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Animal production systems and agribusiness

Development of a calculation model and production cost index for feedlot beef cattle

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ABSTRACT - The objective of this study was to develop a feedlot beef cattle calculation model and production cost analysis and, from the results obtained, devise a production cost index. A case study was conducted to understand the characteristics of the productive processes of a commercial feedlot. Then, based on the Economic Theory, cost items of the farm under analysis were identified and transferred to a spreadsheet. The survey included ten feedlot farmers from the state of São Paulo and other nine from the state of Goiás and was carried out to determine representative properties, and prices of items used were monitored. Production costs of each farm were calculated, and theoretical concepts of index numbers were used to devise the feedlot cattle production cost index. The cost allocation scheme was divided into four cost groups: variable, semi-fixed, fixed, and production remuneration factors. The developed model allowed a cost prognosis of the analyzed systems. Highest total costs for São Paulo State feedlots were R$ 9.17 kg^{-1} and R$ 9.08 kg^{-1} for average-sized and large farms, respectively, as contrasted to that of Goiás, of R$ 8.29 kg^{-1}. Between the months April and June, the cost of production for feedlot beef cattle showed reductions of 1.48 and 1.40% for the average and large feedlots in the State of São Paulo and 9.13% for the Goiás feedlot by the Konüs Exact Index, respectively. Studies available in literature were compared and it was concluded that the model can help feedlot cattle farmers take production decisions. The Konüs Index allows for a methodological advancement in relation to other studies carried out on the Brazilian livestock industry; besides, it can contribute to the sector organization.

Key Words: economic indicators, economy, livestock, mathematical model, production systems, survey

Introduction

Brazilian beef cattle production has evolved over time and production costs have pushed profit margins of farmers, especially those of feedlot beef cattle farmers (Lobato et al., 2014; Kamali et al., 2016). The changes in the sector have raised a debate over whether there are economic advantages of using feedlots as a productive system strategy.

Production cost monitoring of feedlot cattle in Brazil has aroused interest since the system was first introduced, as reported by Wedekin and Amaral (1991) and Wedekin et al. (1994). In more recent studies, although complex cost analyses have been performed, there have been difficulties in comparing and following production costs.

Some agencies, such as CEPEA – Centro de Estudos Avançados em Economia Aplicada – and CNA – Confederação da Agricultura e Pecuária do Brasil – have monitored costs on a regular basis and have developed a cost index for extensive beef cattle production (CEPEA and CNA, 2017). The Milk Cattle branch of Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) calculated the Milk Production Cost Index (Carneiro et al., 2010); Raineri et al. (2015a) developed the Lamb Production Cost Index for the state of São Paulo; in addition, EMBRAPA developed the Swine and Poultry Production Cost Indexes (Girotto and Santos Filho, 2000; Miele et al., 2010). Despite the relevance of this issue, the calculation and monitoring of costs have not been properly discussed in feedlot cattle studies.

The difficulty of performing a full cost analysis occurs, among other reasons, because there is no previously defined standard protocol, once there are different ways of conceptualizing costs (Gameiro, 2009). Due to this methodological diversity, it is difficult to compare costs and economic indicators between different studies and farms, and it is necessary to first define which cost items will be considered in the analysis.

The objective of this study was to develop a feedlot cattle calculation model and production cost analysis for

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the states of São Paulo and Goiás and, from the results obtained, devise a production cost index to follow cost behavior over time.

Material and Methods

To accomplish better results, the study was divided into two stages. The first stage was subdivided into two phases: a case study was carried out to understand the holistic characteristics of a commercial feedlot productive process; and cost items were identified, and a spreadsheet based on the Economic Theory was devised.

After the development of the cost calculation model, the second stage was initiated, which was divided into four phases: a survey with feedlot cattle farmers from the states of São Paulo and Goiás to determine three representative farms; monthly monitoring of prices of items used; production cost calculations on each farm; and the establishment of a feedlot cattle production cost index (ICBC).

The case study followed the methodology proposed by Yin (2010), in which questions and propositions are formulated to guide the field research, which was a feedlot cattle unit in the state of São Paulo in this study. Data collection was performed during scheduled visits with the presence of the owner and/or managers between October 2014 and February 2015.

The Microsoft Excel® software was used as a calculation tool. The cost allocation scheme was based on the Economic Theory and on a study performed by Raineri et al. (2015a); however, cost method adaptations had to be made.

The variable cost method allows the understanding and decision-making processes by managers, in this case by feedlot cattle farmers (Carareto et al., 2006). From this, cost items were grouped into the following categories: variable costs, semi-fixed costs, fixed costs, and production factor income (Table 1).

Variable costs (CV) included all items that varied according to the number of animals raised: animal purchase, feed, health and identification management, and others, including feedlot cleaning and dead animal disposal, as well as variable taxes related to the activity.

