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Estimation of economic equations as a management tool in feedlot dairy farming

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ABSTRACT. The aim of this study was to evaluate Pearson's linear correlations between productive and economic indicators as well as to estimate economic equations as tools in dairy farming. We used the database of the Research Group, registered with CNPq under the title 'Animal and Forage Production in Piaui', which consisted of two experiments with feedlot lactating cows. Economic and productive indicators were employed. Correlations were determined by Pearson's linear correlation analysis, using the 't' test. Equations were estimated via regression, using Saeg software (Statistical and Genetic Analysis System), considering $\alpha = 0.05$. Based on concepts related to Pearson's linear correlation and dairy farming management, we were able to find correlations that allowed us to estimate simple, yet very informative equations, which facilitated the interpretation of the management of a dairy farm. Among the studied variables, net present value, internal rate of return, the cost per liter of milk produced and net margin were those which most contributed to the estimation of equations.

Keywords: cow; internal rate of return; marginal rate of return; milk production cost; net present value.

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Introduction

In its semiannual assessment, the national supply company of Brazil observed a firm demand for animal products despite the impacts of the Covid-19 pandemic on the Brazilian economy and market. The current period is marked by a lower seasonal production in Europe and a seasonal growth in production in South America and Oceania, with an expected increase in world production by the end of 2021.

Despite the catastrophic impact of the pandemic on the production and sale of milk in Brazil, the current livestock scenario denotes positive expectations. Brazilian imports of dairy products have grown again for the third consecutive month, with a 72.8% increase in September, compared with the previous month. In July and August, monthly increases of 13.9% and 66.3% in dairy imports, respectively, had already been observed. The rise in domestic prices over the past four months contributed to neutralizing the exchange rate, which exerted a strong limitation on dairy imports in the first half of 2020 (*Companhia Nacional de Abastecimento* [Conab], 2020).

These data are extremely important, as they provide future prospects for the price of milk in the domestic economy. Variations in the milk price throughout the chain are constantly in the media, constituting a point of attention for the different segments involved. Among producers, discussions about the price paid by industries are a common occurrence, since this is the easiest indicator to be monitored in the management of the activity and the most likely to directly affect their gross income.

On the other hand, there are frequent debates in the industry about the price to be paid to producers for the raw material supplied, due to the harsh price negotiations of their final products with retailers. Retailers, in turn, take advantage of their greater bargaining power and the diversity of suppliers to offer products at attractive prices to consumers, without affecting their margins (Rocha & Rodrigues, 2020).

As discussed above, financial transactions pertaining to the cost of activities related to milk production are directly linked to the return of profit to the producer, given that the valuations of inputs and products used in the dairy activity do not always accompany the rise or drop in the milk price. As a result, profitability from milk is compromised and increasingly left as a major question mark.

In any agricultural activity, monitoring the financial condition and production-performance indices is of paramount importance. However, such monitoring is not so simple, especially for Brazilian producers. This profitability assessment is often done only in the final stage of the project or year of production, thereby reducing or almost extinguishing any possibility of identifying opportunities and making decisions for strategies to improve the farm's management.

According to Flamino and Borges (2020), to elucidate how this management is carried out, among other questions, it is necessary to understand how management models can become efficient. It is a matter of regarding these milk-producing establishments as companies or, simply, rural establishments-enterprises, seeking to diligently undertake entrepreneurial management.

There is a need for tools to be developed that enable the producer to better understand the financial data, as they can facilitate farm management. These tools will improve administration and oranization, making it easier to identify problems on the farm and giving the producer the possibility to reverse the negative scenario to a surprisingly profitable one.

Based on, this study proposes to evaluate Pearson's linear correlations between productive and economic indicators as well as to estimate economic equations as tools in dairy farming.

Material and methods

We used the database of the Research Group, registered with CNPq under the title 'Animal and Forage Production in Piaui', which consisted of two experiments with feedlot lactating cows, where the characterization of the data can be consulted. Both were approved by the Animal Use Ethics Committee (Ceua) at the State University of Piaui (Uespi) (approval no. 0356/19 and 0358/19).

The experiments were carried out on Branquinha Farm, located in Corrente, Piaí State, Brazil. (10° 26' 30'' S and 45° 9' 52'' W). According to the Köppen classification, the climate in the region is an AW type (tropical with winter dry season). Minimum and maximum temperatures in the region are 17.6 and 32.2°C, respectively. Average annual precipitation is 1,035 mm, and the rainy season is concentrated between November and March and may extend until May.

