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Beef Cattle Cycle in the State of Pará, Amazon, Brazil

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Abstract

The production and price behavior of the beef cattle market in the state of Pará, Brazilian Amazon, was evaluated with the objective of characterizing the dynamics of the market and guiding economic decisions made by agents in the beef cattle production chain. Time series of production and prices from the period 1995 to 2021 were analyzed using growth rates and the classical multiplicative method of time series. The cattle herd in Pará showed a growth rate of 4.54% per year from 1995 to 2021, and the slaughter of bovine females fluctuated throughout the historical series with the highest and lowest percentages in the years 2000 and 2011, respectively. There were three complete livestock cycles, differing in duration and amplitude. The average duration of the cycles was 7 years, with a shortening of the cycle over the period of study. Seasonal price indices are higher than 100, which is the annual average index, from September to January and lower than 100 from February to August. The highest price quotations for the arroba of fattened cattle coincide with the off-season period of beef cattle production, which is determined by the carrying capacity of pastures under the influence of weather conditions.

Keywords: cattle slaughter, price analysis, livestock cycle, price seasonality

1. Introduction

The livestock market is characterized by economic cycles in which the price of the arroba of cattle changes over time, with phases of rise and decline that are repeated with some regularity. It is important to mention that in Brazil, an arroba is equivalent to 14.688 kg, rounded up to 15 kg (Rozenberg, 2006), referring to the weight of the bovine carcass (bone-in meat, without by-products). This behavior is known as the livestock cycle (Rosen et al., 1994; Mundlak & Huang, 1996; Petry, 2015). The duration of the livestock cycle is mainly determined by the reproductive biology of the livestock and climatic factors (Mathews Junior et al., 1999; Griffith & Alford, 2002; Petry, 2019; Fliessbach & Ihle, 2020), in addition to economic factors and variations in prices paid by the meatpacking industry. Forecasts of these cycles guide the ranchers in decision making regarding the most favorable moment for the commercialization of the animals for slaughter.

Brazil is one of the main players in global agricultural production, having the largest commercial cattle herd in the world, at 218.2 million heads (Food and Agriculture Organization of the United Nations [FAO, 2020]. In regional terms, 34.58% of the herd is concentrated in the Midwest, 24.03% in the north, 17.16% in the southeast, 13.11% in the northeast, and 11.11% in the south (Brazilian Institute of Geography and Statistics [IBGE], 2022).

Among the states in the northern region of Brazil, the state of Pará has the second largest number of cattle, ranking third in Brazil with a herd of 23.9 million heads, behind Mato Grosso with 32.4 million, and Goiás with 24.3 million in 2021 (IBGE 2022). These cattle graze on natural and cultivated pastures, which are the main form of land use (Almeida et al., 2016), mainly in the southeast and south-west regions of Pará.

Beef production involves the biological phases of breeding, growing and fattening (Malafaia,

2013) and the combination of production factors such as natural resources, capital and labor, illustrating the importance of management in livestock systems production. The price of fattened cattle categories is determined by several factors, such as genetic quality, batch size, nutritional management adopted, distance from the property to the consumer market, and the market structure of the cattle meatpacking industry. In addition, the price of fattened cattle commercialized throughout the year, the expectation of future price quotations, and the variation in the stock of bovine females influence the value of other animal categories, mainly lean cattle and weaning calves (Sachs & Pinatti, 2007).

As an example, if future prices are expected to decline, the rancher will increase the number of bovine females sent for slaughter in order to minimize future losses and cover their production costs. As the supply of animals for slaughter increases, the downward trend in prices is accentuated in the short term (Neves & Couto, 1999; Santos et al., 2019a). Such movement is reflected in the medium and long term, leading to a period of scarcity that compromises the supply of animals for replacement, due to the slaughter of females. Consequently, price quotations will increase, generating expectations of a rise in future prices.

When high prices are forecast, ranchers begin retaining dams and calves, further reducing the supply of animals for slaughter and further reinforcing the upward trend in prices. However, this scenario will lead to an excess of animals for slaughter in the future, generating a decline in prices, that is, the downward phase of the price cycle (Gaio et al., 2005). In this way, a new phase of falling prices begins, historically lasting approximately 6 to 9 years in Brazil (Wolf et al., 2019).

