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Profit Efficiency of Milk Producers in Ethiopia: Empirical Evidence from Western Shewa Milk Shade, Walmara District

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ABSTRACT

The study assessed the profit efficiency and the responsible factors for the inefficiency of dairy farmers in West Shewa milkshed, central Ethiopia. A multistage random sampling method was employed to select sample households. The primary data were collected using structured questionnaires with computer-assisted personal interviews (CAPI). Descriptive and econometric data analysis were performed, and the stochastic frontier model was the model used. The result disclosed that the dairy business is profitable, and the mean efficiency score is 71%, indicating the existence of 29% inefficiency in dairy farming. This result indicates that enhancement of all the efficiencies will enable households to attain a potential profit of 88428.25 birrs. Sex, the price of milk, and the number of cows owned were the main factors that affected the profit inefficiency of the dairy farmers. This study suggests that the profit efficiency of dairy farmers will be enhanced if they choose their dairy farm sizes based on the production resources they have, and if the milk collection centers are availed in all villages.

INTRODUCTION

Livestock production plays a significant role in the economy of Ethiopia, the country that is the home to the largest livestock population in Africa owning 65 million cattle, 51 million goats, 49 million chickens, 40 million sheep, and 8 million camels. The sector supports the livelihood of millions and plays a substantial role in improving food and nutrition security, poverty reduction, providing export commodities, serving as a source of traction power for crop cultivation, serving as an essential mode of transport, sources of income during crop failure, sources of manure to improve soil fertility, and the national economy (CSA, 2021a).

The demand for animal-source protein including milk, milk products, and meat escalated along with the fast population growth, while domestic cow milk production steadily increased and reached 4.96 billion liters in 2020 (CSA, 2021a; Nigel *et al.*, 2023). This created a large gap to be met through imports by spending the scarce foreign currency (Zijlstra *et al.*, 2015; Gebreyohanes *et al.*, 2021), and the country imported more than 24.11 million liters of milk and milk products from 69 different countries spending more than 2.615 billion birrs from 2009 to 2018 (Tesfaye *et al.*, 2019)

The country's livestock sector is mainly characterized by its subsistence, traditional, small-scale, and low productivity. About 95% of the dairy cows are kept by smallholder farmers who own less than five heads of cattle, and each cow produces 1-2 liters of milk per day. This low productivity resulted from animal breeds, diseases, low quality and quantity of feed, poor management, lack of infrastructure, and poor veterinary and AI services (Nigel *et al.*, 2023; Tschopp *et al.*, 2021).

Milk production per cow in urban and semi-urban areas is improving as the result of higher adoption rates of cross-breed cows, better access to commercial feeds, better animal health services, and improved dairy-related extension services, while it is even declining in rural areas. Moreover, the high price of cross-breed cows also contributed much to the low productivity as it is unaffordable to poor rural farmers (Minten *et al.*, 2020).

Efficiency in agricultural production is an integral part of using scarce resources and advanced agricultural technologies to advance food production. Therefore, assessing the level of production efficiency of smallholder dairy farmers will contribute much to the efforts made to increase production and productivity and enhance the profitability of the farmers (Skevas & Cabrera, 2020; Von Keyserlingk *et al.*, 2013). Good management practices for individual cows or the herd can improve cow productivity, leading to higher average milk production, reduced production costs, and improved farm efficiency (Britt *et al.*, 2018; Pulina *et al.*, 2020).

A firm rarely operates on the top of all the possible lists of measures of performance. So, identifying a firm that operates on the best frontier across the relevant measures is an important task (Chen *et al.*, 2015).

Economic efficiency comprises cost efficiency and profit efficiency, which are cost minimization and profit maximization. Cost inefficiency results from allocative inefficiency (bad production plan) and technical inefficiency (poor implementation of the production plan). Cost efficiency evaluates efficiency at a certain level of output, not for the optimal level of output, and it does not account for the quality difference of the output. These shortcomings of cost efficiency have given rise to profit efficiency (Arbelo *et al.*, 2021). Profit efficiency on the other hand refers to the ability of a firm to manage its

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resources to reduce costs per unit of output or produce an output with a greater economic value. It is an indicator that assesses the gap between a firm's actual and potential profit. Therefore, profit efficiency is a better predictor of efficiency compared to accounting and financial indicators in evaluating the overall performance of a firm (Arbelo *et al.*, 2021; Han *et al.*, 2012).

