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ECONOMIC ANALYSIS OF THE MOST IMPORTANT FACTORS AFFECTING THE EFFICIENCY OF BUFFALO MILK PRODUCTION IN BAGHDAD GOVERNORATE

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ABSTRACT

This study aimed to estimate the efficiency of buffalo milk production and address the most important economic and social factors that affect the production of buffalo milk in Baghdad Governorate. A random sample of 96 out of a total of 1600 breeders was taken at a rate of (6%). The stochastic production frontier function was estimated using the maximum likelihood (ML) method between the total milk production and the quantities of production inputs, which included (total production, the quantity of dry fodder, green fodder, concentrated fodder, the number of hours of human work, medicines, vaccines, and energy) in the efficiency model, and social factors such as the family members, experience, education, number of reproduction, and age were included in the inefficiency model. The estimated parameters gave the expected signal and were statistically significant below the 5% level, except for dry food and energy. The total elasticity of productive factors was about 1.0868, which is greater than the correct one, which reflects increasing returns to scale. The average technical efficiency in the study area was (76.6%), and the efficiency ranged between (43% - 100%). This average indicates the possibility of increasing technical efficiency at a rate of (23.4%) if the causes that lead to low efficiency are addressed. In light of these results, we can conclude that there is a possibility of increasing the production of buffalo milk. This study suggests buffalo breeders should replace older buffaloes with new females, and adhere to necessary medications and vaccines to maintain the herd's health.

Key words: **economic efficiency, maximum likelihood, stochastic production frontier, technical efficiency.**

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INTRODUCTION

Buffaloes are one of the most productive animals. It is one of the important agricultural activities that has economic returns, as they feed on cheap quality feed compared to other animals. Buffaloes are very efficient in converting poor-quality feed into animal protein and do not require extensive conditioning yards during summer because they cool themselves in the swamps (30, 44). There, investing in buffalo breeding is a national wealth that has no limits in economic support for the country. Milk is one of the most consumed animal products in the world, as it is an almost complete food that contains many nutrients necessary for the body's growth and vitality. It is a source of high-value animal protein. The Food and Agriculture Organization (WHO) recommends that the average per capita share of milk should reach about 150 kilograms annually and not less than 90 kilograms (12), which is the minimum for

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proper nutrition (Kandil et al., 2019). In Iraq, bovine milk (from cows and buffaloes) constitutes the main source of milk production. Buffalo milk is ranked second in the world in terms of production quantity after cow's milk (Maxhuni, 2016). It also constitutes 12% of global milk production and is distinguished by its composition and nutritional properties that make it suitable for the production of many dairy products. It also contains more calcium, phosphorus, fats, proteins, and lactose than cow's milk (Sharma & Leung, 2000a). Despite the availability of the necessary capabilities and resources for buffalo breeding projects, there is a lack of production, low self-sufficiency, and reliance on imports. This may be attributed to several factors, the most important of which are that buffalo breeders, like other livestock breeders, often lack the optimal use of economic resources and high prices of production factors, especially feed, which led to a decline in production. This situation imposes a reluctance on a group of projects to promote this product. Local (Ali & Fahd, 2012; Ali & Yousif, 2012), and international (Kalirajan & Shand, 1999; Sharma & Leung, 2000b; Alam et al., 2011; Ali & El-Eezi, 2015; Dumilah, 2018; Hassan, 2018; Choi et al., 2022). have focused on the stochastic frontier production function, and production function and economic efficiency (Awoyemi et al., 2003; Stefano, 2004; Kolawole & Ojo, 2007; Odeck, 2007; Effiong & Idiong, 2009; Cechura et al., 2014; Shukur, 2015; Ume et al., 2016; Ng'ombe, 2017; Al-Hachami et al., 2020; Gbigbi, 2020; Zicarelli, 2020). The present study aims to measure the efficiency of buffalo milk production and analyze the factors affecting it, including estimating the stochastic buffalo milk production function to determine the technical relationship between inputs and outputs. The research was based on the hypothesis that there is a lack of optimal exploitation of resources in the production of buffalo milk and that buffalo milk producers have not achieved full technical efficiency. Also, the production of buffalo milk is indirectly affected by management factors that affect inefficiency.