Beef cattle also present short-term seasonal variations, within the same year, due to the seasonality of forage production (Fafchamps & Gavian, 1997). This seasonality influences the availability of cattle for fattening or their sale, which would reduce the number of animals grazing the pasture and thus reduce the operating costs of production; such variations will in turn influence the supply of animals available for the meatpacking industry. Thus, fattened cattle price quotations tend to decrease in the period of abundant forage and rise during forage shortages (Toledo & Santiago, 1984; Sousa, 2005; Harris et al., 2020). This is because livestock production is an open-air activity (Bragança & Bueno, 2010; Ferraz & Felício, 2010; Wedekin, 2017), making both livestock production and the revenue from the activity unstable over time.

Fattened cattle price variation is determined by the interaction between supply and demand, which influences prices depending on the amount of a given consumer good available in a given period as opposed to market demand (Barkley, 2019). As well as factors related to consumers, the price of more immediate substitutes such as chicken and pork meat (Mintert et al., 2001; Ramos et al., 2017) and macroeconomic variables such as inflation, income (Kamienski, 2006; Isaac & Souza, 2010), interest rates and exchange rates (Isaac & Souza, 2010), also directly affect beef demand.

Given that many factors influence the prices of fattened cattle and the agents involved in the production chain, it is essential to understand the livestock cycle and price variations. The

meat market is competitive, and producers do not have the power to set prices, but only receive market signals through the meatpacking industry. However, if the rancher understood pricing through the analysis and forecasting of price cycles, he would be able to anticipate and react to price movements, in terms of choosing the most favorable moment for retention or supply of cattle for the meatpacking industry.

In this context, the objective of this study was to analyze the beef cattle production/price cycle in the state of Pará, Brazil, identifying, through the classic model of analysis of temporary series, the trend, cycles and seasonality of production and prices in the period from 1995 to 2021.

2. Materials and Methods

2.1 Area of Study and Data

The study area was the state of Pará (Figure 1) which has a territorial surface of 1.3 million km² distributed across 22 micro-regions and 144 municipalities, with an estimated population of 8.6 million inhabitants (IBGE, 2017). In the Amazon, Pará is the state in which cattle ranching is most prominent, with the third largest Brazilian cattle herd accounting for 10.20% of the total Brazilian herd (IBGE, 2022).