According to Bach *et al.*, (2020), the efficiency of milk production is mainly determined by feed costs, and the income from milk as nutrition strongly affects farm economics (Bach *et al.*, 2020). In recent years, on-farm measurable partial indicators have been used with their weaknesses and strengths to measure the economic efficiency of dairy farms. Among these partial indicators, the marginal profit of a given input per unit of output is the key indicator (Connor, 2015).

To the best of the knowledge of researchers, no research has been conducted on assessing the profit efficiency of smallholder milk producers in the study area. Therefore, this study aims to contribute to the existing literature by employing the concept of profit efficiency as a measure of performance, and the stochastic frontier model with random coefficients to estimate profit efficiency assuming the heterogeneity of resources. In the remaining part of this article, the research methodology, results and discussion, and the conclusions and recommendations parts were presented respectively.

MATERIALS AND METHODS

Study Area

The study was conducted in the Walmara district in Central Oromia, Ethiopia. The district is located 30 km to the west of Addis Ababa, along the road to Ambo. Geographically it lies between 8°50'-9°15' N and 38°25'-38°45' E. The district has a total area of 77,119 hectares, out of which 64984 is cropland, 2442 is grassland, 4329 is forest land, 1404 is wetland, 3790 serve for settlement, and 170 is water bodies (Urgessa & Lemessa, 2020).

The district's agroecology is classified as highland (61%) and mid-highland (39%). Its altitude ranges from 2060m to 3380m, with an average of 2400 meters above sea level. The district's mean temperature is 14ºc, ranging from 6ºc to 24ºc. The district's average, minimum, and maximum annual rainfall is 1,144, 795, and 1300 mm (Muleta & Getahun, 2022).

According to the population projection report of CSA (2021), the total population of Walmara district was 112,498 (56,200 males and 56,298 females) (CSA, 2021b). According to the information from the district office of agriculture and rural development, the farming system of the district is characterized as mixed, both crop and livestock production similar to other central highlands of the country. The major crops grown in the district during the main season are wheat, barley, tef, pulses, oilseeds, and potatoes. These are the major staple food crops in the study area. Similarly, potatoes, cabbages, tomatoes, carrots, and onions are the major vegetable crops grown during the off-season using irrigation.

Data Collection

This study used primary data collected to assess the profit efficiency of milk producers in the Walmara district, central Oromia, Ethiopia. The data was collected through a cross-sectional survey of 187 dairy farmers based on their consent. A multi-stage sampling procedure was the method followed. Walmara district was purposively selected based on its potential for milk production in the west Shewa milk shed. Out of the 23 peasant associations in the district, four representative PAs were randomly selected. Out of the sample PAs, representative sample households were randomly selected based on the proportional sampling method that is determined using the formula:

$$n_i = (N_i (n))/(\sum N_i) \quad (1)$$

Where n_i is the sample to be selected from i^{th} PA, N_i is the total population living in i^{th} PA, $\sum N_i$ is the summation of the population living in selected four PAs, and n is the total sample size for the district.

For the primary data collection, the researchers included variables like the number of cattle owned, the number of cows owned, milk yields per cow, price of milk, herd managing system, input costs (feed cost, water cost, labor cost, medication cost, cost of artificial insemination, farm maintenance cost), price of milk, milk sold, milk consumed at home, and milk given to calves, lactation length, etc. Moreover, data on access to extension, access to credit services, distance from the milk market, membership in cooperative unions, educational status, sex, age, etc. were also recorded. Secondary data on milk production, marketing, efficiency, and others were collected from different unpublished and published sources.