MATERIALS AND METHODS

Cross-sectional data were obtained through a random sample of buffalo breeder projects in Baghdad Governorate for the production year 2022 through a questionnaire prepared for this purpose. A random sample of 96 breeders was collected, and a total of 1,600 projects represented 6% of the total projects.

Stochastic frontier production function

The Stochastic Frontier Production Function was estimated for buffalo milk production projects using the Maximum Likelihood method (Ukpong & Idiong, 2013). By this function, the numerical values of explanatory variables for the Cobb-Douglas function and the T-test were obtained. The value of the variance of the coefficients, Sigma-Squared σ^2, and the value of Gamma were also estimated. Furthermore, economic and social variables of farms that affect the level of inefficiency of technical requirements for buffalo milk production projects were calculated. It should be noted that the negative values of the inefficiency variables indicate the positive relationship between the level of technical efficiency and the variables included in the model (Sharma & Leung, 2000; Kumbhakar & Tsionas, 2006; Hajivand et al., 2020; Thriveni et al., 2022). That is, the positive trend for these variables indicates a decrease in technical efficiency as the influence of these factors increases.

Description and formulation of the mathematical model: The random frontier production function using the Cobb-Douglas model in the research sample included the following variables (Sharma & Leung, 1998; Phiri & Yuan, 2018; Purnamasari et al., 2018; Saraiva Bresciani, 2018).

$$\boldsymbol{Ln\,Y_i = \beta_o + \beta_1 Ln\,X_{1i} + \beta_2 Ln\,X_{2i} + \beta_3 Ln\,X_{3i} + \beta_4 Ln\,X_{4i} + \beta_5 Ln\,X_{5i} + \beta_6 Ln\,X_{6i} + \beta_7 Ln\,X_{7i} + (v_i - u_i) \ldots.(1)}$$

Where as:

Dependent Variable (y) represents the quantity of milk produced (Kg).

As for the independent variables (Xs), the variables included the following:

X_1: Herd size is expressed in the number of buffaloes on the farm.

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X_2: Quantity of dry feed used in each farm (kg).
X_3: Quantity of green feed used in each farm (kg).
X_4: Quantity of concentrated feed used in each farm (kg).
X_5: The number of humans working represents manual work services (family and fee) that use herd raising a worker /day.
X_6: Quantity of medicines and vaccines used in each farm (vial).
X_7: The amount of energy (electrical energy) (Kilowatt/hour)
Vi: A random variable or measurement error due to variables beyond control, such as diseases, for example.
Ui: A non-negative random variable that refers to variables that the farm can control, such as experience and educational level, and it represents technical inefficiency (Ali et al., 1994; Al-Nuaimy & Ahmed, 2012; Bhattacharyya & Mandal, 2015).

$$U_i = \delta_o + \sum \delta_i Z_i \dots\dots\dots\dots (2)$$

The inefficiency model in the research sample included variables that included the social and economic characteristics of farmers and the following performance indicators within the farm:

$$U_i = \delta_o + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} \dots\dots (3)$$

Where as:
Z_1: Number of family members (individual)
Z_2: age of breeders (year)
Z_3: Experience years
Z_4: Education level (number of schooling years)
Z_5: Number of courses

RESULTS AND DISCUSSION

First: Statistical characteristics: The statistical characteristics of the variables of the stochastic frontier production function for buffalo milk production in Baghdad Governorate include the sample mean, range, and standard deviation for each variable.