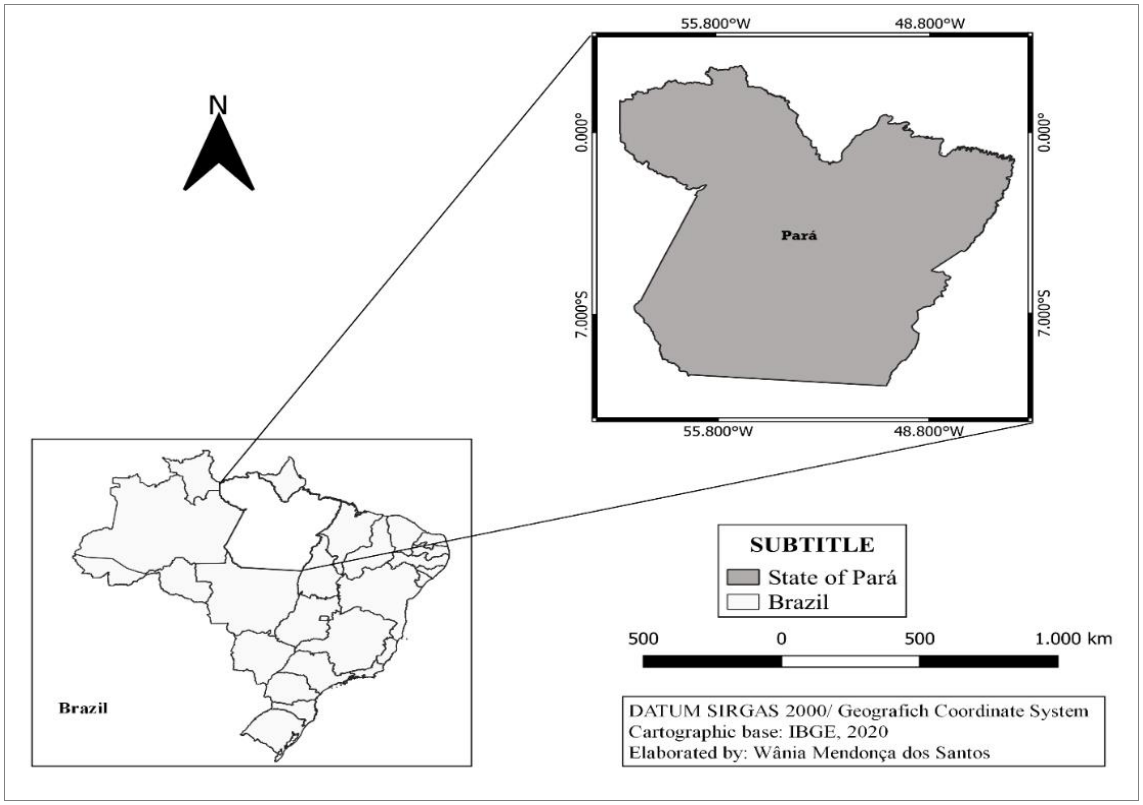

Figure 1. Location of the state of Pará in Brazil

Livestock farming is an activity of great economic importance in the state of Pará, being present in all micro-regions of the state and dominated by extensive farming systems (IBGE, 2022). Production systems are highly heterogeneous, given the different technological levels

present in different municipalities (Santos et al., 2017). Cultivated pastures are the main source of food for herds, with a total area of well-cultivated pasture of 11.5 million hectares, according to data from the 2017 Agricultural Census (IBGE, 2017).

The study was carried out using the analytical descriptive method, which involves a bibliographic survey and the collection and analysis of data from secondary sources. Information regarding changes in the size of the cattle herd (1995–2020) and the total number of cattle slaughtered under inspection (1997–2021) was extracted from official data sources such as the Bank of Statistical Tables stored in the IBGE Automatic Recovery System - SIDRA of the Brazilian Institute of Geography and Statistics (IBGE, 2022) in the state of Pará. Slaughter data were only available from 1997 onwards.

To analyze the behavior of the price of the arroba of fattened cattle, data were obtained from the Brazilian Livestock Yearbook [ANUALPEC] (2021). The data were the monthly averages of the nominal price of the arroba of the fattened cattle received by ranchers in the state of Pará from January 1995 to December 2021. The aim was to identify trends in the price of the arroba, seasonal variations and the occurrence of cyclical price variations.

2.2 Analytical Models

Behavior of cattle production

The slaughter rate of bovine females can be used as a basis for predicting the future price behavior of the arroba of cattle. It is also possible to analyze the price dynamics resulting from the interaction between cattle ranchers and beef agribusinesses, as cattle ranchers may retain cattle in a certain period of the year as a strategy to increase the price of the arroba of the cattle. However, the cattle ranching market is dynamic and changes can occur in the short term for several reasons, with no guarantee to the producer, and it could be costly for the producer to maintain their herd for a prolonged period. Thus, the percentage rates of slaughter and herd growth were obtained by linear regression using the semi-logarithmic model (Gujarati, 2004).

Price behavior

Within the livestock market, the price of fattened cattle is the main economic variable influencing production (Santos et al., 2019a; Carvalho & Felema, 2022). Knowledge of its behavioral dynamics can facilitate decision-making and contribute to greater competitiveness in the production chain. Three basic patterns can be identified in price behavior: trends, cycles and seasonality.

Trend analysis seeks to verify a general or persistent long-term, upward or downward pattern (Goodwin, 1999; Norwood & Lusk, 2008). According to Souza et al. (2006), when the objective is to verify the existence or not of a trend and its meaning, the regression line is an adequate functional form.

Cycles reflect repeated swings or upward or downward movements through four phases: peak, contraction (recession), bottom (depression), and expansion (recovery) (Goodwin, 1999; Norwood & Lusk, 2008). Calculation of the cyclical component makes it possible to analyze

the long-term price variation, allowing the identification of periods of high and low prices of the fattened cattle and the existence or not of regularities in price behavior (Viana et al., 2013).

Livestock production is seasonal, that is, concentrated in certain periods of the year, and the agricultural price reflects this attribute. In calculating seasonality, seasonal indices reflect the relatively regular periodic fluctuations that occur within each 12-months period, year after year (Goodwin, 1999; Norwood & Lusk, 2008).