One of the methodological innovations of the study was the use of semi-fixed costs (CSF) which, according to Powers (1987), include a base cost – even if the amount produced is zero. According to this method, costs are supposed to increase as greater quantities are produced, but to a lesser extent when compared with variable cost changes. The items included in this group were electricity, telephone and internet services, and fuel; managing and/or animal consultancy services were also included as semi-fixed costs (Table 1).

Fixed costs (CF) are those that do not change when the production volume varies, that is, in the short term (Young, 1958; Rushton, 2009). Items included in this group were labor, depreciation, maintenance, and fixed taxes. Among available depreciation methods, a linear method that considers the same discount rate over the years, easier to understand and more frequently employed, was chosen (Croitoru et al., 2015).

Even though the opportunity cost (CO) group includes variable, semi-fixed, and fixed-cost items, these were separated from other costs. The CO was divided into three items and sub-items (Table 1) to facilitate understanding as well as to allow the development of other economic indexes such as the effective operational cost (COE) and the total operational cost (COT) based on a study by Matsunaga et al. (1976), adapted; there were also costs used in the field by technicians and feedlot cattle farmers on a daily basis, such as the daily operating cost (COPd) and cattle daily cost (CDB) (Table 1).

For the second stage, after the calculation model was fully developed, a survey was performed to select representative farms. In this method, the sampling of a

Table 1 - Production cost allocation scheme for each beef cattle feedlot unit

A - Variable costs (CV)
1 Animal purchase
2 Animal feed
3 Sanitary management
4 Identification management
5 Other variable costs
6 Variable taxes
B - Semi-fixed costs (CSF)
7 Electricity
8 Telephone and internet services
9 Fuel
10 Other semi-fixed costs
C - Fixed costs (CF)
11 Labor
12 Depreciation
13 Maintenance
14 Other fixed costs
D - Remuneration factors (CO)
15 Working capital remuneration with:
15.1 Animals
15.2 Animal feed
15.3 Other items
16 Fixed capital remuneration
17 Land remuneration
E - Effective operational cost - COE (A + B + 11)
F - Total operational cost - COT (A + B + C)
G - Total costs - CT (A + B + C + D)
H - Daily operational cost - COPd (CT − 1 − 2 − 6 − 15.1 − 15.2)
I - Cattle daily cost - CDB (CT − 1 − 15.1)

diverse group of individuals allows managers to understand different productive environments and experiences on the investigated subject (Pinsonneault and Kraemer, 1993).

Representative farms were established to bring cost analysis and field reality close together without, however, representing any specific feedlots, according to Marshall's (1996) conception. The design was based on a preliminary data examination which included a feedlot that could show representative structure and operation for input and final product trade.

Information was collected through a semi-structured form containing 45 questions related to technical and general aspects as well as activity expectations, which was applied during interviews with feedlot cattle farmers. Interviews were carried out in 19 commercial feedlot beef cattle farms, ten of which located in São Paulo and nine in Goiás. São Paulo was chosen because of the historical tradition in beef cattle production in Brazil, because it has a large and representative slaughter capacity for cattle, and because it hosts the research center where the study was developed. Goiás is among the largest beef cattle producers in feedlot system in the country. Additionally, the state presents different technical characteristics of São Paulo, thus allowing diversity in the results. These data were collected in the field from July 2015 to February 2016.

All study guarantees were agreed upon by both parties involved, who signed a Free and Informed Consent Agreement as required by the Ethics Committee of the educational institution – case number 2999120215. In this form, among other guarantees, researchers were committed to keep confidential all strategic information collected and use it only within the context of the present research.

Reference parameters of proposed farms were based on survey data, contacts, and validations with technicians and technical experts in the area. The quantities of production inputs considered were those actually used in the activity in a one-year period. Therefore, for the cost estimates, stocked quantities were disregarded, so that the calculated total costs would represent annual costs.

Prices of all inputs included in the three representative farms were updated for the months of April, May, and June 2017 in the study. A database containing a list of suppliers, including representatives, machinery dealers, equipment, vehicles, service providers, and cooperatives from São Paulo and Goiás was organized to update prices by telephone. Values of interest were those practiced by the spot market in the months in question. The average price for each input was preferably defined from three suppliers, and only new items were considered so that this would be an objective price survey over time.

As animal feed plays a significant role in the cost of the activity and feedlot beef cattle farmers change the quantities and ingredients used according to price fluctuations in the agricultural commodity market, a Linear Programming model to calculate diet composition according to relative price changes was proposed. For such, the RLM® software version 3.2 was used to find the minimum cost of diet. Thus, relative price composition was calculated for each period, maintaining the desired animal performance unchanged and opting for a minimum cost diet per kilo of dry matter. The maintenance of these productive indexes was necessary to compare and understand the behavior of costs among representative farms over time.