Table 1. Statistical characteristics of the variables

Variables	Minimum	Maximum	Mean	Standard Deviation
The amount of milk (tons)	1225	2450	1623	296.55
Herd size (number of buffaloes on the farm)	3.00	70.00	21	22.25
Quantity of concentrated feed (kg).	912.5	1825	1368.75	384.96
Quantity of dry fodder (kg).	1642.8	2281.2	1961.85	416.04
Quantity of green fodder (kg).	1861.1	2636.3	2248.9	249.52
Number of human working hours (worker /day)	742.8	1250.4	930.3	124.36
Vaccines and medications(vial)	820.00	2706.00	1098.24	154.32
Number of family members (individual)	5	25	8	3.80
age of breeders (year)	22	69	44	6.47
Experience (years)	10	60	32.2	7.53
Education level (number of schooling years)	0	18	5	3.91
Number of courses	0	4	3	1.47

Source: Prepared by the researcher based on the questionnaire form

The results of the statistical characteristics of the economic and social variables are summarized in Table 1. The results indicate that there is a high agreement between milk production, which ranged from (1225 tons to 2450 tons, with an average of 1623 tons and a standard deviation of 296.55 tons) and herd size (3 heads to 70 heads, with an average of 21 heads and a standard deviation of 15.43 heads). This is consistent with reality, as the larger the size of the herd (females), the greater the quantities of milk produced. The mean concentrated dry and green food was (1368.75 tons, 1961.85 tons, and 2248.9 tons), respectively, with a range of (912.5-1825 tons, 1642.8-2636.3 tons, 2636.3, 1861.1 tons), and a standard deviation of (384.96, 416.04, 249.52) respectively. The results indicate that there is a large variation in the total number of human working hours, as it ranged from 742.8 hours to 1250.4 hours, with an average of 930.3 hours and a standard deviation of 154.32 hours. This is consistent with reality, as this variation in working hours depends on the size of the projects. The average quantity of medicines and vaccines was 1098.24 vials and ranged between a minimum of 820.00 vials and a maximum of 2706.00 with a standard deviation of 154.32 vials. The table also displays the social characteristics of buffalo

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breeders, which included (number of family members, age, experience, education, and number of courses). The number of family members ranged from 5 to 25 individuals, with an average of 12 individuals and a standard deviation. Buffalo breeding is almost the activity of a population with relatively low educational and cultural levels. Thus, breeders tend to increase their offspring regardless of the economic situation to help in managing the herds. The mean age of buffalo breeders was 44 years, ranging from 22 years to 69 years, with a standard deviation of 10.47 years, which reflects that the breeders are elderly in the study area. This corresponds to the level of experience, which ranged from 10 to 60 years, with an average of 44 years. This level is considered to be high enough for buffalo breeders to make optimal use of inputs and achieve the optimal quantity of production. As for the number of cycles, the average number of births of female buffalo was 3 cycles, with a range of 0-4 cycles and a standard deviation of 10.47.

Table 2. Maximum likelihood estimates of the parameters of frontier analysis

Variables	Coefficient	Estimated coefficient values	Standard-Error	t-ratio
Stochastic production function mode				
Constant	β_o	0.36812521	0.17799564	2.0681
Ln Herd size	β_1	0.09542546	0.04715748	.02352
Ln Quantity of dry feed	β_2	-0.12000655	0.17921977	-0.6696
Ln Quantity of green feed	β_3	0.28544100	0.09768644	2.9220
Ln Quantity of concentrated feed used	β_4	0.31200211	0.09614417	3.2451
Ln The number of human working hours	β_5	0.14555241	0.02419653	6.0154
Ln Quantity of medicines and vaccines	β_6	0.12548522	0.04317554	2.9063
Ln The amount of energy (Kw/hour)	β_7	0.02458755	0.05747675	0.4274
Inefficiency model				
Constant	δ_o	2.35485550	0.03335458	0.0785
Number of family members (individual)	δ_1	-0.03452122	0.01400159	-2.4655
Experience years	δ_2	-0.04968572	0.01545201	3.2154-
Education level (number of schooling years)	δ_3	0.02555422	0.0085596	2.9854
Number of courses	δ_4	0.04365552	0.01341412	3.2544
age of breeders (year)	δ_5	-0.03221544	0.01592955	-2.0223
Diagnostic tests				
Return of scale (RTS)	0.868			
Sigma-squared (σ^2)	0.882		0.434	2.031
Gamma (γ)	0.922		0.027	34.05
Log-likelihood	24.52			