The following were used as productive indicators: milk yield (MY), concentrate dry matter intake (CDMI), roughage dry matter intake (RDMI), total dry matter intake (TDMI) total roughage cost (TRC), total concentrate cost (TCC), total cost (TC), cost per liter of milk (CL Milk), gross income from the sale of milk (GISM), income minus feed cost (IMFC), gross income (GI), effective operating cost (EOC), total operating cost (TOC) gross margin (GM) and net margin (NM). As economic indicators, the following variables were applied: marginal rate of return (MRR), internal rate of return (IRR) and net present value (NPV).

For marginal analysis, the partial budget method was employed, considering the elements that vary with the milk production of the animals and with the feeding system of each tested treatment, e.g., sorghum silage, concentrate (sorghum grain, soybean meal, urea, calcitic limestone and dicalcium phosphate) and mineral salt. Diet costs were determined during the experiment.

Subsequently, revenues from the sale of milk per treatment were determined using the price of milk referring to the amount paid in the south of the state of Piaui, according to a quotation survey by the Center for Advanced Studies in Applied Economics at ESALQ/USP. Said revenues were evaluated by the following variables: gross income from the sale of milk (Gism) and income minus feed costs (IMFC): difference between Gism and the total feed cost (TFC). The marginal rate of return (MRR) was calculated following the methodology proposed by Evans (2005), using the formula below:

MRR = (IMFCstandard – TFCstandard/TFCtest – TFCstandard) * 100.

The costs of the diet provided to the animals were determined considering the intakes of roughage and concentrate and prices according to Figueiredo et al. (2021). Accordingly, the roughage price was BRL 0.16 kg^{-1} DM and concentrate price was BRL 0.92 kg^{-1} DM, as charged in the state of Piaui, during the study period.

The information necessary to compose the costs, as well as the data used (prices, useful life, etc.), were collected from rural producers, rural extension technicians and commercial establishments in the region, considering the average annual price. Land costs were calculated based on the purchase of the area, using prices estimated for the region, for silage production. The costs of the kilogram of DM of silage were calculated based on the production per hectare, in addition to maintenance and recovery expenses. To determine the production cost, the operating cost methodologies used by Ipea (*Instituto de Pesquisa Econômica Aplicada*) were considered (Matsunaga et al., 1976).

Depreciation of improvements, machinery, equipment and animals was estimated using the straight-line method of fixed assets, with a final value equal to zero, except for animals. For capital remuneration, the real interest rate of 6% per year was adopted.

For economic analysis, two economic indicators were used: NPV (net present value) and IRR (internal rate of return).

The expression for calculating the NPV is as follows: $NPV = \Sigma^{n=1}_{t=0} NF / (1 + r)^t$, where NPV = net present value; NF = net flow value (difference between inflows and outflows); n = number of flows; r = discount rate; and t = period of analysis (i = 1, 2, 3...).

For IRR, according to the acceptance criteria, the greater the result obtained in the project, the greater the attractiveness of its implementation. Thus, IRR is the value of r that equals the following expression to zero: $NPV = NF_0 + (NF_1/(1 + r)^1) + (NF_2/(1 + r)^2) + (NF_3/(1 + r)^3) + (NF_n/(1 + r)^n)$, where NF = net cash flows (0, 1, 2, 3,..., n); and r = discount rate.

To calculate IRR and NPV, a one-year simulation was carried out to study economic characteristics, on which occasion the depreciation of improvements and machinery in the period were calculated.

The average selling prices for milk (BRL 1.50 L^{-1}) and manure (BRL 40.00 t^{-1}) were those charged in the year the experiment was carried out.

Detailed data on the prices of inputs and services, useful life and value of improvements, machinery/equipment, working animals and land used in the experiment were measured during the experimental period and are available.

Correlations were made by Pearson's linear correlation analysis, using the ‘t’ test. Equations were estimated via regression, using Saeg software (Statistical and Genetic Analysis System) and adopting $\alpha = 0.05$.

Results and discussion

There was no correlation between marginal rate of return (MRR) and the variables of milk yield (MY) (P = 0.0905), concentrate dry matter intake (CDMI) (P = 0.1522), roughage dry matter intake (RDMI) (P = 0.1675), total roughage cost (TRC) (P = 0.1675), total concentrate cost (TCC) (P = 0.2723), gross income from the sale of milk (GISM) (P = 0 .0905) or income minus the feed cost (IMFC) (P = 0.0887) (Table 1).