Variables Included in the Study

Based on the reviewed literature, the following variables (listed in Table 1) were selected to be included in this study.

Table 1: Lists of variables and their expected effect on the dependent variable

Var. code	Description and measurement	Expected effect
π	Normalized profit	
p_i	Normalized prices of inputs	-
p_1	The price of concentrate feeds	-
p_2	Price of roughage feeds	-
p_3	Prices of veterinary medicines	-

p_4	Prices of labor	-
p_5	Prices of AI	-
z_i	Quantity of fixed input	
z_1	Herd size	-
z_2	Capital employed (depreciation)	-
x_i	Variables affecting inefficiency	
x_1	Age of the household head	+
x_2	Education of the household head	-
x_3	Family size	+
x_4	Experience in dairy farming	-
x_5	Lactation length	+/-
x_6	Extension contact	-
x_7	Market distance	+
x_8	Access to credit service	-
x_9	Sex of the household head	+/-
x_{10}	Membership in dairy cooperatives	-

Source: Authors' compilation based on reviewed literature

Analytical Framework

To assess the profit efficiency of small-scale milk producers in Ethiopia, the frontier alternative profit function developed by Berger and Mester (1997) was employed. This function considers profit as a dependent variable, while the amount of outputs and the price of inputs are independent variables. Moreover, the output is considered to be constant, while the input price freely varies to affect the profit (Berger & Mester, 1997).

The frontier profit function is the most frequently used method in assessing profit efficiency in agriculture (Wongnaa *et al.*, 2019; Arbelo *et al.*, 2021; Adnan *et al.*, 2021; Jimoh *et al.*, 2023). It allows the joint estimation of the parameters in the profit function and the inefficiency model (Battese & Coelli, 1995; Wongnaa *et al.*, 2019). This method of estimation has many advantages over the widely used two-step estimation (Kumbhakar *et al.*, 1991; Wang & Schmidt, 2002)

According to the theory of production, a farmer uses input and output bundles that maximize his or her profit given the technology constraints. As the assumptions of perfect competition are not applicable, alternative profit efficiency was employed for this specific study. In this method, the quantity of output and the price of inputs are used as independent variables while the profit is the dependent variable. The quantity of output is constant, and the prices of the inputs are allowed to vary to affect a firm's profit.

The functional forms of the alternative profit function can be expressed as follows:

$$\pi_i = f(y_i, w_i)^{((vi - ui))} \quad (2)$$

Where: π_i is the profit of farmer i, f is the functional form to be used, y_i is the quantity of milk output for farmer i, w_i is the prices of vector input variables for farmer i, u_i is the inefficiency that reduces farm profit of farmer i, and v_i is the random error.

The alternative profit efficiency of a farmer can be defined as the ratio of the current profit of the farmer to the maximum profit that the farmer could achieve if he/she produces on the efficient frontier (u_i =0). This can be expressed as:

$$\pi_i = \pi_{current}/\pi_{max} \quad (3)$$

$$= (f(y_i , w_i)^{(vi - ui)})/(f(y_i, w_i)^{(vi)} \quad (4)$$

$$= \exp^{(-ui)} \quad (5)$$

From the alternative profit function, the greater value closer to 1 is the greater profit efficiency of the farmer. For example, if the value of the profit efficiency ratio of 0.9 indicates that the firm is losing 10% of its maximum profit due to excess cost or inadequate revenue.

According to Battese and Coelli (1995), efficiency varies across firms and over time, and it is logical to ask what factors are responsible for the differences in efficiency. This model states that the determinants of inefficiency are the linear function of explanatory variables that show the inherent characteristics of a specific firm. The random error (v_i) distributed as N(0, δ_v^2) is independent of the inefficiency term (u_i) that is considered as a non-negative random variable distributed as N(μ, δ_u^2) (Battese & Coelli, 1995).

