PRODUCTION CHARACTERISTICS AND TECHNICAL EFFICIENCY OF BUFFALO FARMING IN THANAMALWILA VETERINARY DIVISION, SRI LANKA

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Abstract

Buffalo accounts for a reasonable proportion in the livestock sector in terms of dairy production in Sri Lanka. This study was conducted to identify the important socio-economic determinants and to estimate the technical efficiency of buffalo farming in Thanamalwila veterinary division, Uva Province, Sri Lanka. A sample of fifty buffalo farmers were selected by multi stage sampling. Maximum likelihood estimation was used to determine the stochastic production function of average daily milk production per animal. Breed, average birth weight, shed condition, grazing duration, labor power, frequency of water given, cost of farming and feeding were used as the variables of production function. Breed, birth weight and labor power were the significant variables of Cobb-Douglas function. Monthly income was the only significant variable in technical inefficiency. Frequency of receiving extension services had a great impact in determining the efficiency of buffalo farmers. Buffalo farmers operate with an average of 86.8% technical efficiency. The milk production could be increased by13.2% through better use of extension services and given the current state of technology with extra investment over introducing exotic breeds, quality feeds and adequate labour power. The key findings of this study would help in policy formulation to promote the technically efficient buffalo farming in the area.

Keywords: *Technical efficiency, stochastic frontier production function, Cobb-Douglas model.*

INTRODUCTION

In Sri Lanka almost 30% of land is allocated to agriculture industry. Livestock is spread throughout all regions of Sri Lanka with concentrations of certain farming systems in particular areas due to cultural, market and agro climatic reasons (Ministry of livestock and rural community development, 2012a). Livestock plays a vital role in rural economic development in Sri Lanka. The total contribution of livestock sector to national GDP in 2015 was around 0.6% (Annual report DAPH, 2015). Dairy sector is the most important livestock subsector. Dairy farming is acceptable to ethnic cultures compared to the acceptability of other livestock subsectors such as poultry and swine. Domestic dairy industry has capacity and capability of producing substantial amount of quality milk and milk products (Ministry of livestock and rural community development, 2012b). In 2015 buffalo population in Sri Lanka was record as 323080 animals (Department of Census and Statistics, 2016). In 2015 total domestic annual milk production reached to 5,754,300 liters (Ministry of livestock and rural community development, 2012a). Also Sri Lanka annually spends approximately 34,088 million rupees to import dairy commodities (Central Bank Annual Report, 2016).

Uva province can be recognized as one of the largest milk producing province in Sri Lanka. In 2016, the third highest buffalo population was recorded from the Moneragala District and it was 33610 animals followed by the

Hambanthota and Anuradhapura (Department of Census and Statistics, 2016). Moreover, the area accounts for 15522.08 ha of natural grasslands, 50.75 ha of water logging areas and 123.86 ha of lagoons which can be mentioned as available potentials for livestock in Thanamalwila veterinary region (DAPH annual report, 2012). Even though equal amount of resources have been supplied, output of different farms may change from each other due to variation of the efficiency of different farm units. In the process of making economic policies, it is essential to know that how far particular firm can be expected to increase the output by increasing its efficiency within the constant level of resources (Ferrell, 1957). Further the frontier production functions help to fill the gap between theory and empirical work (Aigner et al., 1976). The limited information available under the prevailing conditions of national data bases does not support for the policy makers to assess the potential to expand the buffalo farming which can greatly influence to uplifting of the livelihood of communities in the area in particular and economic growth of the country at large. Hence, this study was focused to identify the important socio-economic determinants and technical efficiency of buffalo farming of the region relevant to the Thanamalwila Veterinary Division in Uva Province to fill the gap in the sector and facilitate the policy making process.

MATERIALS AND METHODS

Description of the study area, sampling technique, method of data collection

Study was conducted in Thanamalwila veterinary division (6.4397 Latitude Longitude 81.1333 and Mean Sea Level 66 m), Monaragala Administrative District in Uva Province, Sri Lanka. Fifty buffalo farmers were selected using multi stage sampling method where an individual farmer was considered as the sample unit. A random sample of buffalo farmers who were rearing buffalos as primary or secondary source of income were included in the field survey. The number of farmers selected were based on the population distribution in each GN division in Thanamalwila veterinary division. A pre-tested structured questionnaire was used to collect the primary data.

Dependent variable of the study was measured using average milk production of liters per animal per day (L animal-1 day-1). The independent variables of the study, age, education level, labor power, herd size, experience, breeds were formulated based on the responses made for respondent's age (years) at the time of the study, five categorized level of education, labor hours per animal per day (labor hours animal-1day-1), total number of animals own by individual farmers, number of years involved in dairying, composition of buffalo breeds which each individual farmer reared, respectively at the time of study. The condition of the sheds were measured based on the area allocated for each animal, availability of waters and feeders, ventilation, drainage and waste removal systems.