In order to compare prices over time, deflation of historical nominal price data was performed, using the General Price Index – Internal Availability (IGP-DI) as the deflator, as calculated by Fundação Getúlio Vargas [FGV] (2020), and based on 100 in December of 2021, according to the following model:

$$RP_c = \frac{Bi}{Ip} * NP_c \quad (1)$$

where RPc: Real price of cattle, Bi: Base index, Ip: Index of each period, NPc: Nominal price of the cattle.

Statistical models to estimate the arroba price of fattened cattle have been used in many empirical studies, and can be used in time series (univariates), as in the current study. Statistical analysis of the data was based on the classic multiplicative method of time series, which assumes that a historical price series is linked by four basic components: trend, cycle, seasonality and random variations (Franses et al., 2014; Newbold et al., 2019).

Considering the original series of real prices for fattened cattle, the following mathematical model was used:

$$P_t = T_t \times C_t \times S_t \times E_t \quad (2)$$

where Pt: price per arroba of fattened cattle in month t, in R$/arroba, Tt: trend of the time series in period t, Ct: cyclical variation of the time series in period t, St: seasonal variation of the time series in period t, and Et: random variations.

The real price trend was estimated by regression, in which the monthly average real price was considered as the dependent variable and the time period in months was the independent variable. The following equation was estimated, according to Santos et al. (2019a):

$$\hat{Y}_{it} = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + e_t \quad (3)$$

where $\hat{Y}$it : estimated value of the fattened cattle price that reflects the trend in month i, in year t; t: trend variable, assuming the following values (T–0, for 1995, ..., T–24, for 2021); α_0: intercept of the function, represents the average price in the analyzed period; α: angular coefficients of the function; and e_t: random error term.

The trend model was estimated for beef cattle in Pará in order to compare the evolution of fattened cattle prices between the years 1995 to 2021. The cyclic index was calculated by dividing the 12-months centralized moving average by the value of the trend for each month. The seasonal component of the series was analyzed by the centralized moving average method for 12 months and its fluctuations quantified using the standard deviation and the coefficient of variation. Thus, this method distributes or dilutes along the price series some random events that could affect the analysis (Santos et al., 2019a).

Seasonal variations of a time series are short-term fluctuations, which always occur within the year, and which are systematically repeated year after year. To obtain the seasonal indices, the methodology of Mendes & Padilha Júnior (2007) was followed, in which the General Seasonal Index (GSI) of each month was calculated through the relation of the values of the historical series and the respective moving averages, multiplying the values by 100. Then, the average indexes were calculated for each month of the year (SI) and for the average of 12 months. If the average was not equal to 100, the monthly indexes were corrected, given by (100/the Average Index). Finally, the standard deviations of each GSI were calculated, and then added and subtracted from the SI to obtain the Lower (LL-) and Upper (UL+) Limits.

3. Results and Discussion

3.1 Production Behavior

In the last 25 years (1995–2020), the cattle herd in Brazil has presented a growth rate of 1.34% per year; the north, midwest, northeast, southeast and south regions have had growth rates of 4.20%, 1.30%, 1.13%, 0.11%, and -0.05%, respectively. In relation to the percentage share of Brazilian regions in the total herd, in 1995, the positions were as follows: central-west (34.15%), southeast (24.03%), south (17.16%), northeast (14.37%), and north (11.90%). In 2004, the north took second position and, in 2020, these percentage shares were as follows: midwest (34.58%), north (23.09%), southeast (17.24%), northeast (13.11%), and south (11.11%) (IBGE, 2022).

In the same period, the cattle herd in the state of Pará increased by 4.54% per year, from 8.0 million heads in 1995, with a percentage participation of 5% in the national herd, to 22.3 million in 2020, with a 10.20% share in the national herd. One factor that boosted the growth of cattle ranching in the state of Pará was the displacement of cattle ranching from the southern and southeastern regions of Brazil, due to the appreciation of land in these regions, to the northern region. The motivation for this migration was, mainly, the low prices of land compared to the southern and southeastern regions, in addition to the climatic condition of the Amazon region, which has an abundant rainfall regime that benefits the pastures and reduces the need for food supplementation for cattle (Dias-Filho, 2012; Institute of Man and the Environment of the Amazon [IMAZON], 2015).