The transcendental logarithmic production function (translog) was employed in this paper, and its functional form is represented as follows:

$$\pi_i = \beta_0 + \sum_{n=1}^{6} \beta_i lnp_i + \frac{1}{2}\sum_{i=1}^{6} \sum_{k=1}^{6} \varphi_{ik}\, lnp_i lnp_k + \sum_{i=1}^{6} \sum_{l=1}^{2} \theta_{il}\, lnp_i lnz_l + \sum_{l=1}^{2} \gamma_l lnz_l + \sum_{l=1}^{2} \sum_{q=1}^{2} \alpha_{lq}\, lnz_l lnz_q + v_i - u_i \quad \ldots\ldots 6$$

Where β_o is a constant term, β_o, βi, φ_{ik}, θ_{il}, γ_i, and α_{lq} are the parameters to be estimated, u_i is the inefficiency variables, and $\varphi_{(ik)} = \varphi_{ki}$ for all k and i.

$$u_i = \delta_o + \sum_{i=1}^{n} \delta_i x_i + \varepsilon_i \qquad (7)$$

Where δ_o is a constant, δ_i is a vector of parameters to be estimated, x_i is a vector of variables that affect the inefficiency, and ε_i is a truncated random variable.

In assessing the level of efficiency, the two-step estimation procedure is reported to be biased (Battese & Coelli, 1995; Wang & Schmidt, 2002), and the single estimation method was followed to asses both the profit and the stochastic frontier profit inefficiency simultaneously using the maximum likelihood estimation method (Kumbhakar *et al.*, 1991; Battese & Coelli, 1995).

RESULTS AND DISCUSSION

Descriptive Results

The descriptive results of the included variables are depicted in Table 2 and Table 3. From the result in Table 2, the farm households in the study area own more than 2 lactating cows (2.75) on average, and the average lactation length is 285.6 days. Each household has more than 4 family members on average, and the mean age of the sample households is 45.8 years. Moreover, the farm households in the study area have an experience of 19.77 years in dairy farming on average.

The results in Table 2 revealed that the average milk yield in the study area is 2,610.99 liters per lactating season, and the average milk price in the study area is about 47.18 birrs. This indicates that the dairy farmers in the study area are getting an average revenue of 123,186.51 birrs per lactation period. Similarly, the dairy farmers in the area are expected to pay an average production cost of 63,780.92 birrs (31,519.52 birrs for concentrate feeds, 25,390.54 birrs for roughage feeds, 508.62 birrs for medication services, 6,189.88 birrs for labor, and 172.36 birrs for artificial insemination services). These indicate that the dairy farmers in the study area are obtaining an average profit of 59,405.58 birr from the dairy farming business per lactating season.

Table 2: Descriptive results of continuous variables

Variables	Mean	Standard deviation	Minimum	Maximum
Number of cows	2.749	.814	1	4
Family size	4.46	1.844	2	10
Age of the head	45.856	11.951	25	84
Milk price	47.187	5.06	28	55
Lactation length	285.856	57.049	150	420
Concentrate feed	1854.947	1126.448	200	6000
Roughage feed	3170.348	2045.995	120	10950
Profit earned	62731.813	50238.13	2200	221454
Concentrate feed cost	31519.519	21107.527	3552	140000
Roughage feed cost	25390.54	23057.159	720	214704
Labor cost	6189.882	4292.896	49	18144
Milk yield	2610.995	1071.687	480	5260
Medication cost	508.615	193.201	200	980
A/insemination cost	172.364	68.805	50	388
Education of the head	4.813	4.039	0	17
Experience in dairy	19.77	8.695	4	52
Market distance	6.23	5.032	1	24

Source: Authors' survey result

The results in Table 3 confirm that the majority (90.37%) of the dairy farmers in the study area are male-headed households. The reason is that almost all the farm households in the study area are dairy farmers, and the majority of the farm households are male-headed. This result also confirms that the majority of the dairy farmers in the study area (85.56%) don't have access to credit services while the majority of the sample households (85.03%) have access to extension services. Moreover, only 16.58% of the farm households are members of farmers' cooperative unions.

