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Measuring Technical Efficiency of Small-Scale Farms of Beef Cattle Farming in Selected Areas of Bangladesh

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Abstract
The stochastic production frontier was employed to estimate the technical efficiency of small-scale beef cattle farmers. Two Upazilas from the Rajbari district of Bangladesh were purposively selected as the study area. The snowball technique was adopted to select seventy (70) beef cattle farmers for data collection with structured questionnaires in collecting data for the study. The Ordinary Least Square (OLS) technique was used in estimating the coefficients of the logarithmic form of the Cobb-Douglass Production function by SPSS 25 and their determinants in the study area. Linear Programming (LP) was used to estimate technical efficiency by using Microsoft Excel 2013. The mean technical efficiency of the beef cattle farmers was 87%. The results confirm that in some cases, the beef cattle farmers were technically inefficient, implying that there is room to improve 13% technical efficiency with the farmers' current resources and available technology. Age (Table 4) of the farmers had negative but significant effects on their technical efficiency, while education, farming experience, and farm size had significant and positive influences on farmer's technical efficiency. Among the dummy variables, the coefficient of training facilities is negative which reveals that there is a scope of increasing the production of beef cattle by improving the quality and regularity of training. For that, policies that would encourage experienced and educated farmers, to continue beef cattle farming are recommended.

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1. Introduction:

Technical efficiency in beef cattle production is a crucial factor in optimizing resource use and improving overall productivity. Studies have highlighted the significant potential for enhancing efficiency in beef production. For instance, research in Kenya found that the average technical efficiency in beef cattle production was only 69%, indicating substantial room for improvement (David et al., 2014). The study emphasized that improvements in efficiency could be achieved through strategies such as controlled crossbreeding and better farm management practices. In Brazil, a study using Q-methodology identified different farmer typologies, such as the "Profit Maximiser" and "Professional Farmer," who view technical efficiency as essential for balancing economic returns with farm sustainability (Pereira et al., 2016). Similarly, research in South Africa demonstrated that technical and scale efficiencies are critical for improving financial performance in red meat production, particularly in beef cattle farming (Oberholzer et al., 2014).

Additionally, addressing environmental factors, such as methane emissions from cattle, is an important aspect of technical efficiency, as it contributes to both sustainability and performance (Bárbaro et al., 2008). Overall, technical efficiency plays a pivotal role in enhancing productivity, profitability, and environmental sustainability in beef cattle production. Prior studies have demonstrated the significance of technical efficiency in enhancing productivity and sustainability in beef cattle production. In Kenya, David et al. (2014) highlighted that the average technical efficiency in beef production was only 69%, emphasizing substantial potential for improvement through better management practices such as controlled crossbreeding and improved farm management. Similarly, research conducted in Brazil by Pereira et al. (2016) explored different farmer typologies, such as the "Profit Maximizer" and "Professional Farmer," who recognized the importance of technical efficiency in balancing economic profitability and sustainability. This study showed that farmers who were more aware of the need for efficient resource use achieved higher productivity and profitability. In South Africa, Oberholzer et al. (2014) demonstrated that improving technical and scale efficiencies in beef cattle farming was crucial for enhancing financial performance. This research found that the adoption of efficient production practices, such as optimal feed management and better veterinary care, led to improved profitability for beef farmers. Furthermore, Bárbaro et al. (2008) discussed the environmental implications of beef cattle farming, particularly focusing on methane emissions. Addressing inefficiencies in resource use could contribute not only to financial gains but also to the reduction of the environmental footprint of cattle farming.

In Bangladesh, where livestock farming is a significant part of the rural economy, the technical efficiency of beef cattle production has yet to be extensively studied. However, the increasing demand for beef, as reported by the Department of Livestock Services (2022), suggests a growing need for enhancing the efficiency of local farms to meet market demands while ensuring sustainable practices. A key challenge identified by local experts is the gap in technical knowledge and management practices, which, if addressed, could lead to significant improvements in both productivity and environmental sustainability. Agriculture is a key source of income for most developing nations, including Bangladesh. As a part of Bangladesh's agricultural economy, livestock is potential since it provides various functions such as food, nutrition, income generation, savings, draft power, manure, fuel, transport, and cultural function and earning foreign currency by exporting meat, hides and skin value-added waste products, etc. A report by The Dhaka Tribune, (2023) published that about 68.3% of the total population of Bangladesh are rural dwellers, depending largely on subsistent agriculture for their survival. Bureau of Bangladesh Statistics (BBS. 2022-23) also published that the agricultural sector has contributed immensely to the development of Bangladesh’s economy by generating employment for those large populations and accounting for about 47.2% of GDP, with accounting for fisheries, livestock, and forestry sub-sectors are 21.87%, 16.41%, and 14.50% respectively. Bangladesh has achieved its self-reliance over time and expected improvement has been seen in meat and milk production. A calculation from the information of Bangladesh Economic Review 2022 shows that beef production has increased by 4.37 fold since the last 12 years and per head per day demand of meat has reached 137.38 grams. According to the Department of Livestock Services (2022), the livestock sector's share of the overall GDP in FY 2022 was 1.90 percent, a decrease of 0.08 percent from the previous fiscal year. Directly 20% and partly 50% of the people of Bangladesh are engaged in livestock. The share of livestock to GDP is 16.52% which is 0.07% more than last fiscal year 2021-22, and contribution to GDP increased by 1.13 percent in FY-2023 in respect of the previous year.

