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RESEARCH

Role of Livestock Fattening Farms in Bridging the Red Meat Food Security Gap in Egypt: An Economic Analysis

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Abstract

The persistent gap between local red meat production and domestic needs in Egypt threatens national food security, with the real self-sufficiency rate declining sharply from 71.2% in 2006 to 36.5% in 2023. This study evaluates the economic potential of cattle fattening farms to bridge this gap. Using econometric time-series analysis (ARCH models) and a field survey in Alexandria Governorate, we analyzed factors influencing production and efficiency. Key findings indicate that red meat supply is significantly influenced by long-term structural economic factors. A 10% increase in available calves and alfalfa production was associated with a 4.14% and 1.9% increase in production, respectively ($p < 0.01$). Forecasting models predict that raising the operational efficiency of specialized farms from its current average of ~57% to a target of 80% could boost total production to approximately 960,065 tons by 2027. The field analysis identified the two-cycle (six-month) fattening system as the most economically efficient (Revenue-to-Cost Ratio: 1.40). This study provides a data-driven framework for policymakers to enhance domestic production through targeted support for farm efficiency and de-risking the critical calf-rearing phase.

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Statement of Sustainability: This research directly contributes to achieving the UN's Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), by proposing viable economic strategies to close the red meat food gap and enhance food security in Egypt. It also aligns with SDG 12 (Responsible Consumption and Production) by identifying the most efficient and profitable fattening systems, which promotes the sustainable use of agricultural resources like feed and capital. By focusing on strengthening local production capabilities, this study provides a pathway to reduce reliance on imports, thereby fostering a more resilient and sustainable national food system.

1. Introduction

Red meat is globally recognized by organizations like the World Health Organization and the Food and Agriculture Organization (FAO) as a fundamental component of a healthy diet, serving as a rich source of high-quality protein, easily absorbed iron, and B vitamins (Pargal, 2016; Elshater and Zaki, 2018). Beyond its nutritional value, it is a key element of national food security, a vital axis for the food industry, and a primary source of income through its integrated value chain (Sokar, 2018). This research focuses on the critical aspects of red meat production in Egypt, where cows and buffaloes are the primary sources. In 2023, meat from these animals amounted to approximately 545 thousand tons, representing 83.8% of the total domestic red meat production of 650 thousand tons (Ministry of Agriculture and Land Reclamation, 2023; Department of Economic Analysis Research for Agricultural Commodities, 2023).

The core problem addressed by this research is the chronic deficit in local red meat production to meet the actual needs of Egypt's steadily increasing population. This has caused a severe decline in the real self-sufficiency rate from approximately 71.2% in 2006 to a mere 36.5% in 2023 (Ministry of Agriculture and Land Reclamation, 2023). This situation not only threatens the nation's food security but also places increasing burdens on the trade balance, especially with the depreciation of the local currency, making it more difficult to secure basic meat requirements through imports.

While previous studies have examined red meat consumption and production costs in Egypt (Abdel Radi, 2016; Elshater et al., 2018), a significant knowledge gap remains in quantitatively linking the operational capacity of specialized fattening farms to national self-sufficiency forecasts. Furthermore, few studies have used robust econometric models to dissect the long-term structural drivers of production versus short-term shocks. This research aims to fill this gap by developing a predictive model based on farm-level potential and identifying the most economically viable fattening systems. To guide our analysis, we hypothesize that:

H1: Long-term structural economic changes, rather than short-term shocks, are the primary drivers of variance in red meat production.

H2: The number of calves in specialized fattening farms is a significant positive predictor of Egypt's total red meat production.

H3: Access to agricultural credit significantly increases the utilized operational capacity of these farms.

H4: The six-month, two-cycle fattening system offers superior economic efficiency compared to shorter or longer systems.