Table 3: Descriptive results of dummy variables

Variables		Frequency	Percent
Sex of the household head	Female	18	9.63
	Male	169	90.37

	Total	**187**	**100.0**
Access to credit service	No	160	85.56
	Yes	17	14.44
	Total	187	100.0
Access to extension service	No	28	14.97
	Yes	159	85.03
	Total	**187**	**100.0**
Cooperative membership	No	156	83.42
	Yes	31	16.58
	Total	**187**	**100.0**

Source: Authors' survey result

Econometric Results

Before running the stochastic frontier model, heteroscedasticity and multicollinearity tests were conducted, and the results confirmed that there is no problem with heteroscedasticity and multicollinearity. From the result, the mean VIF is 1.7 ranging from 1.1 to 3.6. Similarly, from the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity, $chi^2(18)$ was 47.78 and Prob > chi^2 was 0.0002. Then, using 5 production variables and 12 variables suspected to affect the inefficiency of dairy farmers, an estimation was performed and the model result is presented in Table 4.

Table 4: Stochastic frontier model result (parameter estimate)

Number of obs. = 187	**Wald $chi^2(6)$ = 4072.41**		
Log likelihood = - 452	**Prob > chi^2 = 0.0000**		
Profit	**Coef.**	**St. Err.**	**P>z**
Frontier			
Milk yield	2.173***	0.044	0.000
Labor cost	-0.056***	0.012	0.000
Concentrate feed cost	-0.514***	0.036	0.000
Roughage feed cost	-0.309***	0.027	0.000
Medical cost	-0.063**	0.028	0.023
Artificial insemination cost	-0.052***	0.020	0.008
Constant	3.553***	0.433	0.000
Mu			
Sex of the household head	-0.646*	0.345	0.062
Age of the household head	-0.022	0.018	0.214
Family size	0.020	0.024	0.410
Education of the household head	-0.034	0.066	0.601
Experience in dairy farming	-0.019	0.032	0.551
Distance from the milk market	0.020	0.020	0.315
Cooperative membership	-0.287	0.377	0.447
Access to extension services	-0.028	0.284	0.922
Access to credit services	-0.099	0.439	0.821
Price of the milk	-0.122***	0.030	0.000
Number of cows owned	0.294*	0.162	0.069
Lactation length	0.002	0.002	0.340
Constant	5.124***	1.267	0.000
U_sigma			
Constant	-0.731	0.351	0.037
V_sigma			
Constant	-7.072***	0.738	0.000

Sigma_u	0.694***	0.122	0.000
Sigma_v	0.029***	0.011	0.007
lambda	23.822***	0.120	0.000

Source: Authors' survey result

The results in Table 4 indicated that all the production variables (labor cost, concentrate feed cost, roughage feed cost, medication cost, and cost of artificial insemination) negatively and significantly affected the profit efficiency of the dairy farmers in the study area. Costs of roughage, concentrate, labor, and semen were significant at 1% while medication cost was significant at 5%. Similarly, sex, price of the milk, and the number of cows owned are among the variables that significantly affected the inefficiency of dairy farmers in this study.

Labor cost negatively and significantly affected the profit efficiency of the dairy farmers at 1%, and the sign of the coefficient is as expected. This result in Table 4 indicates that a 1% increase in labor cost will result in a 0.056% reduction in the profit of the dairy farmers. This result supports the finding reported by (Acharya *et al.*, 2021; Lakshmipriya *et al.*, 2023). The cost of concentrate feed also negatively and significantly affected the profit efficiency of dairy farmers at 1%. The sign of the coefficient is as expected, and from this result, increasing the cost of concentrate feed by 1% will reduce dairy farmers' profit efficiency by 0.514%. This result indicates that concentrate feed is the most important input in a dairy farming business. This result is against the finding reported by (Binita Kumari *et al.*, 2020; Lakshmipriya *et al.*, 2023)

Roughage feed cost also negatively and significantly affected the profit efficiency of dairy farmers at 1%. The sign of the coefficient is as expected, and it could be inferred from Table 4 that increasing roughage feed cost by 1% will result in a 0.309% reduction in the profit of dairy farmers. This result also depicts that roughage feed is the second most important input variable in the dairy business.

