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RESEARCH ARTICLE

Technical Efficiency Analysis of Milk Production in Khyber Pakhtunkhwa Province: A Stochastic Frontier Approach

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ABSTRACT

This study was carried out in three districts i.e Peshawar, DI Khan and Mansehra of Khyber Pakhtunkhwa during the year, 2010 with the basic objective to determine the technical efficiency of milk production. The data from 300 livestock farmers (100 from each district) was collected by using multi-stage sampling technique. Herd size, dry fodder, green fodder, concentrate/oil seed cake, hired labor, permanent labor, medicine and vaccination cost and fees were the major determinants that affected milk production. The estimated value of γ is 0.70, implied that if the livestock farmers were operated at full efficiency level they could reduce their input use by 30 percent without any reduction in the level of output and with the existing technology. The results of the study showed that rising age of livestock farmers was cause of decline in the efficiency and is recommended that the Government policy should focus on ways to attract and encourage young people who are agile and aggressive in dairy business. Results also revealed that farmers having more experience were more efficient than those having comparatively less or no experience. Finally more focus should be given on education as high level of education of farmers has positive effect on their technical efficiency.

INTRODUCTION

The importance of dairy industry in the world cannot be over emphasized since it contributes significantly towards the economies of many countries. Dairy industry is a dynamic sub-sector and is a main source of livelihood for millions of households all over the world particularly in developing countries. The total world milk production increased from 526.5 (million tons) in 1991 to 695.68 (million tons) in 2010. Thus, in the last twenty years, increase in total milk production was significant whereas the average annual increase was 2.5%. Out of the total 35% of world milk is produced in Asia followed by Europe which contributes 33.47% towards total milk supply. The strongest growth was observed in Asia, notably in China and India (FAO, 2010).

In livestock products milk is the most important commodity which provides relatively quick returns for small-scale livestock keepers. It provide basic nutrient to household and key element in food security. Milk is mainly produced by rural households who keep either cattle, buffalo, goats and sheep or a few of each in combination. The largest proportion of milk (80%) in Pakistan is produced by small farmers, majority of whom are landless. The primary objective of these producers is to produce sufficient quantities of milk for their own use and to sell the surplus to augment household income (Khan, 1994). In terms of total milk production Buffalos and cows contributed 66.1% and 31.4% of milk by volume respectively during 2009-10 (GOP, 2010a). The above data shows that major part of milk is produced by buffalo and cow, however goat and sheep contribute towards total milk supply in the country.

The importance of livestock sector is relatively more in Khyber Pakhtunkhwa compared to other provinces. In Khyber Pakhtunkhwa the livestock played a vital role

of its contribution of Rs. 62.8 billion to the national exchequer. In the total 74521 square kilometers are the geographic area of our country, Khyber Pakhtunkhwa possess 700 km long and 145 km wide range of hilly land providing grazing land for livestock of sedentary farmers, semi-nomadic and nomadic shepherds (Sadiq et al. 2003). Moreover, the livestock in Khyber Pakhtunkhwa contributes 57.5% towards provincial GNP. This shows that livestock is significant part of the Khyber Pakhtunkhwa economy. In Khyber Pakhtunkhwa total milk production during the year 2009-10 was 5.044 million tons while per capita availability was 141 kg per annum which is higher as compared to national level. Khyber Pakhtunkhwa is milk deficit province and relies on milk from Punjab. Like other farm products, the milk production has not been researched adequately in Pakistan.

There are three possible ways to increase milk production i.e. are by developing and adopting new technologies, by decreasing cost of inputs or by improving management practices (Garcia et al., 2003).The ways to increase milk production by adoption of new innovation is a long term process and it needs more funds to be allocated for research and development. On the other hand, mostly the farmers in Pakistan are illiterate, conservative and traditional (GoP, 2010b). These factors hinder in diffusion and adoption of new technology at farm level. Empirical studies indicate that potential of new technologies has not been fully exploited due to inefficient decision making process at farms. Aspect relating to farm management practices is the most key factor responsible for not fully utilization of potential of new technologies. Moreover, the introduction of new technology is not a single time phenomena as improvement and innovation in new technology is a continuous process. Disequilibria will result due to introduction of new technologies at the farm because introduction of technologies is a continuous process for a long period of time (Kebede, 2001).