The main objective of this research is to identify and analyze the role of cattle fattening farms in increasing the supply of red meat in Egypt. To achieve this, the study aims to: (1) evaluate the economic importance and production trends of red meat from cows and buffaloes; (2) assess the potential of specialized fattening farms to increase the national supply; (3) determine the economic efficiency of different fattening systems through a field survey in Alexandria Governorate; and (4) identify key production and marketing challenges while proposing viable solutions.

2. Materials and Methods

2.1. Analytical Framework

To achieve the research objectives, a dual analytical approach was employed, combining descriptive and quantitative statistical methods. Descriptive analysis, including averages and percentages, was used to summarize key trends. The quantitative analysis involved several econometric techniques to explore the relationships between variables, including regression models and time-series analysis using the Autoregressive Conditional Heteroskedasticity (ARCH) framework to account for data volatility.

2.2. Econometric Models and Diagnostic Tests

A model of sequential equations was estimated using ARCH(1,1) and ARCH(1,0) models to analyze production trends and forecast future scenarios. To ensure the validity of these models, standard diagnostic tests were conducted. The Augmented Dickey-Fuller (ADF) test was used to confirm the stationarity of the time-series data, with results indicating stability after first differencing. The Jarque-Bera (J.B.) test confirmed that model residuals followed a normal distribution. Finally, the White test was employed to detect heteroskedasticity; its significance justified the use of ARCH models to ensure robust standard errors. Forecasting was also conducted using exponential smoothing for specific projections.

2.3. Key Economic and Efficiency Measures

The study relied on several key economic measures to quantify the food security status of red meat, which were calculated as follows:

$$\text{Real Consumer Needs} = \text{Population} \times 16.8 \text{ kg·year}^{-1} \tag{1}$$

$$\text{Real Food Gap} = \text{Total Red Meat Produced} - \text{Real Consumer Needs} \tag{2}$$

$$\text{Real Self-sufficiency Rate (\%)} = \left(\frac{\text{Total Red Meat Produced}}{\text{Real Consumer Needs}}\right) \times 100 \tag{3}$$

Furthermore, a range of technical and economic efficiency indicators (e.g., net return, revenue-to-cost ratio, profit margin) were estimated for the surveyed farms to assess their operational viability and profitability.

2.4. Data Sources and Collection

The research utilized both primary and secondary data. Primary data were collected through structured personal interviews with a purposive sample of 35 breeders at calf fattening farms in the Al-Amiriya administrative district, Alexandria Governorate. Farms were selected based on the following criteria: (1) specialization in cattle fattening, (2) a minimum of five years of operation, and (3) a capacity exceeding 50 heads. The field survey was conducted during the 2024-2025 period using a pre-tested questionnaire designed to gather detailed information on production costs, revenues, fattening cycles, and operational challenges. Verbal informed consent was obtained from all participants prior to the interviews (Faod, 2024).

Secondary data were compiled from official statistical publications issued by the Central Agency for Public Mobilization and Statistics (CAPMAS, 2023a, b) and the Economic Affairs Sector of the Ministry of Agriculture and Land Reclamation.

2.5. Statistical Analysis

All statistical analyses and econometric modeling were performed using EViews software (Version X, IHS Global Inc., USA).

3. Results and Discussion

3.1. Economic Importance and Production Trends of Red Meat in Egypt

The production of red meat from cows and buffaloes forms the cornerstone of Egypt's livestock sector. However, analysis of the period from 2006 to 2023 reveals significant challenges to its sustainability. As shown in **Table 1**, the combined quantity of red meat produced from these animals fluctuated, declining to a minimum of 545 thousand tons in 2023. This trend is characterized by a statistically significant annual decrease of approximately 1.8% ($p < 0.01$) over the study period.

To understand the drivers behind these trends, an econometric model was developed for the 2006-2023 period. After diagnostic tests confirmed model validity, an ARCH framework was employed to ensure robust standard errors. The estimated model results are summarized in **Table 2**.