Source: Calculated using Frontier version 4.1

Second: Economic analysis

Table 2 shows the maximum likelihood estimates for the stochastic frontier production function using the Cobb-Douglas model for buffalo milk production projects for the production year 2022. The results indicated that buffalo milk production in Baghdad Governorate is affected by the explanatory variables, which are (herd size, dry food, concentrated food, green food, human work, medicines and vaccines, the amount of energy (fuel, oils, and electrical energy), according to the following:

- Herd size: There was a positive and significant relationship between herd size and buffalo milk production, and it was significant at the 0.05% level. The elasticity value for the variable herd size was 0.095, implying that increasing the size of the herd by 1% leads to an increase in production by 0.095%.

-Dry food: There is a negative and non-significant relationship between dry food and buffalo milk production. This type of food is used as a supplementary food and is devoid of the basic nutritional elements necessary for milk production. As nutrition directly affects

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the production of buffalo milk, increasing this type of food will be at the expense of concentrated feed, whose costs are relatively high, and thus, the amount of milk produced will decrease.

- Green food: Its production elasticity reached 0.285, which is also positive and significant at the 5% level. This means that increasing the use of green food by (1%) leads to an increase in buffalo milk production by (0.285%). Milk production requires large quantities of energy, inorganic elements, and vitamins, so they must be available in green fodder on an ongoing basis.

- Concentrated food: The elasticity value was 0.312, indicating the direct relationship between concentrated food and the amount of buffalo milk production. This means that increasing the use of concentrated food by (1%) leads to an increase in buffalo milk production by (0.312%). Concentrated food is mainly used within pasture-dependent systems as supplementary food to improve milk production because it contains a high percentage of essential amino acids necessary for milk as well as meat production. In addition, it contains a high percentage of fats, which distinguishes buffalo milk from other domestic animal milk.

- Human labor: The daily allocation of working hours for each animal in buffalo farming was a significant level of 0.01% with an elasticity coefficient of 0.145. This implies that increasing human labor by 1% leads to an increase in production by 0.145%. That is, breeders who own large herds need a large number of work units to manage their herds. Hence, increasing the number of labor units used in buffalo management activities always helps in improving the quality of management and, ultimately, buffalo milk production.

- Medicines and vaccines: regarding medicines and vaccines, the elasticity reached 0.125, meaning that increasing medicines and vaccines by 1% leads to an increase in production by 0.125%. This is due to the large number of diseases that affect buffalo, especially rinderpest and internal parasites, which negatively affect milk production. Therefore, controlling these diseases through vaccination or regular treatment improves the health of the herd and increases its milk production.

- Energy (electrical energy): There is a negative and non-significant relationship between energy and buffalo milk production, as breeding buffalo does not require an air-conditioned environment. Rather, most of the water lakes close to the herd are exploited to alleviate the body temperature, especially in the summer, and therefore, their buffalo breeding projects do not require a continuous electrical current, which eliminates the need for electric generators and the resulting savings in fuel and oil consumption.

The total elasticity of productive factors included in the function was about 1.0868, which is greater than one. That reflects increasing returns to scale and indicates that increasing the used productive resources by (1%) leads to an increase in buffalo milk production by (1.868%). Thus, there is a possibility for increasing milk production when the resources are added in equal proportions. This indicates that buffalo breeders produce within the framework of the first productive stage of the diminishing returns law.