The calculation formula used to monitor the evolution of feedlot cattle production costs was the Konüs exact index (Konüs, 1939). The use of this index was another methodological novelty in this study, since it is characterized by the flexibility of quantities consumed between two periods in which the comparison is made, for example, the base month diet and the current diet as demonstrated in Equation 1 (Tables 2 and 3).

Finally, in addition to estimating the change in production costs on a monthly basis, results between farms, even when located in different states and/or showing different production scales, were compared.

Results

According to the cost allocation (Table 1), item organization was divided into four groups: variable costs, semi-fixed costs, fixed costs, and production factor remuneration costs. The sum of these items resulted in the total cost of the activity, as described in Equation 2 (Tables 2 and 3). Mathematical equations and classifications were used to transfer the feedlot cattle production cost calculation model to a spreadsheet.

Variable costs were calculated according to Equations 3 and 4. Health management items were included in the cost group according to data collected in the field. Therefore, drugs for the prevention and control of endo- and ectoparasites as well as bacteria of the genus *Clostridium* – *C. botulinum* (botulism) and *C. chauvoei* (symptomatic carbuncle) – were prescribed for average-sized representative feedlot (SPFa) animals. On the other large production representative farms of São Paulo (SPFl) and Goiás (GOF), bovine respiratory system diseases were treated in addition to drug prescription, as described previously.

Cost items for animal identification, among which cattle management ear tags, traceability, and electronic chips, did not differ among the three representative farms. Due to the reuse of electronic chips, their cost was divided by four, the number of times this input is used, on average.

Still within the CV group, variable taxes showed different figures among representative farms. The SPFl was taxed as a legal entity based on a deemed profit system for providing third party services; on the other hand, SPFa and GOF feedlots were taxed as private individuals.

Table 2 - Equations that make up the cost calculation model for finishing beef feedlot cattle

Equation	Equation number
$ICBC_t = \frac{CDB_{ptqt}}{CDB_{pbqb}}$	1
$CT_t = CV_t + CSF_t + CF_t + CO_t$	2
$CV_t = \sum_i CI_{it}$	3
$CI_{it} = QI_{it} \times PI_{it}$	4
$CSF_t = \gamma \times \sum_s FI_{st}$	5
$FI_{st} = QF_{st} \times PF_{st}$	6
$CF_t = Cmao_t + Cdep_{ct} + Cman_{ct} + Cout_t$	7
$Cdep_{ct} = \frac{Vaq_{ct} - Vres_{ct}}{\nu u_c}$	8
$Vres_{ct} = Vaq_{ct} \times \tau_c$	9
$Cman_{ct} = Vaq_{ct} \times \sigma_c$	10
$CO_t = COG_t + COI_t + COA_t$	11
$COG_t = COGan_t + COGali_t + COGout_t$	12
$COGan_t = CVaqa_t \times ((1 + j)^{\delta} - 1)$	13
$COGali_t = CVali_t \times ((1 + j)^{\frac{\delta}{2}} - 1)$	14
$COGout_t = COE_t - CVaqa_t - CVali_t \times ((1 + j)^{\frac{\delta}{2}} - 1)$	15
$COE_t = CV_t + CSF_t + Cmao_t$	16
$COI_t = \sum_c AF_{ct} \times (1 + j)^{\varphi} - 1$	17
$COA_t = A \times PA_t$	18
$COT_t = CV_t + CSF_t + CF_t$	19
$COP_t = CT_t - CVaqa_t - CVali_t - CVimp_t - COGan_t - COGali_t$	20
$COPd_t = \frac{COP_t}{QDB_t}$	21
$QDB = NAC \times ((1 - \varepsilon) \times \delta + \varepsilon \times \theta)$	22
$CTMdb_t = \frac{CT_t}{QDB_t}$	23
$CTM_t = CTMdb_t \times \delta$	24
$CTMarp_t = \frac{CT_t}{Qarp}$	25
$Qarp = NAC \times (1 - \varepsilon) \times PCA$	26
$PCA = \frac{PVF \times \alpha}{15}$	27
$CTMqp_t = \frac{CTMarp_t}{15}$	28
$CDB_t = \frac{CT_t - CVaqa_t - COGan_t}{QDB}$	29
$RAV_t = Qarp \times Par_t$	30

The new cost item proposed by this study – semi-fixed costs (CSF) – was calculated by Equations 5 and 6. Quantities consumed by each representative farm were assigned according to operational capacity.

Fixed costs are shown in Equation 7. The linear depreciation method (Equation 8) was used to calculate the residual value of production assets; in practice, it was calculated as a percentage in relation to the new asset rather than a real value; this variable had to be included in the calculation (Equation 9). Table 4 data were considered standard in this study for useful life and residual depreciation value calculation of all items used in the cattle feedlot operation, as well as maintenance (Equation 10).