Rakipova and Gillespie (2000) defined Technical Efficiency as it refers to the capacity to produce the maximum output level for a given quantity of inputs and technology. It provides useful information on the efficiency of farms and the potential to improve productivity with existing resources and levels of technology. The range of technical efficiency coefficients is 0 to 1, where 1 denotes the highest technically efficient process and 0 indicates no technical efficiency. Using

DEA analysis and solving linear programming for each producer results in a technical efficiency coefficient for each producer. The studies mentioned above underscore the importance of improving technical efficiency in beef cattle production to enhance overall productivity, profitability, and environmental sustainability. While much research has been conducted in countries like Kenya, Brazil, and South Africa, the context of Bangladesh has been less explored in the literature, especially with regard to beef cattle farming. This research aims to fill this gap by analyzing the technical efficiency of beef cattle farms in the Rajbari district of Bangladesh. By assessing the input-output relationships specific to the region and identifying factors that contribute to inefficiencies, this study will provide valuable insights for improving farm-level productivity and profitability in Bangladesh's beef cattle sector. It will also inform policy recommendations that align with the objectives of enhancing technical efficiency, fostering sustainable practices, and improving the livelihoods of beef cattle farmers in rural Bangladesh. Therefore, this study aims to analyze the technical efficiency of beef cattle farmers in two Upazilas of the Rajbari district in Bangladesh. The objective is to evaluate the technical efficiency of farmers, identify the variables influencing their technical efficiency, and develop policy suggestions based on the study's results.

2. Related studies

Technical efficiency (TE) in livestock farming, specifically within dairy and beef production, has been a focal point of research worldwide, providing insights into productivity and efficiency improvements across different contexts. This review synthesizes recent studies examining TE in dairy and beef farming, highlighting methodological approaches, findings, and implications for practice. Kovács and Pandey (2017) compared the technical efficiency of the dairy and beef sectors in Hungary using Data Envelopment Analysis (DEA). Their findings indicate that the Hungarian dairy sector is generally more efficient than the beef sector, with large-scale farms performing better in resource management. Specifically, they observed that dairy farms achieved a higher variable returns to scale (VRS) technical efficiency of 72.9% compared to 63.6% for beef farms, with efficiency levels fluctuating between 2014 and 2015. Their study concludes that while Hungarian dairy farms generally outperform beef farms, efficiency improvements are needed across both sectors to meet European standards. In South Africa, Oberholzer et al. (2014) analyzed the technical and scale efficiency of red meat production by examining Boer goat, cattle, and sheep farming using DEA. The study highlights that Boer goat production is financially more viable than cattle and sheep, with smaller livestock species like goats being more adaptable to marginal land. This finding underscores the role of livestock choice in optimizing resource use and suggests that scale efficiency is more easily achieved in sheep farming than in goat or cattle farming. This research provides a framework for South African farmers to assess financial performance across livestock choices, contributing valuable insights for farmers operating in regions with limited grazing land. Alhas-Eroglu (2023) focused on beef cattle farms in Turkey, examining how specialization impacts TE. Using stochastic frontier analysis, the study found that specialized beef farms were more efficient (mean TE of 0.66) than mixed farms, which averaged a TE of 0.55. The study suggests that increased specialization, larger farm size, and better farm record-keeping could improve TE in beef production, as efficiency is sensitive to capital and concentrate feed investments. These findings recommend policy measures that encourage specialization, positioning it as a key driver of efficiency in Turkish beef production. Aguirre, García Suárez, and Sicilia (2024) examined TE in beef cattle production in Uruguay, an established exporter. They found a potential 26.4% efficiency improvement using existing resources, with factors such as primary reliance on livestock farming, outsourced services, and veterinary consultation significantly impacting TE. The findings indicate that adopting improved management practices and optimizing farm inputs could increase Uruguay's beef productivity, which is essential in maintaining global competitiveness. In China, Liang, Bi, and Zhang (2023) evaluated the effect of contract farming on TE in beef cattle farms. Their study showed that contract farming, especially production-management contracts, positively affects TE by creating new market opportunities and addressing market imperfections. The authors argue that contract farming should be further promoted as it improves income and TE for smallholder farmers by fostering cooperation with larger corporations, ultimately supporting sustainable beef production in China. Similarly, Wei et al. (2022) analyzed feed utilization efficiency in Chinese beef cattle farms, emphasizing sustainable development. Their findings indicate a progressive improvement in feed efficiency over three years, with large-scale farmers achieving better TE. The study concludes that while large-scale beef cattle farming can enhance feed utilization, a balanced approach is necessary to prevent overuse of feed resources. This research provides a foundation for improving feed efficiency, crucial for sustainability in China's growing beef industry. In Tanzania, Mlote (2013) assessed the TE of small-scale beef fattening operations, finding that the mean TE was 91%, with herd size being a critical determinant of productivity. Factors like age, education, and access to extension services also influenced TE, underscoring the role of socio-economic characteristics in Tanzanian beef production. This study contributes to regional policy, suggesting that improving technical training and herd management practices can substantially increase TE in small-scale beef farming. Wantasen, Umboh, and Leke (2022) investigated the TE of backyard beef cattle fattening in Indonesia, using stochastic frontier analysis to highlight that green feed and feeder cattle weight were key inputs affecting TE. The study's results show a TE index value of 0.67, pointing to the need for improved management of feed and herd size in Indonesian beef farming. This study supports the importance of knowledge transfer and capital investment to enhance productivity in small-scale, traditional beef operations. Finally, in Malaysia, Mohd Radzil et al. (2023) examined TE in beef farms using DEA, discovering that only a small percentage of farms operate at full efficiency, while others fall below 50% efficiency. The study emphasizes the importance of experience, education, and corporate networking in driving TE, with policy recommendations for promoting Artificial Insemination techniques and providing incentives for younger farmers to enter the industry. These measures could enhance productivity and secure Malaysia's beef supply chain. Moreover, the reviewed studies demonstrate that TE in beef and dairy farming is influenced by a combination of farm size, specialization, management practices, and socio-economic factors. Approaches such as DEA and stochastic frontier analysis offer valuable insights into efficiency levels, revealing that larger, specialized, and better-managed farms generally achieve higher TE. Policy recommendations consistently emphasize the need for technical training, resource optimization, and farm-level management improvements. The findings collectively suggest that with targeted interventions, efficiency improvements are attainable across diverse global contexts, ultimately strengthening the resilience and productivity of the livestock sector.

