maximize milk production in the area.

Determinants of technical efficiency

The analysis of technical efficiency estimates revealed that there were significant technical efficiency differences among the dairy farmers as indicated in previous section. Given a set of the existing technologies and inputs, some farmers were able to achieve higher technical efficiency in milk production while others were found inefficient. This divergence could be related to many factors.

Therefore, it is important to identify the factors which influence the technical efficiency of the dairy farmers to further intervene and increase milk production in the study area. A number of studies have suggested that the technical efficiency of farmers is determined by various socio-economic and demographic factors (Kalirajan and Shand, 1989; Boris and Laszlo, 1991; Suzanne *et al.* 2000) and-farm inputs (Manoharan *et al.* 2004; Saha and Jain, 2004; Nega and Simeon, 2006; Reddy *et al.* 2008).

In the present study, the variables tested as the determinants of technical efficiency were chosen on the basis of past empirical studies. In order to find out the contribution made by each factor, the level of technical efficiency of the farmers was regressed on these factors. The results of regression analysis are presented in Table 2. The regression of technical efficiency with each socio-economic and input factor is hereby discussed separately as under.

Age of the dairy farmers

Age of the respondents had ranged from 23-82 with an average of 44.95 years.

Out of the 240 farmers, only 23 farmers (9.58 percent) were found to fall under the young age group (up to 30 years) while 39 farmers (16.25 percent) were found to be under the old age group (greater than 55 years) (Table 3).

The value of the estimated coefficient of age of the farmers was found to be negative in both the peri-urban and urban areas indicating that farmers with older age were found to be technically less efficient in producing milk. This could be related to the fact that old aged farmers are reluctant to adopt improved dairy husbandry practices that could contribute much in explaining variation in technical efficiency of milk production. It can be inferred that, young and medium aged farmers were better in utilizing the inputs efficiently to convert into milk. The present finding is supported by the findings of Nganga *et al.* (2010) who had reported that aged farmers tend to be technically less efficient in producing milk.

Education level of the farmer

Though not significant, the values of the estimated coefficient of education level were found positive in both periurbn and urban areas (Table 2), indicating that the higher the education level, the higher would be the technical efficiency of the farmer. Education levels of the respondents in the two production systems are depicted in Table 4. The educated farmers might have followed and implemented the technology in a better way and achieved higher technical efficiency. The present finding is in accordance with the findings of Suzanne *et al.* (2000), Reddy *et al.* (2008) and Nganga *et al.* (2010) who had reported that farmers with hi-

Table 1 Maximum likelihood estimates (MLE) of stochastic frontier production function for peri-urban and urban sample dairy farmers[1]

Parameters	Peri-urban (coefficient)	Urban (coefficient)	Overall (coefficient)
B_0 (Constant)	2.2412** (0.1777)	1.5243** (0.4507)	2.1233** (0.1718)
B_1 (Green fodder)	0.0344 (0.0650)	0.0463 (0.0784)	0.0026 (0.0502)
B_1 (Dry fodder)	0.2111** (0.0692)	0.2444* (0.0972)	0.1899** (0.0554)
B2 (Concentrate)	0.0136 (0.0577)	0.3618** (0.1048)	0.1294** (0.0480)
B3 (Expense for AI, treatment and medicine)	-0.0576 (0.0335)	-0.0934* (0.0222)	-0.0781** (0.0173)
B4 (Labor)	0.0726 (0.0781)	0.1679 (0.1822)	0.0608 (0.0689)
Sigma squared (σ^2)	0.3254** (0.0506)	0.4739** (0.0628)	0.4035** (0.0402)
Gamma (γ)	0.9311** (0.0433)	0.9457** (0.0280)	0.9325** (0.0247)
Log likelihood	-77.0777	-115.3055	-201.7019
Mean TE (%)	**67.47**	**63.06**	**65.11**

[1] Figures in parentheses indicate standard error.
* P<0.05 and ** P<0.01

Table 2 Determinants of technical efficiency

Variables	Peri-urban		Urban		Overall	
	Coefficient[1]	S.E	Coefficient	S.E	Coefficient	S.E
Constant term	54.668**	16.417	17.109	23.569	46.471**	12.742
Age of the dairy farmer (years)	-0.227	0.173	-0.085	0.191	-0.066	0.124
Education level of the farmer	0.258	2.991	1.389	3.000	1.836	1.942
Extension contacts of the farmer	-0.863	0.720	-0.352	1.645	-0.398	0.465
Organizational participation	1.683	2.418	5.801	3.097	2.806	1.834
Mass media exposure	2.497**	0.913	0.151	1.485	1.628*	0.749
Training on dairy farming	6.703	4.326	3.788*	1.822	5.122*	2.461
Experience in dairy farming (years)	1.170	2.418	3.146	2.958	0.591	1.863
Green fodder	0.322	0.828	-0.168	1.277	-0.122	0.693
Dry fodder	0.981	0.794	2.250*	1.082	1.078*	0.512
Concentrate feed	-1.597*	0.754	3.101*	1.259	-0.142*	0.062
Expenses on AI, treatment and Medicine	5.204	3.829	-6.054	3.135	-2.630	2.350
Labor	1.398	2.988	4.183	3.903	1.124	2.286
R^2	0.231		0.182		0.114	

[1] * P<0.05 and ** P<0.01.

gher level of education were technically more efficient in producing milk.

