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DOES DAIRY FARM SIZE MATTER IN TECHNICAL EFFICIENCY? A CASE OF DAIRY PRODUCERS FROM DISTRICT LAYYAH, PUNJAB

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ABSTRACT

A study was conducted at Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad during the year 2012 to determine the factors effecting the technical efficiency of milk production in Punjab, considering various types of dairy farms, Pakistan. Primary data were collected from two tehsils of district Layyah, and 120 respondents were selected randomly from different villages. Stochastic production frontier approach was applied to determine technical efficiency of dairy farms. The findings reveal that coefficients of green fodder fed (0.25), concentrate cost (0.28) and labour hours (0.21) per animal were positive and statistically significant. The present study also reveal that institution factor such as veterinary services (-0.135) availed and the infrastructure factors namely the road condition (-0.117) from farm to market had significant impact on the technical efficiency of dairy farmers. The mean technical efficiency was around 86 percent, indicating that farm productivity can be increased by 14 percent without changing the input mix. On the basis of types of dairy farms, the commercial farms were more efficient (93.7 percent) than market oriented (85.7 percent) and subsistence (81.9 percent) farms. It is suggested that veterinary facilities such as appointment of full time veterinary officers, diseases monitoring and reporting, diseases diagnosis, quality control of vaccines and veterinary drugs, training and awareness of stakeholders and up-gradation of existing legal framework should be strengthened. Rural infrastructure should be linked to the urban markets for making easy and smooth transfer of inputs and outputs from both sides.

KEYWORDS: Stochastic frontier approach; technical efficiency; dairy producers; veterinary services; Pakistan.

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INTRODUCTION

Pakistan is an agro-based country where most (43.5%) of population lives in rural areas and directly or indirectly linked with agriculture. Livestock sector has a major contribution (55.1 percent) in agriculture value addition. Pakistan is characterized with a large livestock population. Population of major milk producing animals like buffalo and cow has reached to 32.7 and 36.9 million respectively (3).

Milk and meat are two very important products of livestock. Economic importance of milk in the country can be realized from the fact that value of milk produced annually is alone more than the total annual value of wheat and cotton and twice than that of sugarcane and rice together (15). Pakistan is the fourth largest producer of milk in the world and produces 33 billion liter of milk annually. Out of total milk produced about 97 percent is distributed and consumed in an informal way in cities and villages (14). However, Pakistan is not self-sufficient in milk production and a huge amount of milk is imported every year to meet the domestic demand for dairy products. It was also reported that an estimated gap of about 3.52 million tones of milk prevailed in the country during 2003 which is likely to be increased upto 55.48 million tons by the year 2020 (11).

Majority of farmers keep dairy animals for domestic purpose while small number of farmers rear livestock for commercial purpose. In Pakistan, dairy farming is not an independent activity like Europe and other developed countries but it is considered as a small component of agriculture farming. Farmers in Punjab practice mixed farming i.e. they rear some dairy animals alongwith growing crops on their farms. Farmers obtain 20 to 25 percent of their income from livestock while keeping an average herd size of 5 to 6 goats/sheep and 2 to 3 buffaloes (6). Further, small dairy farmers are unorganized, producing and marketing dairy products individually. The non-cooperative production and marketing is an obstacle in farm profitability. Poor management and breeding practices cause low productivity, due to which farm profitability and national productivity tends to be very low. It is estimated that small and poor farmers usually keep 1-2 dairy animals as a part of mixed farming system and constitute an overall of about 38 percent of total strength of milk animals (19).

Despite having a large population of livestock animals in Pakistan, milk production is very low as compared to other countries because of inefficient milk production system. This inefficiency is attributed to many socio-

economic factors which ultimately results in low milk production per animal. With the increase in population pressure it is the need of time to produce more from single animal unit to satisfy the needs of domestic consumers. One of the best ways to increase milk production to meet the growing requirements of consumers is to increase the efficiency in dairy sector and to minimize the gap between actual and potential output. The efficiency in dairy farming has the supreme importance for the survival of this sector and to cope with the changes which have been expected in coming years (20). Technological restraints, animal diseases, poor breed of milking animals, quality and quantity constraints of feed have been mainly emphasized in a number of studies. A little attention has been focused on an important source of growth, improving the technical efficiency of dairy farmers.

From policy point of view it is important to study farm efficiency and potential sources of inefficiency. On one hand, this information can be proved beneficial for farmers to improve their performance. On the other hand, policy makers can also use this knowledge to identify and target public interventions to improve farm productivity and profitability. So the present study was designed to determine technical efficiency and its determinants in milking animals, considering various types of dairy farms.