In this study the main focus is given on estimation of technical efficiency by estimation ofthe cost and net revenue and technical efficiency of milk production in Khyber Pakhtunkhwa Province. Also to estimate the impact of socio-economic and farmers specific factors on technical inefficiency of farmers and to suggest policy measures to improve the technical efficiency of livestock farmers.

MATERIALS AND METHODS

Description of the universe

For this study Peshawar, DI Khan and Mansehra were purposively selected since major milk producing district in Khyber Pakhtunkhwa. Khyber Pakhtunkwa host 5.986 million and 1.92 and 9.619 million cattle, buffaloes and goat respectively. In addition, the geographical location of these district is such that could give fair representation to each zone of the province.

Data collection procedure and sample size

This research was based on primary data as well as secondary data. The primary data was collected through questionnaire, while the secondary data was amassed from various published and unpublished sources. In the light of study objectives a questionnaire was prepared and pre test in the field. The primary data regarding buffaloes and cow milk was collected directly from 300 sampled respondents.

Sampling technique

A multi stage sampling technique was used for the selection of the sample/respondent. In first stage three districts were selected purposively which have more livestock population i.e Peshawar, DI Khan and Mansehra. Peshawar, DI Khan and Mansehra has 143481, 205634, 191064 and Buffalos respectively. Similarly these districts host 223150, 411432 and 181973, 67208, 248491 and 86729, 265272, 583923 and 316759 and cows, sheep and goats in the same order Majority of the farmers of these districts keep livestock for agricultural purposes as well as to supplement their income. Total milk from Buffalo in DI Khan, Mansehra and Peshawar was 307927, 739765 and 651967 liters respectively during 2006; whereas, milk from cow was 474676, 676686 and 262773 liters in the same order (GO KP, 2010).

In second stage one tehsil/town was taken randomly from each selected districts. The randomly selected tehsils /town were Town-1, Paharpur and Mansehra from districts Peshawar, DI Khan and Mansehra respectively. In stage third from each selected tehsil two union councils were selected randomly. In fourth stage from each union council one village was randomly selected. A pilot survey was carried out for village selection with the help of livestock Assistant of Directorate of Livestock & Dairy Development Department, Government of Khyber Pakhtunkhwa and 60 respondents, 10 from each village was selected.

Then the sample size for this study was estimated by using the formula as follows (Cochran, 1977):

$$n \text{ is } (S * Z_{\alpha/2} / e)^2 \quad (1)$$

Where,

- n is Total sample size
- S is Standard deviation of milk yield (per annum) is 423
- Z (α/2) is 1.96; the value of standard normal variate at 95% confidence level
- e is Error (sampling error) is 48
- n is 298.33 ≈ 300

Out of this estimated 300 sample size, 100 respondents from each district were selected through proportional allocation sampling technique. List of farmers who keeping livestock in each village were prepared with

the help of Livestock Assistant. From this list sample size in each village was selected as follows (Cochran, 1977):

n_i is $n/N \times N_i$ (2)

Where,

- n_i is Number of sample respondents in ith village of each District
- n is Total sample size
- N_i is Total number of livestock farmers
- N is Total number livestock farmers in each District

Model specification for technical efficiency

The first problem encountered with specification of production function is the choice of functional form. It is desirable to choose simple and flexile functional form, which meet the economically reasonable restriction and does not present unreasonably complex estimation problems (Fuss and Mundlak, 1978). In practice these requirements are difficult to fulfill.

Technical efficiency was estimated within the framework of Cobb-Douglas stochastic frontier production function. Cobb-Douglas stochastic frontier production function was estimated by using Maximum Likelihood Estimation (MLE) technique. The Cobb-Douglas stochastic frontier production function for this study is expressed as follows:

$$\ln Q_i \; \beta_0 + \sum_{i=1}^{n} \beta_i \ln X_i + \epsilon_i \quad (3)$$

Where,

Q is total milk produced per animal per annum, X_1 is Herd Size in number, X_2 is Quantity of dry fodder per animal per annum; X_3 is Quantity of green fodder per animal per annum; $X_4$is Quantity of concentrate per animal per annum ; $X_5$is labor number per animal per annum; $X_6$is Expenditure on health care per animal per annum, ϵ_i is composed error term, β_0 is Intercept and β_i is Parameters to be estimated

Technical Inefficiency Estimation

For the estimation of technical inefficiency it is assumed that v_i is distributed as N $(0, \sigma^2_v)$ and u_i is half normal distributed.