This study investigates the technical efficiency (TE) of small-scale beef cattle farmers in Bangladesh, focusing on two Upazilas in the Rajbari district. The analysis employs the stochastic production frontier approach, combined with Ordinary Least Squares (OLS) for the estimation of production function coefficients and Linear Programming (LP) to measure TE. By selecting seventy beef cattle farmers through the snowball sampling technique, this study aims to determine the current levels of TE and identify factors influencing productivity. The study also explores the role of farmer-specific characteristics, such as age, education, farming experience, and farm size, in shaping TE outcomes. The findings indicate that, on average, farmers operate at 87% technical efficiency, with potential improvements identified in areas like training and resource management. The research contributes valuable insights into the practical ways of enhancing TE among small-scale beef farmers, especially in regions with limited access to advanced technologies and training facilities. Therefore, the current study aims to investigate the following research questions:

(i) What is the impact of socioeconomic factors, such as age, experience, herd size, extension effects, and training effects, on the technical efficiency of beef cattle farming in the study area?

(ii) What role do credit facilities and access to imported cattle play in the technical inefficiency of beef cattle farming in Bangladesh?

(iii) How can the average technical efficiency of beef cattle production be improved in Bangladesh, given the current technology and input levels? &

(iv) What is the current level of technical efficiency among beef cattle farmers?

3. Research Methodology

3.1 Data Sources

This study used cross-section data collected from the rural area of two upazila Pangsha and Kalukhali in the Rajbari district of Bangladesh. A well-designed questionnaire was served as the basis of the study. For this study, 70 households on beef cattle farms were selected as the sample size of the study. The study area and the respondents were selected purposively using the snowball technique of data collection.

3.2 Tools to be used

This study used the Ordinary Least Square (OLS) to estimate the parameters of the stochastic production frontier. SPSS version 25, and MS Excel 13 were used to estimate technical efficiency.

3.3 Theoretical Framework

The Cobb-Douglas production function was utilized due to its simplicity, ability to be converted into additive linear forms, and seldom complications. The Cobb-Douglas's production function after being transformed into a linear logarithmic form for the farmer is:

$$lnYi = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + \beta_6 lnX_{6i} + \beta_7 lnX_{7i} + (v_i - u_i) \text{ --(1)}$$

where,
Y_i = quantity of beef cattle produced (weighted in kgs by the current price);
x_1= purchasing cost as a primary investment (weighted in kgs by the current price);
X_2 = land used for cattle farming;
X_3= household labor in man-days;
X_4= Quantity of primary food including forage (green grass), rice polish, and straw in bundles;
X_5 = oil cake, hay and rice, and other different brand of feed (concentrate) in kgs;
X_6 = input value of Veterinary cost including medicine, doctors visits, and additional feed supplying cost in thousand takas;
X_7= other costs including household construction and repaired purpose cost in thousands;
β_0 = intercept; β_1, β_2, β_3, β_4, and β_5 are the estimated parameter coefficients;
v_i - u_i = error terms where vi is the noise effect, and u_i is the effect of technical inefficiency in the model; i= the successive number of beef cattle households. All these inputs in the model represent the highest cost inputs in the operations.
The technical efficiency of beef cattle farms is defined as the ratio between the actual output and the frontier output, using the available technology, formulated as follows:

$$\mathbf{TE = Y_i^*/Y_i = e^{(-ui)}} \qquad (2)$$

The value of technical efficiency is in the range of zero and one, 0 ≤ TEi ≤ 1.Technical efficiency is in contrast to technical inefficiency, so the value of technical inefficiency is 1 - TEi.