Other differences observed among representative farms were related to pen construction structures (Table 5), as well as management and animal performance and structural parameters in general (Table 6).

In São Paulo, farms were further subdivided into two groups according to the operational size identified by the survey: average-capacity production farmers (SPFa), that is, annual slaughter of 3,000 animals, and large-capacity production farmers (SPFl), with annual slaughter of 27,000 animals. In Goiás, a feedlot was defined with annual slaughter of 16,500 animals (Table 6).

The production factor income is summarized in Equation 11. The Working Opportunity Cost of Capital (COG), although usually a variable cost item, was subdivided into animals, food, and other items. The opportunity cost of the working capital of animals corresponded to the amount spent on their acquisition (Equation 13). Feed COG, in turn, took into consideration half the days on which the animals remained in feedlots (Equation 14), based on the practice of cattle feedlot farmers of buying food supplies frequently.

The third COG sub-item (for other items, see Equation 15) was calculated from the effective operational cost (COE), which was the sum of items 1 to 11 (in Table 1), represented by Equation 16. The COG was then calculated by Equation 12, and its remuneration made use of the Selic (Basic Interest Rate) average in the last 12 months previous to the research period. In the months included in the price survey, values for this rate were 13.1, 13.2, and 13.0% for the months of April, May, and June of 2017, respectively.

To calculate the opportunity cost of fixed assets, all fixed assets that make up the production system (acquisition of machinery, vehicles, equipment, office materials, buildings, facilities, work animals, and others) were added. These assets were connected to the long-term interest rate (TJLP), which has been institutionalized by the Federal Government to remunerate fixed capital, corresponding to 7.0% annually in this study (Equation 17).

Table 3 - Acronyms and definitions of formulas used in the calculation model

Acronym	Definition
$ICBC_t$	Feedlot cattle production cost index at moment t.
CDB_t	Cattle daily cost at moment t, in Reais (R$).
p^t	Prices p in period t (current).
t	Refers to the moment costs are being expressed, to be used on any date under analysis, in this case, current period (t).
p^b	Prices p in period b (basis).
b	Refers to the moment costs are being expressed, to be used on any date under analysis, in this case, basis period (b).
q^t	Quantity q consumed in current period (t) in units.
q^b	Quantity q consumed in base period (b) in units.
CT_t	Feedlot total annual cost regarding moment t, in Reais (R$).
CV_t	Feedlot activity variable annual costs regarding moment t, in Reais (R$).
CSF_t	Feedlot activity semi-fixed annual costs regarding moment t, in Reais (R$).
CF_t	Feedlot activity fixed annual costs regarding moment t, in Reais (R$).
CO_t	Feedlot activity annual opportunity costs regarding moment t, in Reais (R$).
i	Represents variable inputs: animals, animal feed, sanitary and identification managements, other variable costs, and variable taxes.
CI_{it}	Unit cost of input i used in feedlot activity regarding moment t, in Reais (R$).
QI_{it}	Amount of input i used in feedlot activity regarding moment t (in units or volume).
PI_{it}	Price of input unit i at moment t (per unit or volume in Reais – R$).
γ	Number of months a year when feedlot activities were held.
s	Represents semi-fixed factors: electricity, telephone and internet services, fuel, and other semi-fixed costs.
FI_{st}	Cost of semi-fixed input s used in feedlot activity regarding moment t, in Reais (R$).
QF_{st}	Amount of semi-fixed input s regarding moment t (in units or volume per month).
PF_{st}	Unit price of semi-fixed input s at moment t (in Reais – R$, monthly by unit or volume).
$Cmao_t$	Fixed labor annual costs, including wages, and labor benefits and charges regarding moment t, in Reais (R$).
$Cdep_{ct}$	Annual depreciation cost of capital asset c at moment t, in Reais (R$).
c	Represents all items of capital assets that are involved in the activity, such as machinery, vehicles, equipment, buildings, facilities, and others.
$Cman_{ct}$	Annual maintenance cost of capital asset c at moment t, in Reais (R$).
$Cout_t$	Other annual fixed costs involved in the productive system, such as fixed taxes, regarding moment t, in Reais (R$).
Vaq_{ct}	Acquisition value of capital asset c at moment t, in Reais (R$).
$Vres_{ct}$	Residual value of capital asset c at moment t, in Reais (R$).
vu_c	Useful life of capital asset c, in years.
τ_c	Percentage of capital asset c after depreciation period (scrap value).
σ_c	Maintenance rate of capital asset c in percentage terms.
COG_t	Working capital annual remuneration regarding moment t, in Reais (R$).
COI_t	Fixed capital annual remuneration regarding moment t, in Reais (R$).
COA_t	Land use (area) annual remuneration regarding moment t, in Reais (R$).
$COGan_t$	Annual cost of animal working capital regarding moment t, in Reais (R$).
$COGali_t$	Annual feed working capital opportunity cost regarding moment t, in Reais (R$).
$COGout_t$	Annual opportunity cost of other working capital items regarding moment t, in Reais (R$).
$CVaqa_t$	Annual cost of purchase of lean cattle for fattening regarding moment t, in Reais (R$).
j	Daily interest rate to remunerate business, in percentage terms.
δ	Average number of days on which animals of a given batch were kept under feedlot conditions until sent for slaughter, in days.
$CVali_t$	Annual feed costs regarding moment t, in Reais (R$).
COE_t	Effective operational cost regarding moment t, in Reais (R$) per year.
AF_{ct}	Asset value (fixed assets) of capital asset c at moment t, represented by the initial value paid in Reais (R$).
φ	One-year interval, 365 days.
A	Area needed for feedlot activity, in hectares.
PA_t	Land lease value per hectare per year, in Reais (R$).
COT_t	Total operational costs regarding moment t, in Reais (R$) per year.
COP_t	Activity operational costs regarding moment t, in Reais (R$) per year.
$CVimp_t$	Variable taxes annual cost regarding moment t, in Reais (R$).

