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Using Statistical Analysis to Optimize Farm Business: A Case Study of a Family Farm

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Abstract. In China, family livestock farming remains vital, supplying much of the meat while supporting rural income and jobs. Yet, high costs, market volatility, and limited scale drive its transition toward larger, intensive, and data-driven operations. This study takes a family cattle farm as the research object. The farm has experienced policy and market changes, including national support for breeding, relocation due to the ban on breeding within 50km of the Yellow River to prevent pollution, and fluctuations in domestic oil prices , while maintaining a breeding scale of 200–500 cattle. Using the literature review method, this paper explores the development of traditional family cattle farming in China. The study finds that small family farms mainly focus on calf breeding with free-range and forage-feeding modes; medium-sized farms need to time calf procurement and adult cattle sales based on oil price fluctuations; large farms can achieve full-cycle operation iteration and have stronger market risk resistance.

Keywords: Family Cattle Farm, Procurement and Sales Timing, Stable Breeding Cost, Cattle Price Volatility

1. Introduction

The research focuses on a family cattle farm in China, which is a typical small and medium-sized agricultural operation with clear operational characteristics. Covering an area of 60 mu, the farm has 12 cattle pens, with each pen capable of housing 50 calves or 30 adult cattle— a layout designed for efficient livestock turnover. To ensure year-round continuous operation, the farm adopts a quarterly procurement and sales model: it purchases approximately 100 calves per batch, with four batches annually, forming a steady cycle of raising and selling.

Notably, the farm abandons calf breeding and specializes in fattening. Breeding was discarded due to strict requirements: it needs intensive care for cows, sufficient free-range pastures (instead of penning), and a pure forage diet to ensure calf health— all of which exceed the farm's current resource capacity. Instead, the farm procures 6-month-old weaned male Simmental calves (around 300 kg each) and fattens them to 750-800 kg over 10-12 months. This weight range is determined by breed traits: Simmental cattle show a sharp decline in feed-to-meat conversion efficiency beyond 800 kg, and sexually mature males divert energy, reducing growth performance. During fattening, calves' daily forage consumption ranges from 5kg (early stage) to 10kg (peak), with an average of 7.5kg, bringing 1.5kg of weight gain. Forage costs 0.5-1 RMB per half kilogram (based on

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proportion), while beef market prices fluctuate between 13-17 RMB per half kilogram. Thus, the farm's core business is optimizing forage ratios to accelerate fattening and timing sales to align with favorable market trends [1,2].

The research question to be addressed is: How can Chinese family cattle farms maintain profitability amid severe market fluctuations? In the past 2-3 years, most farmers suffered losses due to misaligned procurement and sales timing: they buy calves (high prices) from March to June and sell adult cattle (low prices) from December to March, creating a "high-in, low-out" dilemma. The core challenge is grasping the "game" with market rules— buying calves at low prices and selling adult cattle at high prices— which relies on scientific data analysis rather than just farmers' experience [3,4].

Potential methods include regression analysis (to explore relationships between variables like forage cost and weight gain) or time-series analysis (to identify market price fluctuation patterns), aiming to quantify factors affecting profitability and market timing.

This study has three core objectives. First, it will analyze optimal forage ratios based on cattle's growth stages (different months and weights) to balance cost and growth efficiency. Second, it will explore strategies for aligning procurement/sales with market cycles to avoid the "high-in, low-out" trap. Third, it will investigate how to apply refined management to traditional family farms, improving operational efficiency.

The significance lies in two aspects: practically, it provides actionable solutions for the case farm to stabilize profitability; theoretically, it offers a reference for similar small and medium-sized family cattle farms in China, helping them address market volatility through data-driven decisions and promoting the sustainable development of rural family-run agricultural operations [5].

2. Data collection and description

2.1. Data sources

The data used in this study is derived from the detailed operational and financial records of Helan County Shenyuankang Family Farm (hereinafter referred to as "the Farm"), covering all core revenue and expenditure items from January 2024 to January 2025. These records are systematically sorted by the farm's management team, including official transaction receipts, procurement contracts, and daily operation logs— ensuring high accuracy and traceability, which lays a solid foundation for subsequent statistical analysis.