The form of the technical inefficiency function of the i th farmer is:

$$ui = \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + \delta_7 z_7 + \delta_8 z_8 + \delta_9 z_9 + w \qquad (3)$$

with ui = the effect of technical inefficiency;
z_1 = age (years);
z_2 = gender dummy (1: male, 0: female);
z_3 = education level dummy: 0= illiterate, 1= Completing primary Education, 2= Completing Secondary School education, 3= Completing higher Secondary Education; 4= Completing Higher Education;
z_4 = experience in years;
Z_5= Herd size in numbers;
z_6 = extension service dummy: 1- obtaining extension, 0- not obtaining extension;
Z_7= training effect on cattle farming: 1= 'Yes, positive effects, 0= 'No' otherwise;

Z_8= credit effects: 1= 'Yes' positive effect' 0= 'No' otherwise);
Z_9=import effects on beef cattle farming (1= 'Yes' positive effects, 0= 'No' otherwise)
The minimum cost under the assumption of Variable Returns to Scale (VRS) is defined as-

$$C^* = minp^0 x: x \in V(y^0)$$

The minimum cost is obtained by solving the Linear Programming problem. The linear programming is-

$$\min \sum_{i=1}^{n} p_0^i x_i$$

Subject to constraints,

$$\sum_{i=n}^{n} \lambda_j x_{ij} \leq x_i \, (i = 1,2,3,\ldots\ldots\ldots n);$$

$$\sum_{i=n}^{n} \lambda_j y_{rj} \geq y_r \, (r = 1,2,3,\ldots\ldots\ldots m);$$

$$\sum_{i=n}^{n} \lambda_j = 1;$$

The non-negative condition is

$$\lambda_j \geq 0 (j = 1,2,3,\ldots\ldots\ldots N); \quad (1)$$

where p_i is the firm's prices under observation for every input; x_i's are the quantity of inputs, y_i's are the quantity of output produced in a certain time such as weight gain of meat and milk of cattle. Lamda (λ_j) is the coefficient of inputs and output produced. The Sigma of lambda is equal to 1 that is the sigma of weight should be equal to one and all the lambdas are non-negative. In linear programming, there are quantity of output is the dependent variable, and four independent variables are land, labor, primary food, and concentrated food. The target is to estimate technical efficiency with the condition of minimum value of x_i's as well as the minimum value of total cost.

2.4. Hypothesis Test:

The relationship between beef cattle production and input variables has been widely studied and identified in numerous agricultural economics studies. Several factors, such as farm size, feed management, capital investment, and herd management, significantly influence the technical efficiency and productivity of beef cattle farms. For instance, studies like those by Kovács and Pandey (2017) and Oberholzer et al. (2014) show that farm size plays a critical role in determining production efficiency. Larger farms, with more capital and resources, are often more capable of utilizing economies of scale, leading to higher output levels compared to smaller farms. In terms of feed management, Alhas-Eroglu (2023) highlights that inputs like concentrate feed and capital expenditures have a stronger impact on beef production than other inputs like labor. Feed management, especially the balance between roughage and concentrate feed, is a crucial determinant of cattle growth and meat production, thereby influencing overall farm productivity.

Additionally, herd size and herd management practices significantly affect the efficiency of beef cattle farming. Larger herds typically lead to better use of labor and capital, thus improving the overall production process. Furthermore, the role of technological adoption, such as improved feeding practices, veterinary care, and infrastructure, has been found to enhance production efficiency. The research by Aguirre et al. (2024) in Uruguay demonstrated that through better utilization of grazing area, livestock units, and labor, beef cattle production can be significantly improved. These factors, combined with proper farm management, create a more sustainable and efficient production system. Therefore, the relationship between beef cattle production and input variables is crucial, and improving the management of these variables can result in substantial improvements in the efficiency and productivity of beef cattle farms. This forms the basis of the hypothesis that a significant relationship exists between the various input variables and the efficiency of beef cattle production.

***H_0**: There is no significant relationship between beef cattle production and the considered input variables.*

***Ha**: There exists a relationship between beef cattle production and the considered input variables.*

4. Data Analysis and Discussion of Beef Cattle Production:

The average, standard deviation, maximum, and minimum values of land, labor, forage, feed concentrates, veterinary costs, and other costs such as construction, maintenance, etc., are shown in Table 1. The average use of forage feed is greater than that of concentrate feed. This means that most of the farmers in the village feed their cattle with native green grass and straw (GGS) rather than concentrate fodder as oil cake, husk, and broken rice (OHB). This results in lower production costs and higher profitability through proper maintenance. The most used days per cattle farming are 28 days, and the lowest number of working days is 5 days per cattle production.

Table 1: Value of production and use of inputs for beef cattle production in Selected Areas

Variables	Average	Std. Deviation	Maximum	Minimum
Primary Investment	80.05	20.50	132.42	40.01
land	5.39	2.59	15.00	1.00
labor	25.19	10.73	56.26	6.75
GGS	316.15	154.49	809.97	45.02
OHB	65.99	39.47	180.01	1.00
VC	2.50	1.67	12.00	0.50
OC	2.50	4.619	29.99	0.10

***Source:** Derived from Field Survey Data, 2023-2024*

The average veterinary cost (VC) per beef cattle per year is 2.50 thousand which is similar to other costs (OC). However, the distance in standard deviation, maximum, and minimum value is so much in every case, and the VC value is less than the OC value. This indicates that the fluctuation in VC cost is less irregular than that of OC cost. Fluctuation of other costs varies by farm type. However, it appears that the cost of treatment and veterinary remains relatively unchanged. The range of VC is 11.5 and OC is 29.89. This also indicates that the prevalence of medical expenses for cattle husbandry is less than other expenses. That is, in this case, it is also clear that the cost for other purposes is more volatile. According to Table 1, the coefficients of land, GGS (Green Grass and straw), and veterinary cost (VC) are negative. This examines that the increasing use of land, GGC, and VC do not stand for the technical efficiency of beef cattle farming. With the help of this, it was possible to check that the cost of land, grass, and treatment of cattle did not play a satisfactory role in beef production. Rather, unnecessary use of these variables has proven to create technical barriers to production.