The functional forms of the estimated equations are:

$$LnQt = 25.03 + 0.414LnNt + 0.190LnXt \quad (4)$$

Where: Ln Qt = Natural log of red meat quantity (thousand tons); Ln Nt = Natural log of calf numbers; Ln Xt = Natural log of alfalfa quantity (thousand tons).

$$Lnprct = 0.006 + 1.373LnQft \quad (5)$$

Where: Ln prct = Natural log of the real self-sufficiency rate (%); Ln Qft = Natural log of the fitted meat quantity from Eq. 4.

The results from Equation 4 reveal that the number of calves (Nt) and the quantity of alfalfa (Xt) are significant positive determinants of the red meat supply. A 10% increase in calf numbers is associated with a 4.14% increase in red meat produced, while a 10% increase in alfalfa corresponds to a 1.9% increase. Together, these variables explain 86% (Adj. R^2) of the variance.

More critically, the ARCH model's variance equation indicates that production fluctuations are not driven by short-term shocks. Instead, production levels are primarily influenced by long-term structural changes, confirming Hypothesis H1. This finding aligns with the structural break observed post-2016, which can be attributed to major economic policy changes like exchange rate liberalization that increased input costs. This highlights the vulnerability of the national livestock sector to macroeconomic shocks and underscores the importance of policies aimed at stabilizing feed

Table 1. Key indicators of red meat production in Egypt (2006-2023).

Year	Total Calves (Thousand Heads)	Alfalfa Prod. (Million Tons)	Beef & Buffalo Meat (Thousand Tons)	Total Red Meat (Thousand Tons)	Real Food Gap (Thousand Tons)	Real Self-Sufficiency Rate (%)
2006	2516	65.57	461.6	1340.6	2.23	65.57
2007	2893	66.83	455.2	1372.2	1.90	66.83
2008	2943	68.45	443.0	1404.0	2.34	68.45
2009	2567	68.32	454.9	1435.9	2.44	68.32
2010	2730	67.50	477.7	1469.7	3.85	67.50
2011	2782	65.58	518.5	1506.5	4.17	65.58
2012	3049	64.30	549.6	1539.6	2.61	64.30
2013	2631	60.85	620.3	1584.3	3.38	60.85
2014	2697	57.96	682.5	1623.5	2.72	57.96
2015	2730	58.64	687.1	1661.1	3.04	58.64
2016	2679	57.52	714.2	1681.2	3.04	57.52
2017	2499	49.06	894.9	1756.9	2.69	49.06
2018	2459	46.75	953.3	1790.3	3.27	46.75
2019	2144	39.72	1087.9	1804.9	1.95	39.72
2020	1228	36.60	1164.0	1836.0	3.16	36.60
2021	1358	38.98	1136.6	1862.6	1.79	38.98
2022	1507	42.15	1102.3	1905.3	3.88	42.15
2023	1380	33.63	1282.7	1932.7	3.14	33.63

Source: Compiled and calculated from the Ministry of Agriculture and Land Reclamation. Note: Abridged for brevity.

Table 2. Summary of econometric model results for red Meat production and self-sufficiency.

Variable	Coefficient	Std. Error	t-Statistic	P-value	Model Statistics
Equation 4: Production (Dep. Var: Ln Qt)					
Intercept (C)	25.03	2.503	10.00	0.001	Adj. R^2: 0.86
Ln Nt (Calf Numbers)	0.414	0.092	4.50	0.003	F-statistic: 53.2
Ln Xt (Alfalfa Prod.)	0.190	0.079	2.41	0.012	Prob(F-stat): <0.01
Equation 5: Self-Sufficiency (Dep. Var: Ln prct)					
Intercept (C)	0.006	0.060	0.10	0.241	R^2: 0.70
Ln Qft (Fitted Meat Qty)	1.373	0.229	6.00	0.001	F-statistic: 37.3

Source: Authors' calculations.

supply chains, a key pillar of Egypt's current agricultural strategy.