Education not only helps in better management decision, but also places the farmer in a better position to receive the needful information through mass media and other extension services (Tilak, 1993). The policy implication of this finding in milk production is that inefficiency in milk production can be reduced by improving the education level of the dairy farmers. Nowadays, the Government of Ethiopia is arranging basic education for adult non-educated farmers at their village levels. This initiative must be encouraged and must have continuity as it has positive impact in increasing milk production in the country.

Extension contact of the farmers

It is expected that farmers who have contacts with extension agencies will get the timely suggestions making themselves more efficient in the operation and milk production. The regression coefficient of extension contact was found to be negative in both the production systems.

This could be attributed to the fact that farmers who were using optimal combinations of inputs achieved better technical efficiency in spite of having no / less contact with the extension agents. Although respondents in the study area had better extension contacts, they are failed to achieve higher technical efficiency of milk production. This could be attributed to the fact that about half (48.75%) of the respondents in the study area had a primary level of education (Table 4) to better understand the improved dairy husbandry practices which could influence the efficiency of milk production.

It is suggested that extension advice and training on improved dairy husbandry practices should be in such a way that it is simple and more of practical oriented to give clear understanding on the improved practices to increase efficiency of milk production.

Organizational participation of the farmers

The participation of dairy farmers in various dairy farming related organizations could widen their horizons and contribute for better knowledge and adoption of improved dairy husbandry practices which could further improve the efficiency of milk production.

As expected, the regression coefficient of the participation of farmers in dairy related organization was found to be positive indicating that it has positive effect on the farmers' technical efficiency of milk production.

Thus, farmers who had participated in various dairy farming organizations had better technical efficiency of milk production. This is because, if the dairy farmers are member in dairy related organizations, they may have double advantages as they can be contacted as individual and as a group which could enhance their efficiency of milk production. It can be concluded that it is possible to increase the technical efficiency of milk production of the farmers by encouraging their participation in dairy farming related organizations.

Mass media exposure of the farmers

Farmers who have more exposure to mass media such as radio, television, newspapers, etc. would likely to acquire more knowledge and adoption on improved dairy husbandry practices that could improve the milk production efficiency of the farmers.

The regression coefficient of mass media exposure was found to be higher (b=2.497), positive and highly significant ($P<0.01$) in peri-urban area while it was positive but non-significant in urban area. The positive and highly significant regression coefficient of mass media exposure reveals that mass media is the most determinant of technical efficiency of milk production in the peri-urban area. This estimate shows that every 1-percent increase in the mass media exposure of the farmer would result in about 2.50 percent increase in the technical efficiency of milk production.

Training on dairy farming

Training on dairy farming (training given to farmers on some improved dairy husbandry practices) had positive and significant ($P<0.05$) effect on the technical efficiency of milk production of the urban dairy farmers. This finding is in conformity with the findings of Suzanne *et al.* (2000), Nega and Simeon (2006) and Reddy *et al.* (2008). Although the same training was arranged for urban and peri-urban dairy farmers, training had non-significant effect on the technical efficiency of milk production of the peri-urban dairy farmers. This could be attributed to the lower education level of the peri-urban farmers to better understand the improved practices as compared to urban farmers. It is suggested that the type of training given to farmers should take the education level of the farmers into account to enhance efficiency of milk production.

Experience in dairy farming

The experience of farmers in dairy farming had positive effect on technical efficiency of milk production in both the production systems (Table 2) implying that farmers with more experience had better technical efficiency in producing milk. This could be due to the fact that farmers learn more from their previous experiences of milk production and rectify them in the ensuing years to improve their technical efficiency of milk production. This finding is supported by the findings of Ortega *et al.* (2007) and Nganga *et al.* (2010).

Table 3 Age-wise classification of the dairy farmers in each production system

Production systems	No. of farmers in different age groups[1]			Total No. of farmers	Average age (year)
	Young (up to 30)	Middle (31-55)	Old (Above 55)		
Peri-urban	15 (12.50)	87 (72.50)	18 (15.00)	120 (100.00)	43.50
Urban	8 (6.67)	91 (75.83)	21 (17.50)	120 (100.00)	46.39
Total	23 (9.58)	178 (74.17)	39 (16.25)	240 (100.00)	44.95

[1] Figures in the parentheses indicate percentage to the total number of respondents.