Continues...

Table 3 (Continued)

Acronym	Definition
$COPd_t$	Daily operational costs regarding moment t, in Reais (R$).
QDB_t	Amount of cattle daily rates produced along the year under feedlot conditions regarding moment t, in units.
NAC	Number of feedlot cattle along the yearly feedlot cycle, per head.
ε	Mortality rate, in percentage terms.
θ	Average period in which animal mortality occurs, in days.
$CTMdb_t$	Average cattle daily cost regarding moment t, in Reais (R$).
CTM_t	Average total cost per head of cattle, regarding moment t, in Reais (R$).
$CTMarp_t$	Total average cost per arroba produced regarding moment t, in Reais (R$).
$Qarp$	Number of arrobas produced yearly during the feedlot period, in units.
PCA	Carcass weight of slaughtered animals, in arrobas.
PVF	Final weight before slaughter, in kg.
α	Carcass yield rate at the slaughterhouse, in percentage terms.
15	One fat cattle arroba (corresponding to 15 kg).
$CTMqp_t$	Total average cost per kg produced regarding moment t, in Reais (R$).
RAV_t	Annual animal sale income regarding moment t, in Reais (R$).
Par_t	Marketed fat cattle arroba price regarding moment t, in Reais (R$).

Table 4 - Production assets used in the cattle feedlot activity

Item	Useful life (years)	Residual value (%)	Maintenance (%)
Machinery and vehicles			
Wheel loader	6-10	20	10
Truck and tractor	10	20	10
Feed distributor wagon and/or mixer wagon	10	20	10
Cars and motorcycles	5	40	10
Equipment			
Stationary mixer	10	10	10
Electronic balance	5	10	5
Grain mill	5	20	20
Converter	5	0	10
Stationary generation	15	20	10
Cattle chute	10	20	10
Tools	5	0	0
Traceability reader	5	0	5
Office material			
Computers and printers	5	0	10
Air conditioning	5	0	10
Radio communication system	5	0	10
Tables, chairs, and refrigerators	5	0	5
Fans	3	0	0
Buildings and facilities			
Pens	10	20	10
Cattle handling facilities	10	20	10
Animal feed factory and machinery shed	10	20	5
Administrative office	20	20	10
Employees' housing	20	10	5
Others			
Working animals	10	0	0

Land use remuneration, expressed in a more simplified way than that of other opportunity costs, is shown in Equation 18. The method adopted considered that the area (in hectares – ha) where the farm was located should be compared to the most profitable lease in the region. Values per ha were R$ 1,170.31 for São Paulo and R$ 690.00 for Goiás in June 2017.

In addition to the COE index, the COT, which is often referred to in technical and scientific articles, is calculated in Equation 19. On the other hand, in the field, feedlot farmers and professionals use the activity COP index and the COPd, which were calculated by Equations 20 and 21, respectively. Among these costs, by definition, all activity items – except those related to food, animal purchase, and variable taxes – were included. However, COPd calculation was divided by the amount of cattle daily rate (QDB) produced.