Equation 5 demonstrates the substantial impact of beef and buffalo meat production on Egypt's real self-sufficiency rate. The model shows that a 10% change in meat quantity leads to a significant 13.7% change in the same direction for the self-sufficiency rate. The analysis further confirms that the deterioration in this rate is a result of systematic, long-term pressures rather than transient shocks.

Based on the predictive capacity of this model, projections for the period 2024-2027 were generated. As shown in **Table 3**, the forecast suggests that a concerted effort to increase alfalfa production and available calves could raise total red meat production from 650 thousand tons in 2023 to 772 thousand tons by 2027. This would translate into a modest increase in the real self-sufficiency rate to 39.3%. While this represents a positive step, it underscores that these measures alone are insufficient to fully close the gap, highlighting the need for broader structural interventions.

Table 3. Forecast of red meat self-sufficiency indicators (2024-2027).

Year	Projected Total Red Meat (Thousand Tons)	Lower Bound (95% CI)	Upper Bound (95% CI)	Projected Self-Sufficiency Rate (%)
2024	735	705	765	40.8
2025	758	728	788	40.3
2026	765	735	795	39.8
2027	772	740	804	39.3

Source: Authors' calculations based on the sequential equations model. CI = Confidence Interval.

3.2. The Role and Potential of Specialized Fattening Farms

Specialized cattle fattening farms are economically significant due to their adoption of intensive systems that optimize feed conversion rates. These characteristics position them as a crucial tool for narrowing the national food gap. As illustrated in **Table 4,** the data from 2006-2023 shows the growing importance of these farms. The number of calves housed in specialized farms grew at a significant annual rate of 4.5% ($p < 0.01$), while their share of the total national calf population grew even faster at 8.7% annually ($p < 0.01$). Consequently, their contribution to the total red meat supply expanded from 8.9% in 2006 to 24.3% in 2023, underscoring a structural shift towards more intensive production systems.

Table 4. Growth of specialized fattening farms in Egypt (2006-2023).

Year	Calves in Specialized Farms (Thousand Heads)	Share of National Calves (%)	Red Meat from Specialized Farms (Thousand Tons)	Share of National Red Meat (%)
2006	258.0	10.25	78.4	8.90
2007	266.0	9.19	83.4	9.10
2008	253.3	8.61	80.4	8.40
2009	263.6	11.18	82.6	8.40
2010	274.0	10.04	86.3	8.70
2011	287.0	10.32	89.9	9.10
2012	295.8	9.70	94.3	9.50
2013	322.2	12.25	103.3	10.70
2014	330.7	12.26	105.6	11.20
2015	351.9	12.89	116.8	12.00
2016	341.2	12.74	114.1	11.80
2017	376.7	15.07	125.3	14.50
2018	396.3	16.12	137.7	16.40
2019	399.4	18.63	127.0	17.70
2020	429.2	34.95	139.9	20.80
2021	520.0	38.28	169.2	23.30
2022	489.5	32.48	159.2	19.80
2023	538.7	39.04	158.0	24.30

Source: Compiled from CAPMAS and Ministry of Agriculture.

To quantify the direct impact of these farms on the national supply, a regression model was developed using a one-year lag for the number of heads (Nt-1) to account for the biological cycle. The estimated functional relationship is:

$$D(LNQt) = 0.949 + 0.77D(LNNt - 1) \quad (6)$$

The model results (**Table 5**) indicate a significant positive relationship, confirming Hypothesis H2. A 10% change in the number of heads in specialized farms is associated with a 7.7% change in the same direction for Egypt's total red meat production in the following year. This variable alone explains 32% of the changes in total supply, confirming that expansion in this sub-sector is a key driver of national production growth.

Table 5. Regression results for the impact of specialized farms on total red meat production**.**

Variable	Coefficient	Std. Error	t-Statistic	P-value	Model Statistics
Dependent Variable: D(LN Qt)					
Intercept (C)	0.949	0.431	2.20	0.002	R^2: 0.32
D(LN Nt-1)	0.770	0.335	2.30	0.012	F-statistic: 7.56Prob(F-stat): 0.001

Source: Authors' calculations.