Table 4 Distribution of the respondents according to their level of education in the two production systems

Production systems	Levels of education[1]			College	Total
	Illiterate	Primary (Up to grade 8)	Secondary / high schoo (Grade 9-12)		
Peri-urban	27 (22.50)	59 (49.17)	33 (27.50)	1 (0.83)	120 (100)
Urban	7 (5.84)	58 (48.33)	46 (38.33)	9 (7.50)	120 (100)
Total	34 (14.17)	117 (78.75)	79 (32.92)	10 (4.16)	240 (100)

[1] Figures in the parentheses indicate percentage to the total number of respondents.

Green fodder

Green fodder had positive and non-significant effect on the technical efficiency of milk production of the peri-urban dairy farmers which could be due to better availability of green fodder to the peri-urban farmers and thus contributing less to the variation in milk yield and technical efficiency. Green fodder had negative and insignificant influence on the technical efficiency of milk production of the urban dairy farmers.

Technical efficiency is a measure of overall resource use efficiency / optimal combinations of resources / inputs to achieve a given level of outputs. Some farmers are under utilizing the inputs used for milk production while others are over utilizing the inputs which is mainly related to availability of the inputs, price and lack of technical knowledge for optimum allocation of inputs which further leads to variation in efficiency of milk production among the dairy farmers. Therefore, the negative regression coefficient of green fodder indicates the tendency of over utilization of this input in urban area. This result is in agreement with the report of Rajendran (2005).

Dry fodder

The estimated coefficient of dry fodder was positive and significant ($P<0.05$) in urban area implying that increase in the amount of dry fodder will result in increase in the efficiency of milk production i.e. dry fodder is under utilized in urban area because of limited availability. This finding is in agreement with the findings of Saha and Jain (2004), Nega and Simeon (2006), Abid and Mushtaq (2008) and Tuna *et al.* (2010). Though not significant, it had also positive effect on the technical efficiency of milk production of the peri-urban dairy farmers.

Concentrate feed

Concentrate feed had negative and significant ($P<0.05$) effect on the technical efficiency of milk production in peri-urban area.

The negative regression coefficient of concentrate feed in peri-urban area implies that this input was either at its optimal level or exceeded its optimal level of utilization. Thus, any further increase in concentrate feed would result in decrease in the technical efficiency of milk production of the dairy farmers.

In the present study, optimum level, over and under utilization of the inputs were estimated based on the regression coefficient of the different inputs considered for milk production.

If the estimated coefficient of the input is positive and significant, it implies that increase in input significantly increase technical efficiency of milk production which indirectly indicates that the input is under utilized. In the same fashion if the estimated coefficient of the input is negative and significant, it implies that further increase in input decrease technical efficiency of milk production which indirectly shows that the input is either at its optimal level or exceeding the optimal level / over utilized. However, concentrate feed had positive and significant effect on the technical efficiency of milk production in urban area implying that further increase in this input would increase the technical efficiency of milk production of the dairy farmers i.e. this input was utilized at its sub-optimal level. This is because dairy farmers in urban areas are mainly depending on concentrate feeds for milk production due to shortage of green and dry fodders in the area.

Expenses on AI, treatment and medicine

Expenses on AI, treatment and medicine had positive and insignificant effect on the technical efficiency of milk production in the peri-urban area suggesting that there exists scope to further increase these inputs to increase the technical efficiency of milk production in the peri-urban area. However, in urban area, there was a tendency of over utilization of these inputs and any further increase in them would result in decrease in technical efficiency of milk production in the area.

Labor

The average labor spent per day was about 3.59 hours. The estimated coefficient of labor was positive implying that increase in labor spent per day for different dairy operations increase the efficiency of milk production in both the production systems. This finding is supported by the findings of Manoharan *et al.* (2004), Saha and Jain (2004), Rosiane *et al.* (2008) and Cabrera *et al.* (2010). Dwaipayan and Srivastavay (2008) and Tuna *et al.* (2010) had reported the negative effect of labor on the technical efficiency of milk production.

CONCLUSION

The estimates suggest that mass media exposure of the dairy farmers, training on dairy farming, dry fodder and concentrate feeds were the significant determinants of technical efficiency of milk production in the study area. Educational level of the farmer, organizational participation of the dairy farmers, experience of the dairy farmers in dairy farming and labor had also positive relationship with the technical efficiency of milk production. Therefore, there is a need for suitable interventions, specifically targeting the farms/farmers with low technical efficiency level by strengthening the existing extension services to address the determinants of technical efficiency to bring about significant increase in milk production in a study area in particular and in a country in general.

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