This research aimed to assess the technical efficiency of beef cattle producers and identify the types of producers and agricultural practices linked to technically proficient farms. This study of seventy farmers was conducted from July to August of 2023. The results for the Cobb-Douglass production function and the technical inefficiency determinate from the stochastic frontier were analyzed simultaneously. They are presented separately in Table 1 and Table 2 above.

Table 2. Ordinary Least Square (OLS) Estimates for parameters of Cobb-Douglass stochastic production frontier:

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	3.018	.344	8.777	.000
Primary Investment	.591	.057	10.341	.000
ln_land	-.058	.055	-1.053	.296
ln_labour	.005	.061	.081	.936
ln_GGS	-.050	.042	-1.177	.244
ln_OHC	.006	.020	.293	.770
ln_VC	-.023	.045	-.504	.616
ln_OC	.010	.028	.362	.719
a. Dependent Variable: Ln_Y				

Source: *Derived from Field Survey Data 2023-2024*

Furthermore, the estimated coefficients of primary investment, labor, food concentrate, and other costs are positive. It demonstrates that there is a positive correlation between the producer's output of beef cattle, and primary investment, labor, food concentrate, and other costs. This is because these inputs are important determinants in beef cattle production. The positive signs of the coefficients imply that increasing any primary investment, labor, food concentrate, and other costs will result in to increase output of beef cattle in the study area. Therefore, we can say that the null hypothesis considered first is rejected and this can be concluded that there exists a significant relationship between them.

4. Estimating Technical Efficiency of Beef Cattle Production

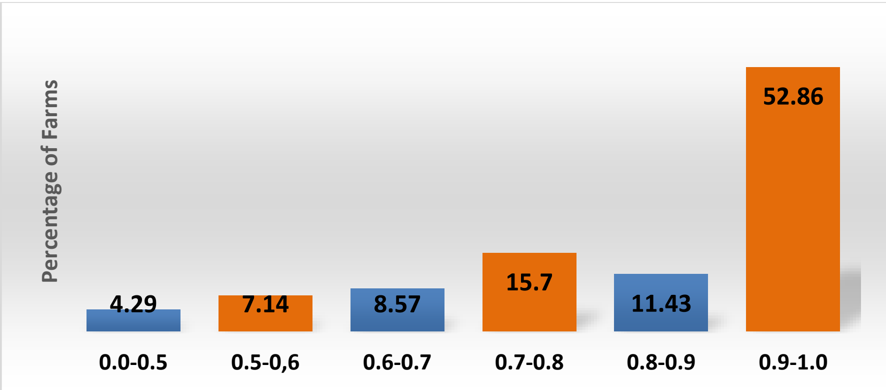
Kalangi et al., (2014) stated that a business is said to be technically efficient if its value is close to 100 percent. Whereas, the results of his research work showed that the average level of technical efficiency of the breeding business in beef cattle in East Java is 0.80 in the highlands. So, it can be said that most cattle farms can't be technically efficient at 100% level. The 60% to 100% farmers of the present study attained an average of 87% technical efficiency. However, Mlote et al. (2013) found that the farm-level technical efficiency ranged between 48 to 98% with a mean of 91% indicating technical efficiency though not at 100%. For ease of discussion, the Technical Efficiency of Table 3 is divided into 3 index levels. In a study by Asmara et al. (2016), it is seen that three criteria in classifying the distribution of technical efficiency values are namely: Category I: 0.80-1, category II: 0.50-0.79, and Category III: 0.00-0.49. Whereas in the present study firstly, the lower index level of TE from 0.00 to 0.60 is 11.43% of total farms, secondly, the middle index level from 0.6 to 0.8 is 24.27% of total farms, and thirdly, the higher index level from 0.8 to 1.00 is 64% or 45 number of farms. In the higher index level, it is noticed that 28 farms which is 40% of total farms are technically 100% efficient. Each of these 28 producers had a technical coefficient of 1, meaning that no other producer used the same set of inputs and produced the same outputs with greater technical efficiency. Considering that cattle farming is well-established in this area, the overall range of technological efficiency was very broad. These results indicate that the production of beef cattle in the selected area is at a higher index level which approaches the maximum level of efficiency. Therefore, the current level of technical efficiency among beef cattle farmers varies, with a majority of farms operating at high efficiency levels but with potential for improvements in a smaller proportion of farms. These findings suggest that while many farmers are approaching full technical efficiency, strategies to enhance practices among less efficient farms could help further increase the overall productivity of the sector.