The cost of artificial insemination and medication cost also had a negative and significant effect on the profit efficiency of dairy farmers. The sign of the coefficient for both variables was as expected, and the cost of artificial insemination and medication cost were significant at 1% and 5% respectively. From the result in Table 4, a 1% increase in the cost of artificial insemination and medication will reduce the dairy farmers' profit by 0.052% and 0.063% respectively.

From the variables hypothesized to influence the inefficiency of the dairy farmers, sex and milk price were the variables found to have a negative and significant effect while the number of cows owned was found to have a positive and significant effect on farmers' inefficiency in dairy farms.

Sex of the household head had a negative and significant effect on household inefficiency in dairy farming, and it is significant at 10%. This is to mean that male households are more efficient in making a profit compared to female households in the dairy farming business. This may be because of the additional roles that women play at home (cooking, cleaning, child care, etc.), and that will contribute to making them profit-inefficient compared with men.

The price of milk showed a negative and significant effect on the profit inefficiency of dairy farmers at 1%. This means that households those getting better milk prices are more efficient. The price of milk varied from 28 to 55 (with an average of 47 birr) across the peasant associations participated in this study. The price variation resulted from the proximity to the town and the availability of the milk collecting agents in the village. Households living close to the main town (Holata) and near the milk collection centers get higher prices and also have higher profit efficiency compared to those farmers living far from the town.

The estimated coefficient for the number of cows owned by the household had a negative and significant effect on the profit inefficiency of the household, and the significance level is at 10%. The sign of the coefficient is as expected, and it indicates that households with a lesser number of cows are more likely to be profit-efficient compared to households having a greater number of cows. This is in agreement with the finding reported by (Acharya *et al.*, 2021; Binita Kumari *et al.*, 2020)

Estimation of the Profit Efficiency Score

The profit efficiency score of the sample households was estimated as presented in Table 5. From the result, the average efficiency score is 70.94% with a standard deviation of 22.55%, and the minimum and maximum efficiency scores of 10.14% and 99.94%, respectively. This implies that the farmers are producing below the profit frontier, and the milk production in the study area is 29.06% short of the maximum possible level of profit-making. This result indicates that farmers would be able to increase their profits from the dairy farm business by 29.06% through efficient utilization of their resources.

From the result in Table 5, the dairy farmers in the study AREA are getting an average profit of 62731 birrs. This implies that the potential level of profit of the farm households is 88,428.25 birrs. Therefore, solving all the inefficiencies sources will add 25,697.25 birr to the

Table 5: Summary of profit efficiency scores

Efficiency score range	Frequency	Percent (%)
< 0.2	008	4.280

0.2 – 0.3		007	3.740
0.3 – 0.4		008	4.280
0.4 – 0.5		012	6.420
0.5 – 0.6		013	6.950
0.6 – 0.7		026	13.90
0.7 – 0.8		032	17.11
0.8 – 0.9		037	19.79
> 0.9		044	23.53
Total		**187**	**100.00**
Mean	**0.7094**	**Minimum**	**0.1014**
Std. dev	**0.2255**	**Minimum**	**0.9994**

Source: Authors' survey result

farmers on average.

CONCLUSIONS

This study assessed the profit efficiency of dairy farmers, and the result indicated that there is about 30% inefficiency in dairy farming in the study area. Concentrate feeds, roughage feeds, the price of milk, the sex of the household head, and the number of dairy cows owned by the households were the variables found to be responsible for the inefficiency. Male-headed dairy farmers were more profit-efficient than female-headed ones. The milk price is also a key variable in the profit efficiency of dairy farmers in the study area. Furthermore, farmers owning a smaller number of dairy cows were in a better position in their profit efficiency than those owning a greater number of cows. Therefore, dairy farmers are urged to choose their dairy farm sizes based on the production resources they have as this factor had a significant contribution to farmers' inefficiencies. Milk collection centers should also be opened in all villages to open milk markets to all dairy farmers at a reasonable price as this factor had a significant contribution to the inefficiencies of the dairy farmers. Similarly, seminars and workshops aimed at maximizing the production, productivity, and profit of dairy farmers through enhanced input utilization should be organized by researchers, agricultural extension officers, and development agents. The authors believe that implementing these recommendations will contribute much to improving the profit efficiency of dairy farmers and make the sector an avenue for job creation and a recipe for sustainable food security in Ethiopia.