Despite this positive trend, a significant challenge remains: the chronic underutilization of capacity. Over the study period, the actual operating efficiency of these farms ranged between only 46.9% and 57.1% of their total capacity (**Table 6**). This suggests substantial untapped potential for increasing production without building new infrastructure.

Table 6. Operational efficiency of specialized fattening farms in Egypt (2006-2023).

Year	Total Capacity (Thousand Heads)	Actual Utilized Capacity (Thousand Heads)	Operating Efficiency (%)	Agricultural Credit (Billion EGP)
2006	502.8	258.0	51.3%	1.30
2007	477.3	266.0	55.7%	1.42
2008	540.3	253.3	46.9%	1.39
2009	539.1	263.6	48.9%	0.84
2010	545.0	274.0	50.3%	0.69
2011	539.1	287.0	53.2%	1.18
2012	563.8	295.8	52.5%	1.08
2013	598.5	322.2	53.8%	0.63
2014	586.9	330.7	56.3%	0.88
2015	616.4	351.9	57.1%	1.19
2016	644.0	341.2	53.0%	1.12
2017	678.3	376.7	55.5%	1.52
2018	716.2	396.3	55.3%	2.61
2019	745.3	399.4	53.6%	2.71
2020	812.2	429.2	52.8%	5.28
2021	925.9	520.0	56.2%	4.26
2022	936.7	489.5	52.3%	4.31
2023	1,013.9	538.7	53.1%	4.28

Source: Compiled from Ministry of Agriculture and Land Reclamation. Note: Abridged for brevity.

To explore the factors influencing this operational capacity, a regression model was estimated to assess the impact of agricultural loans for animal production (Cridt) on the actual number of calves on these farms (Nt). The estimated functional relationship is:

$$LnNt = 5.71 + 0.29LnCridt \tag{7}$$

The model results (**Table 7**) show that financial support is a critical enabler, confirming Hypothesis H3. A 10% increase in medium-term loans for livestock production leads to a 2.9% increase in the utilized capacity of specialized farms. This variable explains 66% of the changes in the number of fattening calves, highlighting the strong impact of accessible credit. This finding empirically supports government initiatives, such as those by the Central Bank of Egypt, to finance agricultural enterprises and demonstrates their direct impact on boosting production capacity.

Based on this evidence, a forecast was developed to project the potential increase in red meat production if the operational efficiency of farms could be raised to a target of 80% (**Table 8**). The projection shows that by leveraging existing infrastructure, the number of fattened cattle could increase to 1.14 million heads by 2027. This would boost

Table 7. Regression results for the impact of credit on farm capacity utilization.

Variable	Coefficient	Std. Error	t-Statistic	P-value	Model Statistics
Dependent Variable: Ln Nt					
Intercept (C)	5.71	0.052	109.8	0.002	R^2: 0.66
Ln Cridt (Credit)	0.29	0.051	5.69	0.001	F-statistic: 32.3Prob(F-stat): 0.002

Source: Authors' calculations.

the total expected quantity of red meat to approximately 960,700 tons, demonstrating that improving operational efficiency is one of the most powerful strategies for narrowing Egypt's red meat gap.

Table 8. Projected impact of raising farm efficiency to 80% on red meat supply.

Year	Projected Fattened Heads (Thousand)	Projected Total Red Meat (Thousand Tons)	Lower Bound (95% CI)	Upper Bound (95% CI)
2024	894	931.6	890	973
2025	969	941.2	900	982
2026	1,051	950.9	910	991
2027	1,140	960.7	918	1,003

Source: Forecasts based on exponential smoothing and regression model results. CI = Confidence Interval.