Technical inefficiency model is expressed as follows:

$$\mu_i \; \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta 3 \; Z_{3i} + \delta 4 \; Z_{4i} + \omega_i \quad (4)$$

Where Z1i is Education of the ith farmer in years , Z_{2i} is Age of the ith farmer in years , Z_{3i} is Family size of the ith farmer in years, Z_{4i} is Farming experiences of the ith farmer in years and δ_0 and δ_i are the parameters to be estimated.

RESULTS AND DISCUSSION

Distribution of livestock population in the study area

Table 2 gives explanation of distribution of livestock population in the study area. Data depicted that farmers kept livestock in varying numbers. Buffaloes, cattle, goats, sheep and asses were raised in the study area. In Khyber Pakhtunkhwa, Buffaloes were 43.65% followed by cattle (30.52%), goats (18.65%), sheep (5.23) and asses (1.63%).

Milk production per day per animals

Table 3 shows that highest average milk production per day was 6.71 liter produce by buffaloe followed by cow (6.02 liters) and goat (1.16 liter).

Cost of milk production

Cost of production of milk includes various expenses incurred on different inputs needed and operations involved in the production process; these are dry fodder, green fodder, con/oilseed cake, hired labor, permanent labor, medicine and vaccine, fees by VO/SA and other cost.

Table 4 shows that on average, total cost of milk production per all three milch animal in all three districts are Rs. 14548. The major cost items are dry fodder (Rs 3714), green fodder (3514), concentrate/ oilseed cake (Rs 4496), hired labor (411), permanent labor (Rs 334), Medicine and vaccination (Rs 838) fees by VOA/SA (Rs 481) and other cost (Rs. 227).

Revenue from milk production

Revenue from milk production of all milch animal as well as individual animal has been worked out. Gross revenue is estimated as total milk produce multiplied by the price per liter. The cost of production is then subtracted from gross revenues to arrive at net revenues. Table 5 shows that on average, the average revenue for milk production all three district was estimated as Rs. 26700, Rs. 23067 and Rs. 631 from buffalo, cow and goats respectively.

Estimation of technical efficiency

For the analysis, two models were estimated. The Model I is traditional response model which is the assumption that there exist no inefficiency effect and

Table 1: Number of Respondents in Selected Villages of the Study Area

Districts	Villages	Population (Livestock farmers)	Sample Size	Sample Size (in each district)
Peshawar	*Phandu Payan*	120	39	100
	Chua Gujar	190	61	
DI Khan	*Rangpur*	170	53	100
	Mandrik Kalah	150	47	
Mansehra	*Eid Gah*	115	54	100
	Dhodiyal	98	46	
Total		843	300	300

Source: Government of Khyber Pakhtunkhwa, 2009-10

Table 2: Distribution of Livestock Population in the Study Area

Kinds	No.	%
Buffaloes	1526	43.65
Cattle	1067	30.52
Goat	652	18.65
Sheep	183	5.23
Asses	57	1.63
Camel	11	0.31
Total	3496	100.00

Source: Field Survey

Table 3: Average milk production per day per animals

	Kind of animal		
	Buffaloes	Cattle	Goat
Mean (Liter)	6.71	6.02	1.16
Standard Deviation	3.03	2.42	4.39

Source: Field Survey

consider the special case of stochastic frontier production function model in which the total variation of output from the frontier output due to technical inefficiency is zero, that is, $\gamma = 0$. The Model II is general model which reflect that there is no constraint and thus $\gamma \neq 0$. Table 7 presented Maximum Likelihood Estimate (MLE) result obtained from STATA. The Maximum Likelihood Estimation function for all animals for all district showed that the influence of the entire explanatory variable except labor on milk production was positive and statistically significant. The value of the estimate of log likelihood ratio (-304.87) was significantly different from zero, which followed Chi-square distribution indicating goodness of fit of model. The estimated value of elasticities for these variables indicated that one percent increase in value of herd size, dry fodder, green fodder, concentrate and health cost would raises the milk yield by 0.22, 0.18, 0.161, 0.15 and 0.20 percent respectively. These figures depicted that milk yield was highly response to these factors. It suggested that the infrastructure facilities need to be strengthened in terms of fodder production, artificial insemination with frozen semen, health care and extension agencies. The services of extension agencies are very much required for further development in the sector concerned, in this area. The estimated value of γ is 0.70, implied that if the livestock farmers were operated at full efficiency level they could reduce their input use by 30 percent without any reduction in the level of output and with the existing technology.