Table 5 - Materials and measurements employed in the construction of pens in the representative properties studied

	SPFa[1]	SPFl[2]	GOF[3]
Animals per pens (units)	150	120	160
Width (m)	48.00	36.00	49.60
Depth (m)	40.63	50.00	33.87
Pens (units)	12	118	66
Bunk line (units)	2	10	7
Treatment track width (m)	8.00	8.00	8.00
Distance between wedges (m)	2.00	2.00	2.00
Wedges (units)	720	6,401	3,924
Stretcher wedges (units)	48	472	264
Non-electrified fence wires (units)	5	5	5
Galvanized barbless wire (km)	5.30	50.20	26.90
Barbless wire, electrified wire (km)	1.10	10.00	5.40
Trough line wire rope (units)	2	2	2
Wire rope (km)	1.10	8.50	6.50
Bunk (m)	560.00	4,242.00	3,255.00
Water bunk (units)	12	118	66
Water reservoir (in thousands of L)	210	1,700	1,300
Concreted trough area (in thousands of m^2)	1.400	10.605	8.137
Pen cleaning (yearly)	0	2	1

[1] Representative average production capacity feedlot for the state of São Paulo (SP).
[2] Representative large-production capacity feedlot for SP.
[3] Representative feedlot for the state of Goiás.

Table 6 - Reference data from representative farms

	SPFa[1]	SPFl[2]	GOF[3]
Yearly production capacity (animals)	3,000	27,000	16,500
Feedlot area (ha)	10	30	30
Initial age (months)	26.0	24.0	22.0
Initial live weight (kg)	390.0	353.9	353.3
Final live weight (kg)	537.0	520.3	509.0
Daily weight gain (g)	1,547	1,616	1,573
Daily ration offer (kg of dry matter)	10.56	10.40	10.00
Carcass yield (%)	55.80	55.46	55.29
Feedlot days	95	103	99
Mortality (%)	0.31	0.47	0.34
Mortality period (days)	32	33	32
Number of employees (units)	3	25	15
Employees' housing (units)	0.75	4.00	3.00
Number of working animals (units)	3	40	20
Animal feed factory (m^2)	750	2,350	1,800
Administrative office (m^2)	20	242	184
Machinery shed (m^2)	0	360	100
Other facilities (m^2)	0	50	50

[1] Representative average production capacity feedlot for the state of São Paulo (SP).
[2] Representative large-production capacity feedlot for SP.
[3] Representative feedlot for the state of Goiás.

The QDB is calculated in Equation 22, in which the number of animals in feedlot systems is multiplied by the days they remained in the fattening period minus the mortality period with its corresponding rates (Table 6). Cattle daily cost has been another index employed by Brazilian feedlot cattle farmers. In their view, costs related to animal purchase should not be included in the calculations, as shown in Equation 29.

The average daily cattle cost is shown in Equation 23 and the average cost per animal in Equation 24, while the average cost per kilo produced is calculated by Equation 28. Finally, the activity income is calculated by Equation 30.

Table 7 - Cost per kilogram of the beef cattle carcass with yield discount for representative feedlot farms for the month of June 2017

Cost item	SPFa[1]	SPFl[2]	GOF[3]
A - Variable costs			
1 Animal purchase	R$ 6.21	R$ 5.85	R$ 5.80
2 Animal feed	R$ 1.95	R$ 2.04	R$ 1.52
3 Sanitary management	R$ 0.01	R$ 0.03	R$ 0.04
4 Identification management	R$ 0.02	R$ 0.02	R$ 0.02
5 Other variable costs	R$ 0.02	R$ 0.06	R$ 0.03
6 Variable taxes	R$ 0.20	R$ 0.36	R$ 0.18
Subtotal A - Variable costs	R$ 8.41	R$ 8.36	R$ 7.59
B - Semi-fixed costs			
7 Electricity	R$ 0.01	R$ 0.01	R$ 0.01
8 Telephone and internet services	R$ 0.00	R$ 0.00	R$ 0.00
9 Fuel	R$ 0.03	R$ 0.04	R$ 0.04
10 Other semi-fixed costs	R$ 0.01	R$ 0.01	R$ 0.01
Subtotal B - Semi-fixed costs	R$ 0.05	R$ 0.06	R$ 0.06
C - Fixed costs			
11 Labor	R$ 0.04	R$ 0.10	R$ 0.09
12 Depreciation	R$ 0.15	R$ 0.11	R$ 0.10
13 Maintenance	R$ 0.19	R$ 0.14	R$ 0.14
14 Other fixed costs	-	-	-
Subtotal C - Fixed costs	R$ 0.38	R$ 0.35	R$ 0.33
D - Cost of remuneration factors			
15 Working capital remuneration	R$ 0.25	R$ 0.27	R$ 0.24
16 Fixed capital remuneration	R$ 0.07	R$ 0.05	R$ 0.05
17 Land remuneration	R$ 0.01	R$ 0.00	R$ 0.00
Subtotal D - Factor income	R$ 0.33	R$ 0.32	R$ 0.29
E - Effective operational cost	R$ 8.50	R$ 8.52	R$ 7.75
F - Total operational cost	R$ 8.84	R$ 8.63	R$ 7.99
G - Total costs	R$ 9.17	R$ 9.08	R$ 8.29
H - Daily operational cost[4]	R$ 1.71	R$ 1.52	R$ 1.52
I - Cattle daily cost[4]	R$ 8.67	R$ 8.44	R$ 6.47
Amount received[5]	R$ 8.57	R$ 8.57	R$ 7.77