According to Figueiredo et al. (2021), Pearson's correlation only detects linear relationships between two factors and the same coefficient of variation. In the case of a non-linear relationship, this coefficient will not be able to adequately describe the association pattern between the variables. Thus, a different statistical analysis is required to interpret the behavior of these variables, e.g., multivariate analysis.

The marginal rate of return demonstrates the input increase according to the production increase, in numerical terms. This rate represents the difference obtained with the increase in return as a percentage of the total additional cost (Figueiredo et al., 2021). It is known that one of the laws that govern this dynamic of MRR is the Law of Diminishing Returns (also known as the ‘law of diminishing marginal productivity’), which, in theory, evaluates the input increase according to the production increase. However, milk production and feed intake do not follow the same context, given possible limitations in intake by the animal and its genetic potential for milk production.

No correlations were found between the productive indicators of concentrate dry matter intake (CDMI), forage dry matter intake (FDMI), total forage cost (TFC), total concentrate cost (TCC), effective operating cost (EOC), total operating cost (TOC) and total cost (TC) and the economic indicators of internal rate of return (IRR) and net present value (NPV) (P > 0.05) (Table 2).

The variables of milk yield (MY), gross income (GI), gross margin (GM) and net margin (NM) showed positive and high correlation (P < 0.05) with internal rate of return (IRR) and net present value (NPV), whereas the cost per liter of milk (CL Milk) showed a high negative correlation with the two (Table 2).

Table 1. Linear correlations between economic indicators and marginal rate of return.

Indicator	Correlation	P-value
Milk yield	0.2765	0.0905
Concentrate dry matter intake	0.2140	0.1522
Roughage dry matter intake	0.2011	0.1675
Total roughage cost	0.2011	0.1675
Total concentrate cost	0.1272	0.2723
Gross income from the sale of milk	0.2765	0.0905
Income minus feed cost	0.2786	0.0887

Table 2. Linear correlations between economic indicators and internal rate of return (IRR) and net present value (NPV).

Variable	IRR		NPV	
	Correlation	P-value	Correlation	P-value
MY	0.8880	0.0001	0.8284	0.0001
CDMI	0.1598	0.2227	0.0705	0.3689
RDMI	0.1464	0.2424	0.0675	0.3743
TRC	0.1464	0.2424	0.0675	0.3743
TCC	0.2364	0.1276	0.1432	0.2474
GI	0.8880	0.0001	0.8285	0.0001
EOC	0.2235	0.1414	0.1820	0.2647
TOC	0.2235	0.1414	0.1320	0.2647
TC	0.2235	0.1414	0.1320	0.2647
CL Milk	-0.9833	0.0001	-1.000	0.0001
GM	0.9769	0.0001	0.9393	0.0001
NM	0.9769	0.0001	0.9393	0.0001

MY - milk yield, CDMI - concentrate dry matter intake, RDMI - roughage dry matter intake, TDMI - total dry matter intake, TCC - total concentrate cost, TRC - total roughage cost, GI gross income, EOC - effective operating cost, TOC - total operating cost, TC - total cost, CL Milk - cost per liter of milk, GM - gross margin, NM - net margin.

Concentrate dry matter intake, roughage dry matter intake, total dry matter intake, total concentrate cost, total forage cost, effective operating cost, total operating cost, and total cost, showed no correlations with IRR or NPV.

According to Padoveze et al. (2020), every financial decision taken *a priori* must be evaluated later, both in its monetary aspects and as an assessment of the performance of the managers who made the decision. Thus, criteria are needed to validate the investment decision that allow comparing the expected future values with the values currently applied, under the same basis of comparison. These criteria should take into account the value of money at the time; therefore, the recommended criteria are NPV and IRR.

This study revealed a positive correlation between MY and IRR, from which a positive equation could be developed (Equation 1):

$$IRR = 5.835 * MY - 51.9920 \ (r^2 = 0.785) \quad (1)$$

In Equation 1, each (1.0) kg of milk produced corresponds to 5.8356 in the IRR value. For Padoveze et al. (2020), the IRR is a decision criterion involving decisions of the ‘accept/reject’ type. If IRR is greater than the cost of capital (hurdle rate), the project is accepted; if it is smaller, then it is rejected. This criterion ensures that the business is getting at least its required rate of return.

The second numerical value of this equation, represented by ‘b’, is negative, indicating that the IRR will only be positive from the approximate milk yield value of 52 kg. This already provides precious information on the minimum milk yield to ‘accept’ the production method used.