Stochastic frontier production functions

The stochastic frontier production function has two error terms one to account for random effects (e.g., measurement errors in the output variable, weather conditions, diseases, etc. and the combined effects of unobserved/uncontrollable inputs on production) and another to account for technical inefficiency in production. The stochastic frontier production function used for the study is;

$$\boldsymbol{Y_i = f(X_i;\beta_i)\exp(\varepsilon_i)}$$

where $i = 1,2,\dots,N$(1)

Accordingly,

$\boldsymbol{Y_i}$ = Output of $\boldsymbol{i^{th}}$ firm,

$\boldsymbol{X_i}$=vector of inputs,

$\boldsymbol{\beta}$= parameter vector to be estimate and

$\boldsymbol{\varepsilon_i}$= error term.

$$\boldsymbol{\varepsilon_i = V_i - U_I}$$

$$i = 1,\dots,N$$

The $\boldsymbol{V_i}$ assumed to be independently and identically distributed as $\boldsymbol{N(0,\sigma_v^2)}$. Error component $\boldsymbol{V_i}$ represent the random errors. The error component $\boldsymbol{U_i}$ assumed to be independently distributed from $\boldsymbol{V_i}$, and to satisfy $\boldsymbol{U_i} \leq 0$. Error component $\boldsymbol{U_i}$ is non-negative random variable which is called technical inefficiency effect associated with the technical inefficiency of the farmer. Error $\boldsymbol{U_i}$ is obtained by truncation (at zero) of the normal distribution with mean $\boldsymbol{z_i \delta}$, and variance $\boldsymbol{\sigma^2}$. The technical inefficiency model can be expressed as follows

$$\boldsymbol{U_i = z_i\delta + W_i}$$

Accordingly, $\boldsymbol{z_i}$ is vector of explanatory variables associated with technical inefficiency of production of firm over time and $\boldsymbol{\delta}$ is and vector of unknown parameter to be estimated. The random variable $\boldsymbol{W_i}$ is defined by the truncation of the normal distribution with $\mathbf{0}$ mean and variance ($\boldsymbol{\sigma^2}$).

Maximum likelihood method used to simultaneous estimation of the parameter of the stochastic frontier model and the technical inefficiency model.

Empirical model for technical efficiency estimation

The following models were used in the analysis of stochastic production function and inefficiency model.

Cobb-Douglas model

$$\begin{aligned}\boldsymbol{ln\,Y_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i}} \\ \boldsymbol{+ \beta_4 lnX_{4i} + \beta_5 lnX_{5i}} \\ \boldsymbol{+ \beta_6 lnX_{6i} + \beta_7 lnX_{7i} + \beta_8 lnX_{8i}} \\ \boldsymbol{+ (V_i - U_i)}\end{aligned}$$

Where, "ln" denotes logarithms to base e , Y_i= Milk yield (L animal^{-1} day^{-1}), X_1= Breed, X_2= Average birth weight (kg), X_3= Condition of the shed , X_4= Grazing duration (hours day^{-1}), X_5= Labor allocation (hour animal^{-1} day^{-1}), X_6= Frequency of water given (number of times per day), X_7= Cost of buffalo farming (LKR per month), X_8= Value of feed, V_i= Random variable, U_i= Non negative random variables

The inefficiency model (Battlese and Coelli, 1995) used is as follow.

$$\boldsymbol{Ui = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + W_i}$$

Where, Z_1 = Age of the farmer (Year), Z_2 = Education level (Year), Z_3 = Monthly income level (LKR), Z_4 = Experience of the farmer (Year), Wi = Unobservable random variables.

RESULTS AND DISCUSSION

Demographical and socio-economic characteristics

Results of the gender analysis showed a clear demarcation between male and female famers indicating 100% involvement of males in buffalo faming. Reasons for 100% male involvement in buffalo management might be large herd size and the difficulties in finding feed for such a large number of animals as also decribed by Abeygunawardene and Abeygunawardene (1998a). Majority of farmers (30%) were belonging to 21-30 years age group. The results also clearly indicated that there was a negative correlation between education level and involvement with dairy farming activities. Reason might be the shifting of the job from farming to government or private sector ventures where farmers gain more financial income without taking a risk in farm failures. The major system of management in the area was extensive (94%) where there were few farms with semi-intensive (4%) and intensive (2%) system farming. Zero supplementary feeding, absence of housing and, free grazing was considered as dominant characteristics of the area. Abeygunwardena and Abeygunwardena (1998b) have also revealed that free-grazing extensive management system and semi-intensive management system as most widespread management systems across Sri Lanka. Supplying of concentrates to buffaloes is hardly practiced (2%) in the area where farmers considered cut and feeding and concentrate feeding as difficult tasks in buffalo farming given the relatively large herd size.