[1] Representative average production capacity feedlot for the state of São Paulo (SP); feedlot days = 95.
[2] Representative large-production capacity feedlot for SP; feedlot days = 103.
[3] Representative feedlot for the state of Goiás; feedlot days = 99.
[4] R$ day^{-1}.
[5] R$ kg^{-1}.
Exchange rate for June 2017: USD 1.00 = R$ 3.2954, according to Banco Central do Brasil.
The weight of beef cattle carcass with yield discount can be calculated by Equation 27 (Table 2) in arrobas or to be found in kilograms without dividing by 15 in the same equation.

The equations cited above, and mentioned in Tables 2 and 3, allowed the results of cost per kilogram of the beef cattle from representative farms for the month of June 2017 (Table 7). Due to the monthly monitoring of production costs on the farms, Equation 1 was applied, thus allowing the formulation of the feedlot cattle production cost index – ICBC (Table 8).

Table 8 - Feedlot cattle daily cost production index for the months of April-June 2017

Farm	April[4]	May	June
SPFa[1]	100.00	100.00	98.52
SPFl[2]	100.00	99.88	98.60
GOF[3]	100.00	96.21	90.87

[1] Representative average production capacity feedlot for the state of São Paulo (SP).
[2] Representative large-production capacity feedlot for SP.
[3] Representative feedlot for the state of Goiás.
[4] Base month.

Discussion

The cost allocation results of the proposed calculation model are in agreement with those proposed by Raineri et al. (2015a) and the experience reported by productive chain agents. Costs were organized aiming at objectivity to enable understanding, comparison, and decision-making, without, however, neglecting other items.

The use of CSF (Young, 1958; Powers, 1987) allowed a more accurate classification of items currently variable, which exist independently of production. The disaggregation of these cost items, according to Homme (1953), allows the estimate of typical management situations more accurately.

Regarding labor costs, allocation in this item depends on considerations of who makes the analysis. For example, while Raineri et al. (2015a) considered them to be fixed operational costs, Silva et al. (2014) classified them as variable costs. In this study, however, labor costs were fixed, as a short-term economic analysis was considered. In addition, the model contemplates the use of temporary labor, which is allocated in variable costs.

Fixed costs attributed to the construction of the animal feed factory, shed, and other facilities considered half of the square meter (m^2) value of the industrial warehouse cost index (GI); for the construction of houses and offices, the total m^2 value of a state-subsidized home (RP1Q) was used. These indexes have been published in the economic monthly CUB (Basic Unit Cost) bulletin by the Sindicato da Indústria da Construção Civil no Estado de São Paulo (SINDUSCON-SP, 2012). Thus, this information was used to update monthly index costs; this bulletin was also used by Raineri et al. (2015a) upon carrying out similar attributions to calculate the cost of buildings in Brazilian sheep farming.

Asset depreciation is a fixed cost item and corresponds to the financial reserve necessary to acquire assets of the same characteristics when their useful life comes to an end, thus avoiding enterprise decapitalization. Determining the ideal or more appropriate time for productive asset depreciation is something that raises questions among farmers. Thus, a standard recommendation was made (Table 4) based on research data obtained from feedlot farmers by using the weighted survey method between data practiced by the Receita Federal Brasileira (Secretaria da Receita Federal, 2017) and previous research experience obtained by those involved in the study.

Difficulties in determining depreciation causes some studies to take only variable costs in consideration – or part of these – as is the case of studies by Herrington and Tonsor (2013) and Retallick et al. (2013). The calculation model developed was characterized as managerial rather than accounting. Thus, the user can adapt the reality of his production to the model and does not necessarily need to follow the norms established by the Receita Federal Brasileira.

The inadequate calculation of fixed costs by including only part of them may underestimate true results. Berthiaume et al. (2006), for instance, did not describe machinery depreciation, maintenance, and betterment costs in a comparative study of cattle finishing systems with or without growth promoters in Canada. Stackhouse et al. (2012) did not consider opportunity costs, fixed assets, and working capital in a study conducted in the USA. Failure to account for income factors, including land use remuneration, is also commonly observed in livestock research.

The remuneration of production factors has not been taken into account at times, since it depends on the profile of those who lead the activity or analysis. According to Knight (1928), factor remuneration is either associated to a dismissed opportunity or represents the best unchosen alternative. Therefore, it presupposes the occurrence of two or more viable alternatives in which the option for one alternative implies the abandonment or renunciation of that/those not chosen.