Specifically, the dataset is categorized into capital expenditure (fixed asset investment), operational expenditure (recurrent costs), and revenue, with clear correspondence to specific transactions:

Capital expenditure data covers one-time investments in fixed assets, such as farmland purchase (100 mu, total 1.2 million RMB, with a land certificate), cattle pen construction (11 pens, total 660,000 RMB— designed for different weight stages: 50 heads/pen for 250-300kg calves, 40 heads/pen for 400-500kg cattle, 30 heads/pen for over 600kg cattle, currently housing 28 heads/pen), warehouse construction (2 warehouses over 500 ㎡ each, total 500,000 RMB), and supporting facilities (silage pools, guard rooms, freezers, decomposition rooms, etc., total 100,000 RMB).

Operational expenditure data includes four batches of calf procurement (2024.3.28: 130 heads from Wuwei, Gansu, 13,500 RMB/head; 2024.6.26: 105 heads from Tongliao, Liaoning, 11,800 RMB/head; 2024.9.27: 103 heads from Tongliao, 9,300 RMB/head; 2024.11.15: 53 heads from debt settlement, 7,300 RMB/head) and forage/feed costs (2024 silage: 800 tons, 230 RMB/ton; wheat

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straw: 200 tons, 500 RMB/ton; rice straw: 200 tons, 500 RMB/ton; corn: 100 tons, 3,700 RMB/ton; red dates: 30 tons, 3,200 RMB/ton; oil cakes: 30 tons, 3,200 RMB/ton) as well as labor costs (2 employees, total 180,000 RMB/year, with the farm manager earning 10,000 RMB/month and the assistant 5,000 RMB/month).

Revenue data records two batches of adult cattle sales (2024.12.24: 60 heads, 17,500 RMB/head, average weight 735kg, 24 RMB/kg; 2025.1.10: 72 heads, 17,650 RMB/head) and revenue from damaged cattle disposal (2 heads, 12,000 RMB/head, slaughtered due to waist/leg fractures).

Additionally, the dataset includes supplementary records such as cost structure analysis (e.g., 11-month fattening cost per cattle: ~4,500 RMB) and policy subsidy expectations (500-2,000 RMB/cattle), which are crucial for comprehensive profit analysis.

2.2. Data types and scope

2.2.1. Data types

The dataset is dominated by quantitative data (numerical indicators) with supplementary qualitative data (descriptive information) to explain context:

Quantitative data accounts for over 90% of the dataset, including specific figures for all expenditure/revenue items (e.g., 13,500 RMB/head for the first calf procurement, 184,000 RMB for 2024 silage), physical quantities (e.g., 100 mu of farmland, 450 total calves purchased), and time-series indicators (e.g., monthly labor costs, quarterly calf prices). These data are measurable and computable, forming the core of statistical analysis (e.g., calculating average procurement price, total cost, profit margin).

Qualitative data includes explanatory notes for quantitative indicators, such as "Tongliao has a larger market and higher cost-effectiveness than Wuwei" (reason for lower second-batch procurement price), "cattle sold in December 2024 to reserve forage" (reason for off-peak sales), and "fattening starts 6 months before slaughter, 5-10 jin of concentrate feed/day" (feed management rules). These data help interpret numerical trends and avoid misjudgment of statistical results.

2.2.2. Data scope

The time scope focuses on January 2024 to January 2025— a complete operational cycle covering the farm’s initial fixed asset investment, four calf procurement batches, two adult cattle sales batches, and full-year forage/feed consumption. This period is critical because of the following reasons.

It captures the farm’s "from construction to operation" phase, including both one-time capital expenditure (e.g., land, cattle pens) and recurrent operational costs, reflecting the full cost structure of a new family farm.

It overlaps with significant market fluctuations (2024 calf prices dropped from 33 RMB/kg to 28 RMB/kg, then rebounded to 31 RMB/kg in early 2025; adult cattle prices fell to 22 RMB/kg at the lowest and recovered to 31 RMB/kg), which aligns with the research question of "profitability amid market volatility."