For Padoveze et al. (2020), despite being considerably more difficult to calculate by hand than NPV (Net Present Value – another investment analysis method), IRR is possibly the most used sophisticated technique for evaluating investment alternatives.

There was a positive correlation between MY and NPV, in a negative quadratic equation (Equation 2):

$$NPV = -0.1557 * MY^2 + 8.553 * MY - 73.318 \ (r^2 = 0.7573) \quad (2)$$

The second equation can be considered a negative, second-degree model, with a maximum point of 27.466 kg of milk and a NPV of 1.070. With a downward concavity, positive NPV are noted between 11 and 44 kg of milk.

The net present value can be classified as positive, negative or neutral. If NPV is negative, it can be stated that the investment will result in losses. A positive NPV is a sign that the investor will have financial gains and earn value for their money. As a third possibility, a neutral NPV means the investment to be made will be balanced.

There was a correlation between GI and IRR ($P < 0.05$):

$$IRR = 3.8876 * GI - 52.565 \ (r^2 = 0.7885) \quad (3)$$

Equation 3, a positive first-degree model, can be estimated from the correlation between GI and IRR, where the ‘b’ value is negative. With this, with each GI unit, IRR increases by 3.8876. From the approximate GI value of BRL 14.00, the IRR value will be positive.

There was also a correlation between GI and NPV ($P < 0.05$):

$$NPV = 0.091 * GI^2 + 5.7179 * GI - 74.151 \ (r^2 = 0.7554) \quad (4)$$

The equation estimated using GI and NPV corresponds to a negative quadratic model, with a maximum point of 41.374 for GI and 41.457 NPV.

This equation is a promising tool, as the present-value method comprises the present value, all cash flow values during the analyzed period, considering a given interest rate. In this way, different investment alternatives can be compared without great complications.

The cost per liter of milk (CL Milk) was negatively corrected with IRR, generating a positive linear equation (Equation 5), whereas with NPV a negative linear equation was generated (Equation 6) (P < 0.05):

$$IRR = 187.23 - 131.97 * CL\ Milk\ (r^2 = 0.9669) \quad (5)$$

$$NPV = -65.805 * CL\ Milk + 93.594\ (r^2 = 0.9999) \quad (6)$$

Equation 5 shows the relationship of proportions between IRR and CL Milk, which indicates that the greater the CL Milk, the greater the IRR.

In Equation 6, NPV showed the inverse of IRR, following a negative linear model, where the higher the CL Milk, the lower the NPV. It is worth noting that NPV reflects the revenue amounts from expenses related to the production of raw material. One possibility to reverse negative NPV values is cost management.

Cost management refers to the collection, organization, interpretation and analysis of data to provide information to various users, helping in the decision-making process (Lizot, Andrade Júnior, Lima, & Magacho, 2016). One of the main difficulties faced in cost management is the allocation and distribution of indirect costs, since incorrect apportionments can lead to wrong decisions, compromising the profitability of businesses and their decision-making process (Dumer et al., 2018).

The unit cost of milk is directly influenced by the production system with supplementation, which may interfere with the profitability of the farm. In this case, to maximize profit, it is necessary to evaluate the costs and price of the product (milk). In cases where cost reduction is an issue, the solution is to add value to the product, increasing the gross income from the sale of milk.

Milk yield, gross margin and net margin correlated positively with IRR and NPV (P < 0.05) (Equation 7 and 8):

$$IRR = 5.0966 * NM - 4.9238\ (r^2 = 0.9544) \quad (7)$$

$$NPV = -0.125 * NM^2 + 4.8902 * NM - 4.2487\ (r^2 = 0.9813) \quad (8)$$

Net margin represents the relationship between the net profit and the generated revenues. Thus, it indicates how much the company earns for each Brazilian real entering as income, i.e., the real gain generated by the business as a result of its operation.

Equations 7 and 8 are extremely informative, the former being characterized by a first-degree and positive model that showed linearity between IRR and NM. Net present value, in turn, related NM in a negative second-degree equation. Equation 8 showed a point of maximum at 0.306 NM and 0.681 NPV. This equation will indicate whether the farm is making a profit and, if so, what percentage of it is represented by the NM value and will represent the revenue amounts from expenses related to milk production with NPV. For this reason, the values expressed in Equation 8 are a strong indicator that the prices adopted are in line with long-term business strategies, which ensures the sustainability of the sale of milk.

Conclusion

Using concepts related to Pearson's linear correlation and dairy farming management, we were able to determine correlations that allowed us to estimate simple, yet very informative equations that facilitated the interpretation of the management of a dairy farm.

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