Five buffalo breeds and their crosses were identified in the area. However, majority of farmers (80%) have been rearing local buffalo and Murrah/Niliravi crossbreds. Herd size ranged between 2-185 animals where the majority of farmers (38%) were keeping 21 to 40 animals in their herds. Study showed that farmers tend to rear relatively large buffalo herds. Abeygunawardena and Abeygunawardena (1998a) also clearly stated that the average buffalo herd size in Sri Lanka was 22.5 animal and herd size ranged from 1-242 animal.

The average daily milk production in the area was 4.14 L /animal and 60% of farmers have recorded less than 4-6 L of milk per day. Maximum and minimum values for average daily milk production per animal were 2 L and 10 L, respectively in the sample. Results further demonstrated that using animals for draft power has significantly been replaced with agricultural machineries in the Thanamalwila veterinary Division.
Breed, average birth weight, breed and labor hour allocation per animal per month were the significant variables to determine the milk production according to the Maximum Likelihood Estimate (MLE) and Ordinary Least Square estimates (OLS), respectively (Table 1). The MLE coefficient for breed showed a positive value of 0.5830 and was significant at 1% level. Exotic River type buffalo breeds have considerably higher milk production compared to local type.

These result indicate that replacing of local buffalo type by exotic crossbred as a better option to increase the total herd milk production than keeping large herd of local type animal in Thanamalwila veterinary division. MLE coefficient for average birth weight was also significant in the region and it has impact on output of production function of the study. Birth weight of the animal is determined by the type of breed. In general, the exotic breeds tend to have high birth weight over local buffalo type.

Table 1: Estimates of stochastic production function- buffalo farming

Variable	**Coefficient**		**Standard error**		**p value**	
	OLS	MLE	OLS	MLE	OLS	MLE
Breed	0.4768^{**}	0.5830^{***}	0.1834	0.1428	0.013	0.000
Birth weight	0.5367	0.6169^{**}	0.3802	0.2856	0.166	0.031
Shed condition	-0.1626	-0.2230	0.1798	0.1375	0.371	0.105
Grazing duration	-0.0047	-0.0833	0.2994	0.2237	0.988	0.709
Labour hours	0.0941^{*}	0.2054^{***}	0.0528	0.0564	0.082	0.000
Frequency of water supply	0.0086	0.1461	0.1152	0.1183	0.941	0.217
Cost of buffalo farming	0.0341	0.0187	0.0275	0.0217	0.223	0.391
Feeding method	0.0954	0.0570	0.2038	0.1674	0.642	0.733
Cons	-1.1127	-0.7375	1.5874	1.1581	0.487	0.524

OLS= Ordinary Least Square estimation MLE= maximum Likelihood estimation
*Significant at 10% **Significant at 5% ***Significant at 1%

Moreover, nutrition during dry period is important for proper body condition score of the pregnant animal and delivering a calf with acceptable and healthy birth weight. Daily allocation of labor hours per animal on buffalo farming is significant at 1% significant level with 0.2054 of positive coefficient. It indicates that labor power allocation in buffalo management as a determinant of the output of the production function. Buffaloes are managed as large herd and increasing the numbers of man hour allocation will help to give more attention individually on each animal. Getting animals to good grazing land, providing water for animal, milking can be considered as difficult and labor consuming tasks. During the draught season in Thanamalwila area, farmers those who can find out good grazing lands and water sources will always win the competitive advantage in buffalo management. Hence, farmers with large herds, always require a high number of labor units to manage their herd. Thus, increasing the number of labor units used in buffalo management activities is always helpful to improve the quality of management and eventually the output from the animals. Cost of buffalo farming was also not a significant determinant in production function. Most of the farmers in Thanamalwila veterinary division practice buffalo management as a low cost activity. Expenditure of buffalo farming is only determined by expenses such as cost of drugs, vaccines, materials for build dwellings (barbed wire). Saravanakumar and Jain (2007) also stated same relationship between cost and output of production function.

Technical inefficiency estimates

Monthly income was the only significant variable of inefficiency model in the study (Table 2). Due to dry climatic condition in the Thanamalwila area, with the higher income level, farmers tend to invest their money on livestock management than cash crop cultivation. Further livestock is considered as a less risky business and an option for crop failure. Therefore with the high income level, farmers have tendency to increase the investment on livestock farming for activities such as purchasing quality breeding animals, feeds, drugs and veterinary services where it subsequently increase the income of the buffalo farming.

Age, education level of the farmer, experience in buffalo farming and number of times contacts with veterinary or livestock development officer also were not significant in determining the inefficiency of buffalo farmers in Thanamalwila area.