Technical inefficiency effect model

Socioeconomic, demographic, environmental, institutional and non-physical factors are expected to effect the efficiency (Kumbhakar and Bhattachery, 1992). The technical inefficiency effect model for buffalo, cow, goat and all animals in all districts shows that the shortfall observed in output from the frontier output is due to primarily the factors within the control of the farmers. These factors are education level, age of farmer, family size and experience in year. The results of the inefficiency effect showed that the coefficient of education, family size and experience in year was estimated to be negative and significant. This indicates that these factor increase efficiency of the farmers. The predicted coefficient of age of farmer was positive and significant implying that increasing these factors efficiency decrease.

Table 4: Cost of milk production

Animal	Variables	Unit	Quantity	Price/Unit	Amount
Buffalo, Cow and Goat	Dry fodder	Kg	666.4567	1193.107	3714
	Green fodder	Kg	950.6333	508.9367	3514
	Con/oil seed cake	Kg	179.06	1705.003	4496
	Hired Labor	No	51.6	252.6667	411
	Permanent Labor	No	51.45	237.6667	334
	Med and Vacc	Rs.	--	--	838
	Fee by VOA/SA	Rs.	--	--	481
	Other	Rs.	--	--	227
	Total	Rs.	--	--	14548

Table 6: Revenue of milk Production per year

Variables	Unit	Buffalo	Cow	Goat	All animal
Quantity of milk	Liter	1299.8	1145	93.9	846.2
Price/Liter	Rs.	36	34	22	31
Value of Milk	Rs.	46717	39159	2052	29309
Cost of milk production	Rs.	20017	16092	1421	12510
Cost of milk production/Liter	Rs.	19.3	18.3	22.7	20.1
Average Revenue	Rs.	26700	23067	631	16799

Table 7: Maximum likelihood estimates of stochastic frontier production function

Variables	Parameters	Model-I	Model –II
Constant	B_0	3.05(11.26)	3.21(7.98)
Ln Herd Size (No)	B_1	0.55(1.248)	0.22(4.62)
Ln Dry Fodder (Kg)	B_2	0.55(1.35)	0.18(3.49)
Ln Green Fodder (Kg)	B_3	0.54(9.822)	0.161(4.89)
Ln Concentrate/oil seed cake (Kg)	B_4	0.13(2.107)	0.15(6.81)
Ln Labor (No)	B_5	-0.35(-7.28)	-0.17(-4.24)
Ln Health care cost (Rs)	B_6	0.28(8.26)	0.20(4.04)
Technical Inefficiency function			
Constant	δ_0	0	-2.75(-11.03)
Education level	δ_1	0	-0.011(-4.01)
Age of farmer	δ_2	0	0.41(3.56)
Family Size	δ_3	0	-0.93(-2.41)
Experience in year	δ_4	0	-0.81(-1.41)
Sigma-U	σ_u	0	0.37
Sigma-V	σ_v	0	0.24
Lemda	Λ	0	1.54
Gamma	Γ	0	0.70
Log likelihood function	Llf	-129.09	-304.877

Source: Authors calculation from STATA; Value in parentheses are t-ratio at 5 percent level of significance

Frequency distribution of technical efficiency of individual farmers in statistical frontier production function

The technical efficiency of individual farmers is defined as ratio of observed output to the corresponding frontiers output, conditional on the level of input used by the farmers. Hence the technical efficiency of the individual livestock farmer is expressed as:

TEi = Qi / Qi*

Where: Qi is the observed output and Qi* is the frontiers output. The TE ranges between 0 and 1 that is 0 d TEd 1.

Table 7 shows the frequency distribution of individual farmers of all milch animals in all three districts. The mean technical efficiency was estimated as 73 percent. The results show that mostly (42 percent) of respondents lied between (50-59) efficiency ratings.

Conclusions and Recommendations

The result of the analysis indicate that the technical efficiency was 0.70, implied that if the livestock farmers were operated at full efficiency level they could reduce their input use by 30 percent without any reduction in the level of output and with the existing technology. It is also important that the role of achieving higher efficiency levels on output, productivity gains stemming from technological innovations remain of critical importance in livestock sector. Hence, research efforts directed toward the generation of new technology should not be neglected.

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