Third: Diagnostic tests

Diagnostic tests for the stochastic production frontier model Table (2) indicate a good fit of the model and that the parameters are highly significant through the estimated value of square sigma ($\sigma 2$), which was 0.88 and significant at the 1% level. It implies that 88.0% of the variation in total production can be attributed to the effects of production inefficiency, while the remaining 12% is the result of white noise. This indicates that fluctuations in production were primarily caused by inefficiency and not by the stochastic distribution of deviations from frontier production. The estimated value of the γ parameter, which determines the ratio of the inefficiency variance to the composite error variance, was 0.92 and was statistically significant. Accordingly, the majority of the deviation between buffalo milk production projects and optimal production limits can be attributed to inefficiency, while only a small

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portion can be attributed to random errors. This result was further supported by the likelihood ratio (LR) test statistic. This test is performed under the assumption that all parameters of the inefficiency function are equal to zero. This means that there is no inefficiency in the model, as expressed by the null hypothesis. (H0: $\gamma = \Delta = \Delta 1 = \cdots = \Delta 7 = 0$). The likelihood ratio test for the one-sided error resulted in a value of 24.52, which summons zero hypothesis rejection at a 5% significance level. Therefore, it has been proven that the presence of inefficiencies accounts for a significant portion of the variance in profitability among small and medium projects.

Estimation of technical efficiency

By estimating the stochastic frontier production function, the technical efficiency of buffalo milk production in Baghdad Governorate was measured through the study variables using the Frontier Version 4.1 program. The technical efficiency was reviewed according to the frequency of each category. It is clear from Table 3 that the mean technical efficiency for producing buffalo milk in the study area was 76.6%, and ranged between (43% - 100%) . This average indicates a potential increase in technical efficiency at a rate of 23.4% if the reasons that lead to a low level of this efficiency are manipulated. Therefore, it is the responsibility of the breeders in the sample to produce the current amount of buffalo milk using only 76.6% or less of the inputs. The table shows that the included herds had the highest level of efficiency, which falls between (90%-100%), as it was able to achieve the highest output of buffalo milk with a specific volume of inputs. This implies that breeders follow the principles of good practice in the production process. Thus, they approach the Possible Production curve derived from the total sample. As for the lowest level of technical efficiency percentage, it was 40-49% and was achieved by one farm. For this farm to reach the efficiency stage, the breeder must produce the current amount of milk. Buffalo or more using 23.4% less than current inputs.

Table 3. Distribution of the technical efficiency estimate for buffalo milk production

Technical efficiency level	Frequency	Percentage (%)
0.40-0.49	1	1.04
0.50-0.59	3	3.13
0.60-0.69	19	19.79
0.70-0.79	43	44.79
0.80-0.89	23	23.96
>0.90	7	7.29
Total	96	100%
Maximum	100	
Minimum	43	
Mean Economic	0.76	

Source: Calculated using Table 3

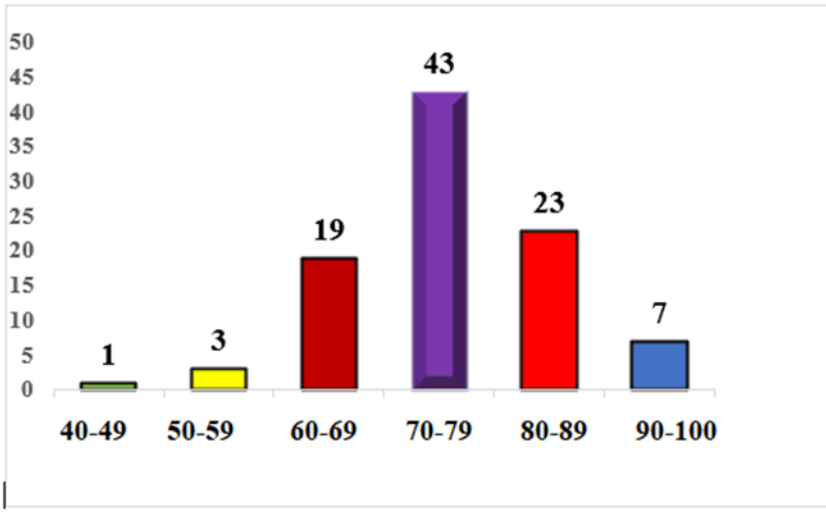

Figure 1. Distribution of Technical efficiency estimate for buffalo milk production
Source: Prepared by the researcher based on Table 3