Table 3: Distribution of technical efficiency values of beef cattle production in Study Area

Efficiency Class	Frequency	Percentage
0.0-0.5	3	4.29
0.5-0,6	5	7.14
0.6-0.7	6	8.57
0.7-0.8	11	15.7
0.8-0.9	8	11.43
0.9-1.0	37	52.86
Mean	0.86	-
Standard Deviation	3.25	-
Maximum	1.00	-
Minimum	0.42	100

Source: *Derived from Field Survey Data 2023-2024*

The average Technical efficiency of this study is 0.87 0r 87% which states that the farmers of this area are more technologically advanced in the field of beef cattle rearing and the rearing of beef cattle is profitable in this area. This means that production can still be increased by 13% to reach the frontier, which is the maximum productivity that can be achieved with the best management system. The results of the research by Kalangi et al. (2014), showed that the average level of technical efficiency of the breeding business in beef cattle in the highlands of East Java is 0.80 which is connectable with the present study. The highest number of cattle farms (37 as 52.86%) is in the highest class distribution of Technical Efficiency from 0.90 to 1.00.



Source: *Derived from Field Survey Data 2023-2024*

Figure 1: Distribution of technical efficiency values of beef cattle production

Figure 1 shows the class-wise variation of technical efficiency. This shows that the majority of farms are fairly technologically efficient. The technical efficiency of the lowest two classes (from 0.00 to 0.60) is 11.53 which is very low.

5. Estimating Technical Inefficiency of Beef Cattle Production

The Ordinary Least Square Estimates of the Cobb-Douglass stochastic production frontier function for beef cattle farmers in the study area are presented in Table 4. To assess the socioeconomic role of socioeconomic factors in technical efficiency, the following inefficiency table 4 can be used. From Table 4, we see that the coefficient of age, experience, herd size, extension effects, and training effects of the farms in beef cattle farming are negative and insignificant and the value tends to zero. This indicates that these factors positively impact the effectiveness of beef cattle farming in the selected area. Besides, the coefficients of the gender of the farmers, education level, access to credit effects and access to import effects in cattle farming are positive and insignificant. This positive value of technical inefficiency indicates that the farms are not operating on the efficiency point of line. And therefore, it is meant that there is enough scope for improvement though it hampers the beef cattle production for progress. So, it is needed to take care of importing cattle and necessarily, implement policy on importing cattle, and take initiatives against cattle draining illegally from the neighboring countries so that the inland farms could be able to make profit and sustain themselves.

Table 4: Ordinary Least Square Estimates for parameters of Cobb-Douglass stochastic production frontier

Coefficients						
Model		Unstandard. Coefficients		Stand. Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.14	.22		.63	.53
	age	-.01	.00	-.22	-1.6	.11
	gender	.02	.06	.03	.27	.79
	education	.01	.03	.06	.45	.65
	Experience	.00	.01	-.08	-.66	.52
	Herd size	.00	.01	-.04	-.35	.73
	Extension effects	.01	.08	-.01	-.08	.94
	Training effects	-.03	.09	-.04	-.32	.75
	Credit effects	.12	.06	.26	2.02	.05
	Import effects	.02	.04	.08	.62	.54
a. Dependent Variable: u_i						

Source: *Derived from Field Survey Data, 2023-2024*

The coefficients of credit facility, and import facility as a dummy variable of beef cattle farming is positive and insignificant. This means that it has a positive impact on the inefficiency of farmers. However, in the study area of Bangladesh, poor cattle farmers lack credit facilities. They can not buy food, medicine, and pieces of equipment for raising cattle on time. Rezaul Karim (ULO, Kaligonj Upazila Livestock office, Jhenaidah) said in an interview that beef cattle farmers could make beef farming profitable, and all other factors effective, if credit facilities are available with easy terms and conditions.

Conclusion

Production of any sector in the economy mostly depends on production performance, current technology used, and the efficiency level of the producers. The target of this study is to identify the factors that affect the efficiency level of cattle farmers and to estimate their efficiency. The study estimated the average technical efficiency of beef cattle production is 87 %. This implies that an increase in output with a decrease in cost could be obtained using available technology. This revealed that there is an opportunity to increase the average TE of beef farmers by 13% without any change or improvement in technologies at full efficiency scale of farmers' operation. The average level of technical efficiency suggests that from a technical standpoint, the opportunity exists to expand beef cattle production using the current level of inputs and the technologies already available in the area. On the other hand, we see that the coefficient of age, experience, herd size, extension effects, and training effects of the farms in beef cattle farming are negative and insignificant and the value tends to zero. This indicates that these factors positively impact the effectiveness of beef cattle farming in the selected area. Besides, the coefficients of the gender of the farmers, education level, access to credit effects, and access to import effects in cattle farming are positive and insignificant.

Livestock officials, small-scale farmers, and experienced cattle producers have provided a range of suggestions and recommendations aimed at improving the economic prospects of small beef cattle farmers. These recommendations focus on strategic planning and practical measures to enhance productivity and efficiency. First, future planning should prioritize grazing lands and animal supplies, especially for farms that have access to financial resources. Additionally, the time between cattle purchase and sale should be carefully considered, with a recommended time frame of four to five months. This allows farms to reduce costs and generate more income in the short term. Another important recommendation is to base purchasing and selling decisions on current market prices, ensuring that farms remain competitive and profitable.