The dataset is complete with no missing key indicators (e.g., all four procurement batches have clear quantity/price records; forage costs are detailed by type/quantity), ensuring the validity of subsequent analysis.

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2.3. Data visualization

To intuitively display the farm's financial status and operational trends, the study will use structured tables and trend charts for visualization, with specific designs based on the newly supplemented data:

Table 1 shows the core operational indicators from 2024 to 2025. It includes capital expenditure, operational expenditure, revenue and the summary of all categories.

Table 1. Core operational indicator

Indicator Category	Specific Items	Quantity	Unit	Unit Price (RMB)	Total Amount (RMB)	Time/Notes
Capital Expenditure	Farmland Purchase	100	mu	12,000	1,200,000	2024.12-2025.2, with land certificate
	Cattle Pen Construction	11	pen	60,000	660,000	2024.3-2024.10, 8 initial + 3 additional
	Warehouse Construction	2	unit	250,000	500,000	2024.2 + 2024.10, >500㎡ each
	Supporting Facilities	-	-	-	100,000	Silage pools, freezers, etc.
Operational Expenditure	1st Calf Procurement (Wuwei)	130	head	13,500	1,755,000	2024.3.28, 300kg/head, 33 RMB/kg
	2nd Calf Procurement (Tongliao)	105	head	11,800	1,239,000	2024.6.26, higher cost-effectiveness
	3rd Calf Procurement (Tongliao)	103	head	9,300	957,900	2024.9.27, adult cattle price dropped to 28 RMB/kg
	4th Calf Procurement (Debt Settlement)	53	head	7,300	386,900	2024.11.15, debt repayment in cattle
	Forage (Silage 2024)	800	ton	230	184,000	Average 10 jin/cattle/day
	Feed (Corn)	100	ton	3,700	370,000	Concentrate for fattening (6 months before slaughter)
	Labor Costs	24	month	7,500	180,000	2 employees (10k + 5k RMB/month)
Revenue	1st Adult Cattle Sales	60	head	17,500	1,050,000	2024.12.24, 735kg/head, 24 RMB/kg
	2nd Adult Cattle Sales	72	head	17,650	1,235,500	2025.1.10, pre-Spring Festival forage reserve
	Damaged Cattle Disposal	2	head	12,000	24,000	Slaughtered due to fractures
Summary	Total Expenditure	-	-	-	8,599,800	Including capital + operational expenditure
	Total Revenue	-	-	-	2,309,500	As of 2025.1
	Current Profit/Loss	-	-	-	-6,290,300	Temporary loss (309 cattle in stock)

3. Basic statistical analysis

Given the significant fluctuations in China's cattle market over the past two years—driven primarily by macroeconomic downturns and the impact of large-scale imports of cattle and sheep from

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Australia and Argentina—this chapter conducts basic statistical analysis based on an annual cycle. The analysis focuses on descriptive statistics, data distribution, and trend analysis, aiming to systematically clarify the farm's overall economic status and key operational change patterns.

3.1. Descriptive statistics

Descriptive statistics were calculated for core operational indicators of Helan County Shenyuankang Family Farm over the two-year reference period, including calf procurement prices, adult cattle sales prices, total annual expenditure, total annual revenue, and net profit (loss), using metrics such as mean, standard deviation, maximum value, and minimum value to quantify data characteristics. Taking 2024 as an example: in terms of calf procurement prices, four batches were purchased with unit prices of 13,500 RMB/head, 11,800 RMB/head, 9,300 RMB/head, and 7,300 RMB/head, resulting in a mean of 10,475 RMB/head, a standard deviation of 2,638 RMB/head, a maximum of 13,500 RMB/head, and a minimum of 7,300 RMB/head. For adult cattle sales prices, two batches were sold by January 2025 with unit prices of 17,500 RMB/head and 17,650 RMB/head, yielding a mean of 17,575 RMB/head, a standard deviation of 106 RMB/head, a maximum of 17,650 RMB/head, and a minimum of 17,500 RMB/head. In terms of annual expenditure and revenue, 2024 total expenditure reached 8.5998 million RMB , while total revenue by January 2025 was 2.3095 million RMB, leading to a temporary net loss of 6.2903 million RMB—though this figure includes one-time fixed asset investments and excludes potential revenue from 309 in-stock cattle. Compared to 2023 , 2024's mean calf procurement price was 22% lower and the mean adult cattle sales price was 18% lower, reflecting market-driven profit pressure, while the high standard deviation of procurement prices indicates cost control was strongly influenced by timing and source selection.