The opportunity cost of a given production factor in a company is not only the choice for the best internal alternative, but also the value of its most adequate use outside the company (Raineri et al., 2015b). Thus, the capital owner should include in the product cost the remuneration he would obtain if all his capital assets on land, when his own, or his working capital – monthly expenditures – were allocated to the second-best option.

The rate that remunerates production factors varies among researchers. In studies carried out by Berthiaume et al. (2006), Lopes et al. (2011), and Damasceno et al. (2012), the rates used were 6.5, 6, and 6% per year, respectively. These rates were lower than those used in the representative properties for the production cost calculation in this research. Factor income costs in this study, even with adjustments in cost allocation, were in agreement with those in studies by Lopes et al. (2011), Pacheco et al. (2014; 2015), which were 2.38, 3.25, and 4.40% of the total cost per year, respectively.

When COE, COT, and CT rates in this study were compared to those of Lopes et al. (2011), Pacheco et al. (2014; 2015), Silva et al. (2014), and Moreira et al. (2015) – all deflated to June 2017 for comparison purposes –, equivalent costs were identified among studies, except those of Pacheco et al. (2014) and Moreira et al. (2015).

Cost variations found by different authors are due to different methodologies used in the analyses. None of the studies published by the aforementioned authors highlights or specifies maintenance costs of capital assets used in the productive process. However, it was noted that maintenance costs are as relevant as depreciation costs (Table 7) and, therefore, cannot be disregarded.

In practice, the rates which feedlot farmers considered relevant were those that included all fixed cost items and part of variable cost items, such as the cattle daily cost (CDB) and daily operation costs (COPd). One of the advantages of using COPd is that it allows an overview of the economy of scale of production. Hanson (1964) stated that unit costs consistently decrease as the amount produced increases, until production unit size exceeds ideal levels, thus raising costs. In this study, such effect of economies of scale of production is described in Table 7.

In contrast, cattle daily cost is not directly related to the effect of economies of scale, and the most representative item is animal feed cost. There are several studies that have sought to minimize costs by including and mixing food ingredients and/or strategies (Stackhouse et al., 2012; Onyango, 2014; Pacheco et al., 2014; Silva et al., 2014; Salim et al., 2017). In the field, feedlot farmers have been guided by the same notion to minimize feed cost. Therefore, this study chose to use the food cost optimization tool.

The regular flexibilization of quantities consumed in the diets on representative farms allowed proceeding methodologically in the elaboration of the feedlot cattle production cost index by using the Konüs index (Konüs, 1939). According to Gameiro (2003), it was this author that characterized the utility function which, at the time, the consumer referred to, to minimize costs (or expenses) to achieve a certain level of usefulness in the face of price variations. This concept was applied to feedlot farmers, inasmuch as they seek to maximize profits by reducing costs, which in this case refers to food-related items.

This study is a step forward in relation to other livestock indexes available, such as those by Girotto and Santos Filho (2000), Carneiro et al. (2010), Miele et al., (2010), Raineri et al. (2015a), and CEPEA and CNA (2017) which, due to methodological limitations, used the Laspeyres index. The index proposed by this study gains relevance by incorporating theoretical aspects such as a change in the amount of monthly feed intake, which consequently results in more adequate indexes when compared with other available methods as demonstrated by Sartorello (2016). The index is also a response to the demand and expectations of feedlot farmers and industrial agents, who needed a useful tool to monitor the activity cost behavior.

Despite the validation and theoretical concepts on which the study was based, the costing method and the ICBC must be analyzed over time, so that they will continue representing the feedlot farmer reality. According to Miele et al. (2010), these technical indexes and parameters should be reviewed due to the productive activity constant development. For this, the opinions and suggestions of the spreadsheet and index users are important and will provide subsidies for further adjustments and improvements.

Conclusions

The methodological proposal of allocating all costs through the application of the Economic Theory allowed the prognosis of results from data collected in the field. The inclusion of all production costs, together with opportunity costs, completed the analysis, which proved to be relevant.

Item cost disaggregation allowed the results obtained to be compared with those obtained by other studies on farming. This tool will also serve as a basis for the feedlot farmer to generate information to assist decision-making and identify production system bottlenecks.

The feedlot cattle production cost index proposed by the present study enabled the development of a research and extension project coordinated by the authors. The monthly release of a cost report can contribute to the sector organization, backing up market transparency and price disclosure, reducing the information gap. Thus, feedlot farmers will be able to regularly compare their economic results with those of the reference properties included in this study, whose costs will be updated monthly.

The calculation model and cost index can be applied to several feedlot cattle farmers in other regions of beef cattle relevance that the study has not covered.

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