The authorities should also pay attention to the implications of beef cattle imports and exports, as these factors play a significant role in shaping the market environment. Furthermore, the amount of feed for cattle should be determined based on the time gap between purchase and sale, while grain-based food should be provided to the cattle one month prior to sale to optimize weight gain. Farmers are also advised to select red-colored cattle, which tend to maintain consistent demand year-round, thereby reducing the risk of losses due to fluctuations in market demand. Encouraging farmers to raise crossbred cattle, particularly Brahman crosses or combinations of local and crossbred breeds, is another key recommendation. Local breeds have been associated with lower efficiency, while crossbreeds offer better productivity, especially when fed on readily available resources such as grass, vines, and leaves. There is also an opportunity for management improvements to increase technical efficiency, with a focus on breeding programs, improved nutrition, and the use of higher-quality bulls.

To further enhance farm performance, it is crucial that farmers and farm managers develop stronger managerial skills, particularly in organization and oversight. Providing systematic training in farm management, veterinary practices, and animal husbandry will help farmers optimize their operations. In addition, more advisory services should be offered to less productive farms, with extension agents receiving the necessary knowledge and skills to offer effective support. Finally, experienced farmers should play a key role in the strategic planning for the growth of the beef cattle industry, as their expertise significantly impacts farm efficiency. Additionally, there is a strong need for skilled personnel and veterinary services to support farmers' operations. Further studies are also recommended to better understand the productivity and efficiency levels within the beef cattle industry, particularly considering that the cattle population outside the TAC accounts for approximately 84% of the total cattle population in the country. This highlights the potential for substantial improvements in efficiency across the broader industry.

Limitations and Future Research Directions

This study provides valuable insights into the technical efficiency of beef cattle farming; however, there are several limitations that should be acknowledged. First, the study focuses on a specific geographical region, which may limit the generalizability of the findings to other areas with different agricultural practices, climate conditions, or market dynamics. The data used for the analysis were collected during a specific period (2023-2024), and changes in the farming environment, such as technological advancements, government policies, or market fluctuations, may impact the results over time. Second, the study primarily relies on quantitative methods to measure technical efficiency, which may not capture all the qualitative factors affecting farm performance, such as the experience and skills of farmers, or their social networks and access to information. These factors, while difficult to quantify, may still play a significant role in the efficiency of beef cattle production. Future studies could include qualitative methods, such as interviews or case studies, to provide a more comprehensive understanding of the factors influencing technical efficiency. Third, while the study identifies several key factors influencing technical efficiency, it does not delve deeply into the reasons behind the inefficiencies or the barriers that prevent farmers from achieving higher levels of efficiency. Future research could explore the underlying causes of inefficiency, such as institutional barriers, inadequate infrastructure, or limited access to credit, and investigate strategies to overcome these challenges. Additionally, the present study primarily examines the technical efficiency of beef cattle production, but it does not consider economic efficiency or profitability. Future research could expand the scope to include an economic efficiency analysis, which would provide a more holistic understanding of farm performance by factoring in both costs and revenue. This would allow policymakers and farmers to identify not only ways to improve technical efficiency but also how to ensure that these improvements translate into greater financial sustainability. Finally, the study recommends further exploration of management practices, including training programs, breeding strategies, and the use of improved feed and nutrition. Future research could investigate the impact of specific management interventions on efficiency and explore how different farm characteristics (e.g., farm size, type of cattle raised, labor availability) influence the effectiveness of these interventions. Furthermore, there is a need for longitudinal studies that track changes in technical efficiency over time, which would help in understanding the long-term impact of different strategies on beef cattle farming productivity. Moreover, while this study makes important contributions to understanding the technical efficiency of beef cattle farming, future research can build on these findings by exploring the broader economic implications, identifying the root causes of inefficiencies, and testing specific management practices that can further enhance farm performance.

References

Abdulai, A., & Tietje, H. (2007). Estimating technical efficiency under unobserved heterogeneity with stochastic frontier models: Application to Northern German dairy farms. *European Review of Agricultural Economics, 34*(3), 393-416.

Aguirre, E., García Suárez, F., & Sicilia, G. (2024). Technical efficiency in beef cattle farming in Uruguay: Insights from census data. *Agrociencia Uruguay*, *28*. https://doi.org/10.31285/AGRO.28.1237

Aigner, D. J., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics, 6*, 21–37.

Alhas-Eroglu, N. (2023). Does specialization matter for technical efficiency in beef cattle farming? *Tropical Animal Health and Production*, *55*(1). https://doi.org/10.1007/s11250-022-03416-z

Ali, M., & Chaudry, M. A. (1990). Inter-regional farm efficiency in Pakistan's Punjab: A frontier production function study. *Journal of Agricultural Economics, 6*, 41.

Ali, M., & Flinn, J. C. (1989). Profit efficiency among Basmati rice producers in Pakistan's Punjab. *American Journal of Agricultural Economics, 4*, 71.

Asmara, R. (2012). Analisis daya saing dan faktor-faktor yang memengaruhi produksi susu Indonesia. *Jurnal Manajemen & Agribisnis, 13*(1), 1-15.

Bangladesh Economic Review (BER). (2012). Ministry of Finance, Government of the People's Republic of Bangladesh.

Bárbaro, N., Gere, J., Gratton, R., Rubio, R., & Williams, K. (2008). Measuring the methane emitted by grazing cattle of the Argentinian beef system. In *Australian Journal of Experimental Agriculture* (Vol. 48).