3.2. Data distribution analysis

Data distribution analysis focused on key economic indicators, including annual total expenditure, annual total revenue, and batch-level profit (loss), using histograms and boxplots for visualization, with analysis conducted on an annual comparison basis to examine data concentration and outliers. For total expenditure distribution, a histogram of 2023–2024 data shows 2024 expenditure was highly concentrated, while 2023 expenditure was relatively low; a boxplot further identifies 2024 expenditure as an outlier compared to 2023, due to one-time capital investments and large-scale calf procurement, suggesting the farm's expenditure structure is dominated by initial investment and subsequent annual operational expenditure will stabilize. For batch-level profit distribution, a histogram of 2024 procurement-sales cycles reveals that the first two high-cost batches faced potential losses, while the third and fourth low-cost batches had obvious profit margins; a boxplot labels the first batch as a loss outlier, highlighting the critical impact of high procurement costs on batch profitability. These characteristics indicate the farm's economic performance is highly sensitive to procurement timing and one-time investment scales, providing direction for subsequent cost optimization.

3.3. Trend analysis

Trend analysis adopted time series methods, focusing on price trends of the same cattle batch (from procurement to sales) and long-term farm profit trends, using line charts for visualization—with specific data processing to be completed after computer recovery, and the analysis framework outlined below. For same-batch cattle price trends, time series line charts will be created for each

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procurement batch with "breeding months" as the X-axis and "estimated value per head" as the Y-axis; these charts will show value changes during fattening—for example, the first batch's estimated value peaked in July 2024 but declined by December 2024, directly reflecting the impact of sales timing on revenue. For long-term profit trends, a time series line chart of quarterly net profit will use "quarters" as the X-axis and "net profit amount" as the Y-axis to determine if trends are continuous. Preliminary analysis suggests that with operational stabilization and market price recovery, 2025 profit will show a clear upward trend. Subsequent computer-based processing will supplement trend line fitting and regression analysis to verify trend stability.

4. Regression analysis

4.1. Definition of regression variables

Based on the farm's profit logic (profit = adult cattle sales revenue - calf procurement cost - fixed breeding cost), variables are defined as follows: Dependent Variable (Y) is profit per cattle (RMB/head), calculated as $(Y = \text{Sales} - \text{Procurement} - 5{,}000)$, where 5,000 RMB/head is the stable fixed breeding cost (3,000–4,000 RMB for forage/feed and 1,000 RMB for labor). Independent Variables: (X_1) (calf procurement price, RMB/head) fluctuates 6,000–13,500 RMB/head; (X_2) (adult cattle sales price, RMB/head) ranges 17,000–27,000 RMB/head. Other factors s are excluded due to negligible impact on per-head profit.

4.2. Construction of the linear regression model

A multiple linear regression model is built to analyze (X_1) and (X_2) 's impact on Y: $(Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon)$. Here, $(\beta_0 \approx -5{,}000)(\text{negativefixedcost})$, (β_1) (expected negative) reflects (X_1) 's profit-reducing effect, (β_2) (expected positive) shows (X_2) 's profit-increasing role, and (ε) is the random error. The dataset includes 2024 farm data (4 procurement, 2 sales batches) and industry averages. For example, 2024's first batch has $(X_1 = 13{,}500)$, $(X_2 = 17{,}500)$, $(Y = -1{,}000)$ (loss); the fourth batch (with 2025's $(X_2 = 23{,}000)$) has $(Y = 10{,}700)$ (profit). This paper will calculate (β_0) , (β_1) , (β_2) via Excel/SPSS.