REFERENCES

Acharya, K. K., Malhotra, R., Sendhil, R., & Kumari, B. (2021). Profit efficiency among peri-urban dairy farms in Odisha: An application of the stochastic frontier function. *Agricultural Economics Research Review, 34*(2), 207–215. https://doi.org/10.5958/0974-0279.2021.00029.X

Adnan, K. M. M., Sarker, S. A., Zannat Tama, R. A., & Pooja, P. (2021). Profit efficiency and influencing factors for the inefficiency of maize production in Bangladesh. *Journal of Agriculture and Food Research, 5,* 100161. https://doi.org/10.1016/j.jafr.2021.100161

Arbelo, A., Arbelo-Pérez, M., & Pérez-Gómez, P. (2021). Profit Efficiency as a Measure of Performance and Frontier Models: A Resource-Based View. *BRQ Business Research Quarterly, 24*(2), 143–159. https://doi.org/10.1177/2340944420924336

Bach, A., Terré, M., & Vidal, M. (2020). Symposium review: Decomposing efficiency of milk production and maximizing profit. *Journal of Dairy Science, 103*(6), 5709–5725. https://doi.org/10.3168/jds.2019-17304

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*(2), 325–332. https://doi.org/10.1007/BF01205442

Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? *Journal of Banking & Finance, 21*(7), 895–947. https://doi.org/10.1016/S0378-4266(97)00010-1

Binita Kumari, B.S. Chandel, Ravinder Malhotra, Tulika Kumari, & Priyanka Lal. (2020). Profit Efficiency of Women Dairy Farmers in Begusarai District of Bihar. *Indian Journal of Economics and Development,* 472–476. https://doi.org/10.35716/ijed/NS20-054

Britt, J. H., Cushman, R. A., Dechow, C. D., Dobson, H., Humblot, P., Hutjens, M. F., Jones, G. A., Ruegg, P. S., Sheldon, I. M., & Stevenson, J. S. (2018). Invited review: Learning from the future—A vision for dairy farms and cows in 2067. *Journal of Dairy Science, 101*(5), 3722–3741. https://doi.org/10.3168/jds.2017-14025

Chen, C.-M., Delmas, M. A., & Lieberman, M. B. (2015). Production frontier methodologies and efficiency as a performance measure in strategic management research: Production Frontier Methodologies in Strategic Management Research. *Strategic Management Journal, 36*(1), 19–36. https://doi.org/10.1002/smj.2199

CSA. (2021a). Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey 2020/21 [2013 E.C.] *Volume II Report on Livestock and Livestock Characteristics* (Private Peasant Holdings).

CSA. (2021b). Population Projection at Wereda level as of July 2021. https://www.statsethiopia.gov.et/wp-content/uploads/2020/08/Population-of-Weredas-