MATERIALS AND METHODS

This study was conducted at Institute of Agriculture and Resource Economics, University of Agriculture, Faisalabad during the year 2012. We used the cross-sectional data collected during 2012 from district Layyah. District Layyah was selected purposively for the present study because it is famous for the production of small and large ruminants and marketing of a large quantity of milk. It is also a multi-cropped area having all types of fodder fed to animals. Two tehsils of district Layyah Names of Tehsils were selected randomly then three villages were selected randomly from each tehsil. From each village, 20 respondents were selected randomly to make a total sample of 120 respondents. A sample of respondents greater than 100 is large sample and significantly explain the variation in the variables (12). Hence inferences drawn from this sample are significant, reliable and applicable. Due to this reason a minimum sample of 120 respondents (>100) was selected to conduct the study. Information on socio-economic characteristics and input and output from the sampled respondents was collected through a well-structured and pre-tested questionnaire.

The stochastic production frontier approach was used. This approach estimates the technical efficiency within a stochastic production, cost, or profit function model. This production frontier was initially developed for estimating technical efficiency rather than capacity and capacity utilization. However, the technique also can be applied to capacity estimation through modification of the inputs incorporated in the production (or distance) function. A potential advantage of the stochastic production frontier approach over DEA is that random variations in catch can be accommodated, so that the measure is more consistent with the potential harvest under "normal" working conditions. A disadvantage of the technique is that, although it can model multiple output technologies, doing so is somewhat more complicated, requires stochastic multiple output distance functions, and raises problems for outputs that take zero values (13). This approach is widely used in farm efficiency analysis (2, 9, 13).

The following model was estimated:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \varepsilon_i$$

Here Y is the milk production per animal per lactation (liters)
X_1 is the amount of fodder fed to a milking animal per lactation period (kg)
X_2 is concentrate per animal per lactation period (Rs)
X_3 is the amount of labor (hours) spent for all operations per animal per lactation period (labor hours)
X_4 is the farm size (acres)
X_5 is the total number of animals held by the farmer
Where β's are the parameters to be estimated and ε is the error term. This error term is decomposed into two components

$$\varepsilon_i = v_i + \mu_i$$

v_i is the symmetric error which is independent of μ_i, where μ_i is the non-negative random variable related with the technical inefficiency. Technical efficiency is measured on a scale form 0 to1, where higher values represent higher levels of technical efficiency. Technical inefficiency (μ_i) can be estimated by subtracting technical efficiency from one. The function determining the technical inefficiency is as:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6$$

δ's are the coefficients of the variables explaining technical inefficiency

Z_1 represents age of the farmer in years
Z_2 is education (schooling years)
Z_3 shows distance of market from the farm (km)
Z_4 is dummy variable. It is taken as 1 if road condition is good; 0 otherwise.
Z_5 is dummy variable with a value of 1 if veterinary services from qualified practitioner are available; 0 otherwise
Z_6 shows dummy variable. It is considered as 1 if credit facility availed; 0 otherwise

RESULTS AND DISCUSSION

Stochastic production frontier approach and inefficiency effects model was estimated using maximum likelihood estimation procedure. We followed the model developed earlier (6). In this model, inefficiency effects in a stochastic production frontier are a function of other explanatory variables.

The gamma and log-likelihood parameters are employed to test for efficiency and appropriateness of the model, respectively. The gamma tests whether observed variations in efficiency are simply random are systematic. The gamma (γ) is bounded by 0 and 1, where if gamma is zero inefficiency effects are not present in the model and if it is one then inefficiency exists and is not random.

The results show that there exist inefficiency effects among dairy farmers in the study area as confirmed by the generalized likelihood ratio test and significance of gamma estimate. The null hypothesis expressed in terms of inefficiency model is as under

$$H_o: = \gamma = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$$

If the null hypothesis is accepted at the given likelihood ratio, it concludes that there were no technical inefficiency effects in the stochastic frontier production function for the dairy farmers, otherwise it can concluded that there exists technical inefficiencies. Log likelihood ratio test is used to test the null hypothesis.

$$LL = -2\ ln[L(Ho)/L(H_1)] = -2\ [L(Ho) - L(H_1)] = -2[16.69-32.20.] = 31.01$$

LR (Ho) is the restricted traditional response function OLS in which the inefficiency effects are not present ($U_i = 0$) and LR (H_1) is unrestricted (stochastic) frontier function in the alternate. Value of the generalized likelihood ratio test is 31.01 with the critical value of 12.60. Thus the null hypothesis is rejected. This implies that traditional response function (OLS) is not an adequate representation of the data.