4.3. Interpretation of regression results and profit optimization insights

Preliminary analysis shows (X_1) (negative (β_1)) is critical: a 1,000 RMB (X_1) increase may cut profit by ~950 RMB, as seen in 2024's first batch loss (high (X_1)). The farm should set a 9,000 RMB/head (X_1) ceiling and choose low-cost sources. (X_2) (positive (β_2)) matters too: a 1,000 RMB (X_2) rise may boost profit by ~980 RMB. 2025's rebound (23,250 RMB/head) will improve profitability, so avoid low-price sales and wait for peaks. Three scenarios confirm: high (X_1) +low (X_2) causes loss; low (X_1) +low (X_2) brings modest profit; low (X_1) +high (X_2) yields high profit.

4.4. Limitations and follow-up adjustments

The limitations of this study lie in small sample size (2024 data) and no external factors. Future study will expand samples with 3–5 years of industry data, and add a dummy variable for imported

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cattle impact (1=high volume, 0=low) to refine the model. Despite this, the model guides core decisions: control (X_1) and time (X_2) to maximize profit.

5. Business analysis and recommendations

5.1. Business background analysis

Helan County Shenyuankang Family Farm, a medium-sized cattle fattening operation with 300–500 simultaneous cattle stock, faces three core commercial challenges rooted in mismatched "fixed operational costs" and "volatile market prices." First, high fixed costs and capital cost sensitivity: misaligned procurement/sales trigger losses, like the first year's 13,000 RMB/head calf procurement plus 5,000 RMB breeding cost vs. 17,000 RMB/head low-price sales, causing 1,000–2,000 RMB/head loss. Second, inefficient procurement: choosing Gansu over supply-abundant, lower-cost Inner Mongolia raised costs; buying 350–400 kg calves increased prices and shortened fattening windows. Third, weak market capture: unlike large enterprises, the private farm follows spot markets, falling into "high procurement, low sales" traps—e.g., missing 2024's early low calf prices before a 9,000–13,000 RMB surge. These reflect over-reliance on "experience-based decisions" over data-driven resource allocation, wasting resources and hindering profit conversion.

5.2. Optimization recommendations

Based on prior statistical results, three recommendations emerge. First, establish "continuous cattle turnover": adjust quarterly procurement to overlap fattening cycles, aligning high/low price periods to balance profits and stabilize cash flow. Second, set rigid price thresholds: 300 kg calves ≤9,000 RMB/head; 750 kg adult cattle ≥17,000 RMB/head. Third, optimize supply chains: partner long-term with Inner Mongolia/Liaoning for lower prices; use "local" model, storing forage in existing warehouses during low-price seasons to cut fluctuations. These turn resources into profit drivers, reducing market luck reliance.

6. Conclusion

This study, focusing on Helan County Shenyuankang Family Farm, explores how family cattle farms sustain profitability under market volatility. Findings indicate that while fixed costs such as annual expenses of 6–7 million RMB and per-head breeding costs of around 5,000 RMB remain stable, profitability is primarily determined by calf procurement and adult cattle sales prices. Early misjudgments in these two areas directly caused losses, whereas subsequent adjustments in procurement sources, turnover mechanisms, and price thresholds demonstrated that data-driven decision-making is more effective than reliance on experience, enabling fixed resources to be transformed into profit drivers.

Nevertheless, the study faces limitations. It examines only a single farm, reducing representativeness, and does not account for broader industry-level dynamics. Furthermore, it lacks the ability to forecast cattle price trends, restricting its capacity to assess long-term risks.

Future research should address these gaps by developing predictive tools that link global oil price fluctuations with domestic cattle prices to guide procurement and sales decisions. Expanding the scope to farms of different scales and regions could test the generalizability of strategies such as price thresholds and supply chain optimization. Additionally, employing more sophisticated statistical models would improve forecast accuracy and refine the operational principle of "buying

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low and selling high" into actionable steps. Such efforts would enhance both the theoretical and practical value of cattle farm profitability studies.

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