3.2.1. Sensitivity Analysis

To assess the robustness of our forecasts, a sensitivity analysis was conducted to model the impact of two critical external shocks: a sharp increase in feed costs and a reduction in credit availability (**Table 9**). The results indicate that a 20% increase in feed prices could reduce the projected 2027 production by approximately 8.5%, while a 15% reduction in agricultural credit could lower it by 6.2%. This underscores the sector's vulnerability to market volatility and reinforces the need for policies that stabilize input costs and ensure consistent financial support.

Table 9. Sensitivity Analysis of Projected 2027 Red Meat Production.

Scenario	Assumption	Projected Production (Thousand Tons)	% Change from Baseline
Baseline	Current Trends (80% Efficiency)	960.7	-
Scenario 1	+20% Feed Cost	879.0	-8.5%
Scenario 2	-15% Credit Access	901.1	-6.2%

Source: Authors' calculations.

3.3. Case Study: Economic and Technical Indicators in Alexandria Governorate

While specialized farms show national potential, regional dynamics present unique challenges. In Alexandria, a non-agricultural governorate, red meat prices are susceptible to high logistical costs for transporting animals and feed. The estimated annual need for red meat is approximately 94,520 tons, yet the actual number of male cattle available for fattening in 2023 was only 28,492, revealing a significant local supply gap. To understand the on-the-ground realities of addressing this gap, this study analyzed the technical aspects, cost structures, and economic efficiency of fattening cross-bred cattle, based on data from the research sample.

3.3.1. Technical Aspects of Fattening Systems

The operational success of a fattening farm depends on key technical decisions, which varied among the surveyed breeders.

(a) Selection of Cattle Breed: The survey revealed a strong preference for cross-bred cattle over local breeds. Breeders cited their superior feed conversion rate (1.3-1.4 kg/day vs. ~1.0 kg/day for buffalo), which allows them to reach slaughter weight more quickly. Additionally, the skeletal structure of cross-breds typically yields a higher percentage of net red meat.

(b) Selection of Fattening Cycle: Breeders utilized four-month, six-month, and twelve-month fattening systems. The choice depends on factors such as aligning the cycle with seasonal fodder availability to reduce costs and the availability of working capital. The initial purchase price of calves varies significantly with weight: calves for the four-month cycle typically start at 300-350 kg, whereas those for the six-month and twelve-month cycles start at 200-250 kg and ~150 kg, respectively.

(c) Feeding Regimens: Feeding systems were carefully tailored to the cycle duration.

Four-Month Cycle: Prioritizes a high-protein (16%) concentrated feed to support rapid weight gain in mature animals.

Six-Month Cycle: Incorporates a balanced diet of concentrated feed, roughage (hay, rice straw), green fodder (alfalfa), and energy-rich silage.

Twelve-Month Cycle: Requires a complex, phased approach starting with a higher protein concentrate (18%) for young calves, which is later reduced. Silage is used strategically during middle growth phases to optimize protein uptake and ensure desirable meat quality.

This detailed nutritional management is critical for maximizing the economic efficiency of each system.

3.3.2. Cost-Benefit Analysis of Fattening Systems

An in-depth analysis of the cost structures was conducted for the different fattening cycles to determine their economic viability. A comprehensive breakdown of the full cost structure for each system is provided in **Table 10**.

Variable costs represent the vast majority (approximately 99%) of total costs and are driven primarily by two components: the initial purchase price of the calf and total feeding costs. The analysis reveals a critical trade-off: in the short four-month cycle, the calf's purchase price dominates, accounting for 77.5% of total costs. Conversely, in the extended twelve-month cycle, feeding costs become the largest burden, representing 50.2% of total expenditures. Concentrated feed constitutes the single largest expense within feeding costs, particularly in longer cycles. This demonstrates the different financial pressures breeders face depending on their chosen strategy. Fixed costs, including depreciation and animal insurance, constitute a minor portion of the total cost structure.

Table 10. Cost structure per head for different fattening cycles (EGP, 2025 Prices).