CONCLUSION

The study results showed that buffalo milk production in Baghdad Governorate is positively and significantly affected by herd size, green and concentrated food, human working hours, medicines and vaccines, while dry food and energy did not show a clear significant effect. The results also showed that the average technical efficiency reached 76.6%, with a range between 43% and 100%, which indicates the existence of an efficiency gap that can be addressed, as the level of efficiency can be raised by about 23.4% through improving the use of resources and the technical management of projects. The results of the current text also indicate that there is an opportunity to increase production when improving the use of inputs, which confirms that the main problem is not only the scarcity of resources, but also the poor efficiency of their use within production units, especially concerning the management of nutrition, health care, and work organization within the project. The researchers recommended the necessity to guide breeders towards the most efficient use of production inputs focusing on the deliberate expansion of the use of green and concentrated food, given their proven positive impact on increasing production, attention to regular health care through the timely provision of medicines and vaccines, improving the organization of human labor within breeding projects, as well as encouraging breeders to replace older females with more productive ones. Furthermore, there must be intensified agricultural and veterinary extension and practical training for breeders to enhance their administrative and technical efficiency, because addressing inefficiencies is the direct path to increasing buffalo milk production and improving the economic return of projects.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us.

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AUTHOR'S CONTRIBUTION STATEMENT

Fahad S. Hamad: The first author conducted the descriptive analysis, prepared the conclusions and recommendations section, collected data, wrote the abstract, prepared the methodology, and wrote the results and discussion section, the introduction, and the bibliography. Zahra H. Mahmood: The second author formulated the research idea, provided technical support throughout all stages of the work, and oversaw and managed the research.

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تحليل اقتصادي لاهم العوامل المؤثرة في كفاءة إنتاج حليب الجاموس في محافظة بغداد*

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المستخلص

هدفت الدراسة الى تقدير كفاءة إنتاج حليب الجاموس ومعرفة اهم العوامل الاقتصادية والاجتماعية التي تؤثر على إنتاج حليب الجاموس في محافظة بغداد. أخذ عينة عشوائية مكونة من 96 من إجمالي (1600) مربيا وبنسبة (6٪). تم تقدير دالة الحدود الإنتاج العشوائية باستخدام طريقة الاحتمالية القصوى (ML) بين إجمالي إنتاج الحليب وكميات مدخلات الإنتاج والتي شملت (كمية العلف اليابس والعلف الأخضر والعلف المركز وعدد ساعات العمل البشري والأدوية واللقاحات) في نموذج الكفاءة، والعوامل الاجتماعية مثل عدد أفراد الأسرة والخبرة والتعليم وعدد الدورات والعمر في نموذج عدم الكفاءة. أعطت المعلمات المقدرة الإشارة المتوقعة وهي ذات معنوية إحصائية تحت مستوى 5% باستثناء متغير العلف اليابس والطاقة. بلغت المرونة الإجمالية للعوامل الإنتاجية التي تضمنتها الدالة نحو 1.0868 وهي أكبر من الواحد الصحيح، والتي تعكس عوائد سعة متزايدة. بلغ متوسط الكفاءة الفنية لإنتاج حليب الجاموس (76.6%) وقد تراوحت الكفاءة ما بين (43%– 100%). يشير هذا المتوسط الى إمكانية زيادة مستوى الكفاءة الفنية بمعدل (23.4%) إذا ما تم معالجة الأسباب الى تؤدي الى انخفاض مستوى هذه الكفاءة. على ضوء هذه النتائج يمكن أن نستنتج أن هناك إمكانية لزيادة إنتاج حليب الجاموس على نحو متزايد. توصي الدراسة مربي الجاموس باستبعاد الجاموس الأكبر سنا ما بعد الدورة الخامسة لإنتاج الحليب وتعويض القطيع بإناث جديدة، والالتزام بالأدوية واللقاحات الضرورية لإدامة صحة القطيع.

الكلمات المفتاحية: الكفاءة الاقتصادية، الإمكان الأعظم، حدود الإنتاج العشوائية، الكفاءة التقنية.

البحث مستل من رسالة الماجستير للباحث الأول.