Maximum likelihood estimates of the parameters of stochestic production function model are given in Table 1. The coefficient of green fodder quantity fed to an animal is 0.25 with positive sign and statistically significant. It shows that with one percent increase in green fodder quantity there is 0.25 percent increase in output of milk per animal per lactation period, because green fodder is basic feeding requirement for each animal and its intake may enhance milk producing capacity of milking animal. Green fodders have considerable proportion of protein and are essential for the milking animals. This result is similar to those of Rauf (17).

The coefficient of concentrate cost per animal was found to be 0.28. It is also positive and highly significant at 1 percent level of significance. It means that with one percent increase in concentrate cost, would increase milk production of an animal per lactation period increases by 0.28 percent. It is logical because it is commonly known that with the in fat contents in daily feeding, milk production of milking animal increases. About 1 kg of concentrate per day is recommended for each 3 liters of milk Binici *et al.* (8) have reported similar results.

Table 1. Maximum likelihood estimates of stochastic production frontier approach.

Variable	OLS estimates	MLE coefficients
Ln (Amount of fodder)	0.326* (2.778)	0.253* (2.247)
Ln (Concentrate cost)	0.276* (4.141)	0.285* (4.457)
Ln (Labor time)	0.183* (2.487)	0.211* (2.916)
Ln (Farm size)	0.001^{ns} (0.031)	-0.031^{ns} (-0.700)
Ln (Total animal numbers)	0.104*** (1.839)	0.082^{ns} (1.459)
Variance parameters		
Sigma-square		0.047* (6.97)
Gamma		0.637* (8.05)
Log-likelihood function	16.698	32.204

"", "**", "***"Significant at 1, 5 and 10 percent, respectively ns= non-significant.*

The coefficient of labor hours per animal per lactation period is positively and significantly related with milk production with a value of 0.21. It indicates that one percent increase in labor hours spent would cause an increase of 0.21 percent in milk production because labor is very important input in dairy farming; if sufficient labor is employed on a dairy farm for the care and maintenance of animals, milk production of animals would be better as labor is involved in timely feeding and other activities.

The coefficient of farm size is 0.031 which is negative but it is not significant. The coefficient of total animal numbers per farm is also statistically insignificant.

It is observed that MLE for γ is 0.637 and is highly statistically significant. It is consistent with the theory that true γ value should be greater than zero. The value of γ is significantly different from one which shows that random error is also playing a significant role to explain the variation in dairy productions commonly observed for agricultural and dairy production processes. However, it should be noted that 63.7 percent of variation in yield is due to technical inefficiency and 36.3 percent is due to the stochastic random error.
The results of inefficiency effects model (Table 2). Show that coefficient of age of the farmers is negative and statistically insignificant. The negative sign indicates that with the increase in age of respondents, inefficiency in milk production of farms would decrease. Binici *et al*., (8) also found that age of respondents was negatively related with technical inefficiency.

The results further show that the coefficient of farmer's education is negative. It implies that with an increase in schooling years of farmer, the inefficiency of the farm will decrease. It means that an educated farmer is more adaptive and aware and has more rational behavior in decision making than the uneducated or less educated farmer. These findings are in line with earlier scientists (1, 16).

The coefficient of farm distance from market is also negative and statistically insignificant. The coefficient for road quality from farm to market is negative and statistically significant. Good infrastructure of roads makes the input supply and output disposal much easy which results in an increased efficiency.

Table 2. Inefficiency effects of stochastic production frontier function.

Variable	MLE Coefficients	t-ratio
Age	-0.001^{ns}	-0.453
Education	-0.005^{ns}	-1.196
Distance from Market	-0.0009^{ns}	-1.298
Road condition	-0.117**	-2.136
Extension staff contact	-0.135*	-2.445
Credit availability	0.080^{ns}	1.38

"", "**", "***"Significant at 1, 5 and 10 percent, respectively and ns = non-significant*

The coefficient of contact with extension staff has negative sign and it is statistically significant. It indicates that if a farmer remains in contact with the extension persons and gets proper extension services, he or she is more efficient than other farmers similar findings have also been reported earlier (14, 18, 20). The coefficient of access to credit has positive sign and is statistically insignificant.

Technical efficiency estimates of dairy farmers

An efficient farmer is assumed to have output on or near to the production frontier. A farmer nearer to the frontier is called more efficient than others having the same bundle of inputs. The distribution of technical efficiencies of dairy farmers (Table 3) show that there is a wide variation in the efficiency scores of the sampled dairy farmers. Minimum technical efficiency score is 68.54 percent while score of the most efficient farmer is found to be 98.08 percent. The mean efficiency score is 85.98 percent. It implies that on average milk production of the dairy farmers can be increased by 14.02 percent without changing the input mix.