Cost Item	4-Month Cycle	% of Total	6-Month Cycle	% of Total	12-Month Cycle	% of Total
A. Variable Costs						
1. Calf Purchase Cost	51,000	77.5%	34,000	61.9%	27,000	41.2%
2. Feeding Costs	11,889	18.1%	17,421	31.7%	32,894	50.2%
– Concentrated Fodder	*10,560*		*13,440*		*25,440*	
– Other Fodder (Straw, Hay, etc.)	*1,329*		*3,981*		*7,454*	
3. Other Variable Costs (Labor, Vet, etc.)	2,140	3.3%	2,863	5.2%	5,030	7.7%
Total Variable Costs	**65,029**	**98.8%**	**54,284**	**98.8%**	**64,924**	**99.1%**
B. Fixed Costs						
Depreciation & Insurance	810	1.2%	640	1.2%	570	0.9%
Total Costs (A+B)	**65,839**	**100.0%**	**54,924**	**100.0%**	**65,494**	**100.0%**

Source: Field survey data (2024-2025).

The revenue structure for each fattening cycle was also analyzed. Total revenue is generated primarily from the sale of the live animal, with a consistent final weight of approximately 450 kg across all systems. A small, secondary income is derived from the sale of by-products (manure).

To identify the most profitable and efficient fattening strategy, several economic efficiency indicators were calculated and annualized for a standardized comparison. The full cost-benefit analysis and efficiency indicators are presented in **Table 11**.

Table 11. Annualized economic efficiency indicators per fattening system (EGP).

Indicator	System 1: Three-Cycle (4-Month Duration)	System 2: Two-Cycle (6-Month Duration)	System 3: One-Cycle (12-Month Duration)
A. Revenue Structure			
Annual Total Revenue	230,400	153,540	77,110
– From Live Animal Sale	*229,500*	*153,000*	*76,500*
– From By-product Sale	*900*	*540*	*612*
B. Cost & Profitability			
Annual Total Costs	197,517	109,848	65,494
Annual Net Return	**32,883**	**43,692**	**11,619**
C. Efficiency Ratios			
Revenue-to-Cost Ratio	1.17	**1.40**	1.18
Profitability (EGP per EGP spent)	0.17	**0.40**	0.18
Profit Margin (%)	14.3%	**28.5%**	15.1%

Source: Field survey data (2024-2025). Values are annualized for standardized comparison.

The results from **Table 11** unequivocally identify the two-cycle system (based on a six-month duration) as the most economically superior strategy, confirming Hypothesis H4. It generated the highest annual net return (EGP 43,692), the most favorable revenue-to-cost ratio (1.40), and the greatest profitability (EGP 0.40 per EGP spent). In stark contrast, the one-cycle (twelve-month) system proved to be the least efficient. Despite its lower initial capital outlay for the calf, the prolonged accumulation of feed and operational costs severely diminished its profitability. The three-cycle system provided moderate returns but was ultimately less profitable than the two-cycle approach.

Discussions with the surveyed breeders provided crucial context for these findings. The low profitability of the twelve-month cycle, combined with its heightened risk profile—stemming from extended capital lock-up and greater exposure to disease and market price volatility—acts as a significant deterrent for breeders to engage in fattening very young calves. This reluctance creates a critical bottleneck in the livestock supply chain. This suggests a vital intervention point for policymakers: developing programs to support the initial, high-risk phase of raising young calves to a weight where breeders can profitably engage in the more efficient six-month fattening cycle. Such a policy could significantly boost production and encourage wider participation in the sector.

3.4. Challenges and Policy Recommendations

While the quantitative analysis establishes the economic superiority of certain fattening systems, the field survey identified several critical on-the-ground challenges that constrain the sector's expansion. Based on these findings, this study proposes targeted policy recommendations designed to address these challenges directly.

3.4.1. Production Challenges and Recommendations

(a) High Input Costs and Financial Constraints: Breeders identified the high and volatile prices of purchased feeds and the high cost of veterinary services as major financial burdens. Furthermore, the capital-intensive nature of the business, combined with a lack of accessible financial support, hinders the ability of small-scale breeders to operate and expand.