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

Battese, G. E., & Corra, G. S. (1977). Estimation of a production frontier model with application to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics, 21*, 169–179.

Bureau of Bangladesh Statistics. (2022-23). Planning Section, Department of Livestock Services and Bangladesh Economic Review 2024. Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh.

Coelli, T. J. (1995). Recent developments in frontier modeling and efficiency measurement. *Australian Journal of Agricultural Economics, 39*(3), 219–245.

Coelli, T., Rahman, S., & Thirtle, C. (2002). Technical, allocative, cost, and scale efficiencies in Bangladesh rice cultivation: A non-parametric approach. *Journal of Agricultural Economics, 53*(3), 607-626.

David, J. O., Lionel, H., & Eric, R. (2014). Assessment of technical efficiency and its determinants in beef cattle production in Kenya. *Journal of Development and Agricultural Economics*, *6*(6), 267–278. https://doi.org/10.5897/jdae2013.0525

Erwin Wantasen, Sintya JK Umboh, & Jein R Leke. (2022). Technical efficiency of beef cattle production in the regency of Minahasa Tenggara, province of North Sulawesi, Indonesia. *GSC Advanced Research and Reviews*, *12*(2), 204–215. https://doi.org/10.30574/gscarr.2022.12.2.0211

Huang, C. J., & Bagi, F. S. (1984). Technical efficiency of individual farms in Northwest India. *Southern Economic Journal, 51*, 108–115.

Jondrow, J., Lovell, C. A. K., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics, 19*, 223–238.

Kalangi, L. S., Syaukat, Y., Kuntjoro, S. U., & Priyanti, A. (2014). Technical efficiency of beef cattle breeding business in East Java Province. *Media Peternakan, 37*(2), 136-136.

Kovács, K., & Pandey, R. (2017). Hungarian dairy and beef production sector technical efficiency comparsion using DEA. *Applied Studies in Agribusiness and Commerce*, *11*(3–4), 131–138. https://doi.org/10.19041/apstract/2017/3-4/18

Kumbhakar, S. C., Ghosh, S., & McGuckin, J. T. (1991). A generalized production frontier approach for estimating determinants of inefficiency in US dairy farms. *Journal of Business and Economic Statistics, 9*, 279-286.

Liang, Y., Bi, W., & Zhang, Y. (2023). Can contract farming improve farmers' technical efficiency and income? Evidence from beef cattle farmers in China. *Frontiers in Sustainable Food Systems*, *7*. https://doi.org/10.3389/fsufs.2023.1179423

Mlote, N. (2013). Estimating technical efficiency of small scale beef cattle fattening in the lake zone in Tanzania. *Journal of Development and Agricultural Economics*, *5*(5), 197–207. https://doi.org/10.5897/jdae12.0436

Mlote, S. N., Mdoe, N. S. Y., Isinika, A. C., & Mtenga, L. A. (2013). Estimating technical efficiency of small-scale beef cattle fattening in the lake zone in Tanzania. *Journal of Development and Agricultural Economics, 5*(5), 197-207.

Mohd Radzil, R. H., Hamzah, H. Z., Ahmad Sidique, S. F., & Hadi Samsudin, A. A. (2023). Technical Efficiency of Beef Cattle Farms in Peninsular Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *13*(7). https://doi.org/10.6007/ijarbss/v13-i7/17545

Oberholzer, M., Buys, P. W., Fourie, W., & Middelberg, S. L. (2014). Estimating Technical and Scale Efficiency of Red Meat Production: A South African Case Study. *Journal of Economics*, *5*(2), 141–151. https://doi.org/10.1080/09765239.2014.11884991

Oberholzer, M., Buys, P. W., Fourie, W., & Middelberg, S. L. (2014). Estimating Technical and Scale Efficiency of Red Meat Production: A South African Case Study. *Journal of Economics*, *5*(2), 141–151. https://doi.org/10.1080/09765239.2014.11884991

Otieno, D. J., Hubbard, L., & Ruto, E. (2012). Determinants of technical efficiency in beef cattle production in Kenya. *International Association of Agricultural Economists (IAAE) Triennial Conference, Foz Do Iguacu, Brasil, 18-24 August, 2012.*, 18–24.

Pereira, M. A., Fairweather, J. R., Woodford, K. B., & Nuthall, P. L. (2016). Assessing the diversity of values and goals amongst Brazilian commercial-scale progressive beef farmers using Q-methodology. *Agricultural Systems*, *144*, 1–8. https://doi.org/10.1016/j.agsy.2016.01.004

Rakipova, A., & Gillespie, J. (2000). Technical efficiency of beef cattle producers in Louisiana. *Research Report No. 103*, Louisiana State University.

Sobhan, Z. (2023, November 28). 68% Bangladeshis live in villages. *The Dhaka Tribune*. https://www.dhakatribune.com/bangladesh/332419/report-68%25-bangladeshis-live-in-villages

Wei, M., Zhou, H., Ma, J., Khan, N., Cao, J., & Hu, X. (2022). Research on Technical Efficiency of Feed Use for Sustainable Beef Cattle Breeding in China: Evidence from 169 Beef Cattle Farmers. *Sustainability (Switzerland)*, *14*(24). https://doi.org/10.3390/su142416430

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