Table 2: Technical inefficiency estimates of Buffalo farming in Thanamalwila area

Variable	Coefficient	Standard error	p-value
Age	0.0459	0.039481	0.243
Education level	0.1189	0.615439	0.846
Gender	22.9430	5376.763	0.997
Monthly income	-0.0005*	0.000026	0.052
Experience	-0.1057	0.085551	0.217
Number of times contact with VS/LDI	-0.3871	1.024504	0.709

VS (Veterinary Service), LDI (Livestock Development Instructor)
*Significant at 10% **Significant at 5% ***Significant at 1%

However, positive coefficient for age of the farmer indicates that younger farmers are more efficient in buffalo management than older farmers. Strategies of buffalo management practices were not widely vary with experience of the farmer. Almost all farmers were practicing the same types of strategies in buffalo management practices and that may be the reason for present observation. Mean technical efficiency value for buffalo farmers in Thanamalwila veterinary division is 86.83%. Majority of buffalo farmers belong to 90-100% of technical efficiency category. There were no any farmers in the sample fall below 40% of technical efficiency category. Saravanakumar and Jain (2007) also observed the similar results in their study, and reported that estimated average technical efficiency for buffalo farms as 85.10%, indicating that the output could be increased by 13.7% if all farmers achieved the technical efficiency level of the best farmer. A study conducted by Thiwyatharshan et al. (2013) on dairy cattle farming in Moneragala division revealed that estimated mean technical efficiency as 68.86%. Therefore, findings of this study implied that buffalo farmers in Thanamalwila veterinary division are comparatively high in efficiency.

CONCLUSION

Breed, feed, average birth weight, and level of labor power allocation on farming have greater and significant impact on milk production of buffalo farms in Thanamalwila veterinary division. The efficiency of farmers is determined by the level of income and the frequency of receiving extension services. The milk production could be increased by13.2% through better use of extension services, and given the current state of technology with extra investment on introducing exotic breeds, quality feeds and adequate labour power. The findings are helpful in planning dairy development activities in the area.

REFERENCES

Abeygunawardena, H. and Abeygunawardena, I.S., (1998a). Water buffalo farming in Sri Lanka: Production systems, uses, potentials and constraints. In: D.H.A. Subasinghe, N.U. Horagoda, H. Abeygunawardena, and J.A. de S. Siriwardena, eds. 1998. Water buffalo-improved utilization through new technologies. Colombo: National Science Foundation. pp 11-22

Abeygunawardena, H. and Abeygunawardena, I.S. (1998b). Water buffalo: classification, origin, distribution, myths and misconceptions. In: D.H.A. Subasinghe, N.U. Horagoda, Publication NARESA.

Aigner, D.J., Lovell, C.A.K., and Schmidt, P., (1976). Formulation and estimation of stochastic frontier production function models, Journal of Econometrics 6, pp. 21–37.

Battese, G.E., Coelli, T. J., (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empirical Econ. 20: 325-332.

Central Bank Annual Report. (2016). Sri Lanka Socio Economic Data. Statistics Department Central Bank of Sri Lanka, Colombo, Sri Lanka.

Charnes A, Copper WW,Saravanakumar, V. and Jain, D.K., (2008). Technical efficiency of dairy farms in Tamil Nadu. Journal of the Indian Society of Agricultural Statistics 62 (1), pp. 26-33.

Department of Animal Production and health. (2015). Annual report-*2015*, Peradeniya: Department of Animal Production and Health- Sri Lanka.

Department of animal production and health-Sri Lanka, (2017). Livestock statistic-population. [online] (11 October 2017) Available at: <*http://www.daph.gov.lk/web/index.php?option=com_content&view=article&id=115&Itemid=104&lang=en* > [Accessed 11 October 2017].

Department of Census and Statistics. (2017). Livestock Statistics. [online] (11 October 2017) Available at: *http://www.statistics.gov.lk/agriculture/Livestock/LivestockPopulationSubnational.html#CattlePopulation*. [Accessed 11 October 2017]

Farrell, M.J. (1957). The measurement of productive efficiency, Journal of the royal statistical society, 120(03), pp. 253-281.

Ministry of livestock and rural community development, (2012a). Milk collection, production and milk powder imports. [online] Available at: < *http://www.livestock.gov.lk/site/en/statistics* > [Accessed 17 April 2014]

Ministry of livestock and rural community development. (2012b). *The livestock sector in Sri Lanka*. [online] Available at: < *http://www.livestock.gov.lk/site/en/profile-of-the-livestock-sector* > [Accessed 17 April 2014]

Thiwyadharsan, R., Rathnayaka, R.M.S.D. and Samaraweera, A.M. (2013). Technical Efficiency of Cattle Farming in Moneragala Veterinary Region: A Stochastic Frontier Approach. Uva Wellassa University, Badulla, Sri Lanka Proceedings of the Research Symposium. pp. 45-47.