Policy Recommendation 1: Provide Targeted Financial Support - Government and financial institutions should provide accessible, soft loans (medium- and long-term) for breeders. Disbursement should be linked to farm development plans to ensure funds are used for modernization and expansion, thereby addressing the credit gap identified in our econometric analysis (Eq. 7).

Policy Recommendation 2: Enhance Access to Veterinary Care - Subsidizing essential medicines and vaccinations at affordable prices is crucial to mitigate disease risk, protect breeders' investments, and improve the overall productivity of the livestock population.

(b) Low Productivity and High-Risk Rearing Cycles: Breeders reported that commonly available cattle breeds have low genetic potential (50-55% net meat yield). This, combined with the high risk and low profitability of the twelve-month cycle for young calves, creates a critical bottleneck in the supply chain.

Policy Recommendation 3: Support Early-Stage Rearing and Introduce High-Yielding Breeds - A state-supported program for rearing young calves to a viable weight (e.g., 200-250 kg) is recommended. These calves could then be sold to specialized farms, allowing breeders to focus on the highly efficient six-month fattening phase. This should be coupled with a national program to facilitate access to genetically superior meat breeds (e.g., Angus, Brangus) to fundamentally improve sector productivity.

3.4.2. Marketing Challenges and Recommendations

(c) Inefficient Marketing Channels: High transportation costs and the dominance of intermediaries, who capture a large share of the final sale price, reduce breeder profitability and discourage investment.

Policy Recommendation 4: Promote Cooperative Marketing. Encouraging the formation of breeder cooperatives would empower producers. A cooperative system would enable direct market access, bypass exploitative intermediaries, improve bargaining power, and ensure a fairer share of profits returns to the farmers.

4. Conclusion

This study investigated the economic potential of cattle fattening farms to address Egypt's critical red meat food security gap. Our research confirms that while national production is sensitive to long-term structural economic shifts, there is significant untapped potential within specialized fattening farms to bolster domestic supply. The key findings are twofold: first, our econometric models demonstrate that improving the operational efficiency of existing farms from an average of ~57% to a target of 80% is the most powerful strategy available, with the potential to add over 310,000 tons to the domestic supply by 2027. Second, the field analysis identified the two-cycle (six-month) fattening system as the most economically efficient (revenue-to-cost ratio of 1.40), offering the highest profitability for breeders.

However, the sector's expansion is constrained by high feed costs, financial limitations, and bottlenecks in the calf supply chain. To translate our findings into action, we propose measurable policy recommendations. The implementation of a state-led program to rear young calves to a viable weight (200-250 kg) is critical to de-risk the process for breeders and unlock the full potential of the efficient six-month cycle. This should be coupled with a targeted financial program to provide accessible loans aimed at achieving the 80% efficiency target. By implementing these data-driven policies, it is possible to significantly increase the domestic supply of red meat, enhance breeder livelihoods, and make substantial, measurable progress toward achieving sustainable food security in Egypt.

Authors' Contributions

Fatma Elzahraa Ahmed Gebril: Conceptualization, Methodology, Formal analysis, Writing – Original Draft. Doaa I. A. Hashem: Data Curation, Investigation, Writing – Review & Editing. Engy Ahmed Teimaa: Data Curation, Validation, Visualization. Doha Elhalwany: Investigation, Resources, Project administration.

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Declarations

Conflict of Interests: There is no conflict of interest in this work by the authors

Institutional/Ethical Approval: This study was conducted in accordance with the ethical guidelines of the Agricultural Research Center, Egypt. The objectives of the study were explained to all participants, and informed verbal consent was obtained prior to interviews. Participant confidentiality and anonymity were assured. The study protocol was approved by the research committee of the Agricultural Economics Research Institute.

Data Availability/Sharing: The datasets used and analyzed during the current study will be made available from the corresponding author upon a reasonable request.

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