as-of-July-2021.pdf
Gebreyohanes, G., Yilma, Z., Moyo, S., & Mwai, O. A. (2021). Dairy industry development in Ethiopia: Current status, major challenges and potential interventions for improvement.
Han, Y., Kim, M. H., & Kim, W.-J. (2012). Determinants of profit efficiency: Evidence from Korean savings banks. *Applied Financial Economics, 22*(12), 1003–1016. https://doi.org/10.1080/09603107.2011.636019
Jimoh, S. O., Baruwa, O. I., & Kolapo, A. (2023). Analysis of profit efficiency of smallholder beef cattle farms in South-West Nigeria. *Cogent Economics & Finance, 11*(1), 2181786. https://doi.org/10.1080/23322039.2023.2181786
Kumbhakar, S., Ghosh, S., & McGukin, J. (1991). A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in U.S. Dairy Farms. *Journal of Business and Economics Statistics, 9*. https://doi.org/10.2307/1391292
Lakshmipriya, P., Sinha, D. K., Singh, K. M., Ahmad, N., Raju, R., & Roy, A. (2023). Profit Efficiency among Dairy Farmers in Southern India: An Application of Stochastic Frontier Profit Function. Indian Journal of Animal Research, Of. https://doi.org/10.18805/IJAR.B-5096
Minten, B., Habte, Y., Tamru, S., & Tesfaye, A. (2020). The transforming dairy sector in Ethiopia. *PLOS ONE, 15*(8), e0237456. https://doi.org/10.1371/journal.pone.0237456
Muleta, G., & Getahun, A. (2022). Technical, Allocative, and Economic Efficiency of Potato Producers in Central Oromia, Ethiopia. *International Journal of Business and Economics Research, 11,* 158–165. https://doi.org/10.11648/j.ijber.20221103.17
Nigel Ross Hughes. (2023, July 31). Green milk? Sounds good to Ethiopia's dairy industry. https://blogs.worldbank.org/africacan/green-milk-sounds-good-ethiopias-dairy-industry
Pilar, P.-G., Marta, A.-P., & Antonio, A. (2018). Profit efficiency and its determinants in small and medium-sized enterprises in Spain. *BRQ Business Research Quarterly, 21*(4), 238–250. https://doi.org/10.1016/j.brq.2018.08.003
Pulina, G., Tondo, A., Danieli, P. P., Primi, R., Matteo Crovetto, G., Fantini, A., Macciotta, N. P. P., & Atzori, A. S. (2020). How to manage cows yielding 20,000 kg of milk: Technical challenges and environmental implications. *Italian Journal of Animal Science, 19*(1), 865–879. https://doi.org/10.1080/1828051X.2020.1805370
Skevas, T., & Cabrera, V. E. (2020). Measuring farmers' dynamic technical and udder health management inefficiencies: The case of Wisconsin dairy farms. *Journal of Dairy Science, 103*(12), 12117–12127. https://doi.org/10.3168/jds.2020-18656
Tesfaye, M., Asfaw, A., Degefa, K., & Regassa, H. (2019). Evaluate the Trend of Imported Milk and Milk Products in Ethiopia.
Tschopp, R., Gemechu, G., & Wood, J. L. N. (2021). A Longitudinal Study of Cattle Productivity in Intensive Dairy Farms in Central Ethiopia. *Frontiers in Veterinary Science, 8*. https://www.frontiersin.org/articles/10.3389/fvets.2021.698760
Urgessa, T., & Lemessa, D. (2020). Spatiotemporal Landuse Land Cover Changes in Walmara District, Central Oromia, Ethiopia. *Earth Sciences, 9*(1), 32. https://doi.org/10.11648/j.earth.20200901.14
Von Keyserlingk, M. A. G., Martin, N. P., Kebreab, E., Knowlton, K. F., Grant, R. J., Stephenson, M., Sniffen, C. J., Harner, J. P., Wright, A. D., & Smith, S. I. (2013). Invited review: Sustainability of the US dairy industry. *Journal of Dairy Science, 96*(9), 5405–5425. https://doi.org/10.3168/jds.2012-6354
Wang, H.-J., & Schmidt, P. (2002). One-Step and Two-Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels. *Journal of Productivity Analysis, 18,* 129–144. https://doi.org/10.1023/A:1016565719882
Wongnaa, C. A., Awunyo-Vitor, D., Mensah, A., & Adams, F. (2019). Profit efficiency among maize farmers and implications for poverty alleviation and food security in Ghana. *Scientific African, 6,* e00206. https://doi.org/10.1016/j.sciaf.2019.e00206
Zijlstra, J., Tinsae Berhanu, Vernooij, A., & Lee, J. V. D. (2015). Investment opportunities in the Ethiopian Dairy sector. https://doi.org/10.13140/RG.2.2.19356.13440