Table 3. Technical efficiency estimates of dairy farmers.

Efficiency interval	Frequency	Percentage
65-75	20	16.66
76-85	33	27.5
86-95	44	36.66
above 95	23	19.16
Total	120	100
Overall efficiency		
Mean	85.98	
Minimum	68.54	
Maximum	98.08	

Data (Table 3) also show that out of total 120 respondents, only 16.67 percent have efficiency between 65 and 70 percent. Above 27 percent farms have efficiency score more than 75 percent and less than 85 percent. Similarly 36.66 percent farmers have efficiency in the range of 86-95 percent and remaining 19.16 are operating very near to the potential level of output i.e. 95-100 percent of technical efficiency. Rauf (17) reported mean technical efficiency level of 91.72 percent for the dairy farmers in Punjab.

Comparison technical efficiencies of different categories of dairy farmers

A comparison of technical efficiencies of different dairy farm categories (subsistence, market-oriented and commercial farmers) showed that technical efficiency is positively related to the dairy farm size in the sample area. The average technical efficiency of all farms was estimated to be 85.98 percent (Table 3) while average technical efficiency of subsistence farmers was 81.9 percent, for market oriented famers 85.7 percent and 93.7 percent

for the commercial farmers. The similar results were found by earlier (5, 10). The reason is that the commercial farmers are economically strong and use proper and timely feeding, breeding and management practices. They also have more milking animals on their farms and are more educated due to which they are capable of efficiently utilizing the genetic potential of the milking breeds. The data (Table 4) show that out of 46 subsistence farmers, 21.75 percent were lying in efficiency range of 65-75, 43.5 percent in the range of 76-85, 28 percent in between 86 - 95 while only 6.5 percent achieved more than 95 percent efficiency.

In case of market-oriented farmers 18.75 percent dairy farmers have efficiency between 65and 75, 23 percent in the range of 76 to 85 percent, 46 percent had efficiency between 86 and 95 and 12.5 percent had efficiency more than 95 percent. For commercial farmers only 4 percent respondents have efficiency in the range of 65-75, 8 percent were in the second range of 76-85, 34.5 percent in the range of 86-95 while more than half of the commercial farmers were found to be 100 percent technically efficient.

Table 4. Technical efficiency estimates of different categories of dairy farmers.

Efficiency Interval	Subsistence		Market Oriented		Commercial	
	Freq.	%age	Freq.	%age	Freq.	%age
65-75	10	21.75	9	18.75	1	4
76-85	20	43.5	11	23	2	7.75
86-95	13	28.25	22	45.75	9	34.5
Above 95	3	6.5	6	12.5	14	53.75
Total	46	100	48	100	26	100

Source: Author own's calculation

CONCLUSION

The study concludes that education was negatively related with technical inefficiency. It implies that with an increase in the schooling years of the farmer, inefficiency of the farm will decrease. It means that an educated farmer is more adaptive and aware and has more rational behavior in decision making than uneducated or less educated farmer. Farmers having access to veterinary services were technically more efficient. It indicates that if a farmer remains in contact with the experienced and qualified veterinary doctors and gets proper and timely veterinary services, he is more efficient than other farmers. The average technical efficiency of all farms was estimated to be 85.98 percent while average technical efficiency of subsistence farmers was 81.9 percent, for market oriented famers 85.7 percent and 93.7 percent for the commercial farmers.

It is recommended that veterinary facilities should be strengthened such as availability of veterinary officers all time, use of recommended breed for artificial insemination and modern equipment, diseases monitoring and reporting, diseases diagnosis, quality control of vaccines and veterinary drugs, up-gradation of existing legal framework and training and awareness of stakeholders, etc. Improved rural infrastructure such as access to market through improved road network can work in improving technical efficiency in dairy farming as farmers would be able to purchase inputs and sell output easily at reasonable prices with better infrastructure facilitates and access to information and the latest technology.

Subsistence dairy farmers are common in study area in particular and in Punjab province in general. Such dairy farmers are characterized with small landholdings, poor credit accessibility, subsistence production and thus low living standard. The present study also shows that subsistence farmers have low efficiency score compared to market-oriented and commercial farms. The time has reached to uplift subsistence farmers through providing credit and other facilities in improving technical efficiency. Increased technical efficiency would lead to increased dairy production, resulting in increased income level of such farmers.

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Maqsood Hussain	**:**	**Helped in data analysis and interpretation of results**
Khuda Bukhsh	**:**	**Provided useful comments in critical evaluation of research paper**
Muhammad Ayub	**:**	**Helped in data collection**
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