The state of Pará presented the third highest average annual growth rate of the cattle herd during the analyzed period, behind the states of Acre and Rondônia. Despite this position, Pará occupies second position in the ranking of cattle ranching in the Brazilian Amazon, behind the state of Mato Grosso (IBGE, 2022). Beef cattle ranching in the Amazon has been

boosted, mainly due to the expansion of the agricultural frontier, with the incorporation of new lands (Martinelli et al., 2010) destined to become pasture, supporting an increase in the cattle herd and in the gross value of livestock production (Santos et al., 2019b).

The growth of the cattle herd in Pará has largely been due to the increase in pasture area, combined with animal health control, in addition to public investments, such as the availability of rural credit (Santos et al., 2012; Freitas Junior & Barros, 2021; Santos et al., 2022a), which together have generated gains in livestock productivity. The intensification of livestock activity through the proper management of pastures, the recovery of already deforested areas and the use of genetic improvement, through project financing (Rodrigues & Silva, 2016), has also led to an increase in productivity, in addition to being a way of mitigating deforestation.

The growth of the cattle herd in the six mesoregions of the state of Pará is shown in Table 1. Those with the largest number of cattle are the southwestern and southeastern parts of the state. The southeastern mesoregion of the state of Pará produced more than 60% of all cattle herd of Pará in all the years analyzed, indicating the importance of this mesoregion for the livestock sector of Pará. Historically, the expansion of livestock production towards the Amazon began at the end of the 19th century, reaching the southeast of Pará, with the aim of making the region more productive, in addition to being a way to provide evidence of the practice of land grabbing, whereby lands were destined for the ruling classes (Mendes & Gomes Junior, 2021), the so-called vacant lands (Meiners-Mandujano & Alves, 2018).

Table 1. Herd growth in Pará mesoregions (1995–2020)

Mesoregion	1995		2005		2015		2020		
	Thousand head	%*	Thousand head	%*	Thousand head	%*	Thousand head	%*	Annual GGR**
Lower Amazon	691	8.6	1,063	5.9	1,253	6.2	1,447	6.5	3.6
Marajó	601	7.5	349	1.9	261	1.3	250	1.1	-3.1
Metropolitan of Belém	96	1.2	95	0.53	81	0.4	85	0.4	1.4
Northeast of Pará	797	9.9	1,313	7.3	1,338	6.6	1,432	6.4	2.9
Southwest of Pará	940	11.7	2,626	14.6	3,577	17.6	4,073	18.3	7.0
Southeast	4,933	61.2	12,614	69.8	13,763	67.9	14,979	67.3	4.7
State of Pará	8,058	100	18,064	100	20,272	100	22,267	100	_

Notes * Relative share of each mesoregion in the total herd in the state of Pará.
** Geometric growth rate (% per/year), for the period from 1995 to 2020.

The five municipalities with the largest herds in the state of Pará were São Félix do Xingu, Marabá, Novo Repartimento, and Cumaru do Norte, belonging to the southeast mesoregion of Pará. Much of the growth of the cattle herd in Pará is due to genetic improvement, improvements in pasture management, the low price of available land, favorable climatic conditions, stabilization of the economy (promoted by the Real Plan), as well as the increase in beef exports and live cattle from the state (Florindo et al., 2015). Furthermore, according to Santos et al. (2017), municipalities in the micro-regions of Conceição do Araguaia, Redenção,

Paragominas, and Parauapebas, belonging to the southeast mesoregion, have production systems with a higher technological level than the other micro-regions of Pará. It is worth noting that this dynamism has attracted the construction of more meatpackings in the state of Pará (Santos et al., 2018).

3.2 Price Behavior

The rancher is a price taker, both during the production process and in the commercialization process, as he is not able to define the prices of the inputs used in production, nor the prices of his animals during the slaughter and marketing of beef (Souza et al., 2012; Bolfe, 2018). Beef livestock producers operate in a competitive market, as there are a large number of producers with little or no differentiation of the final product (beef for slaughter). In addition, there is no restriction on the entry of new producers, making competition intense, which gives the meatpacking agribusinesses negotiation power over the producers (Meiners-Mandujano & Alves, 2018).

The variations in real prices of fattened cattle in the state of Pará show periods of high and low prices, corresponding to the periods of increase and decrease in the livestock cycles (Figure 2).

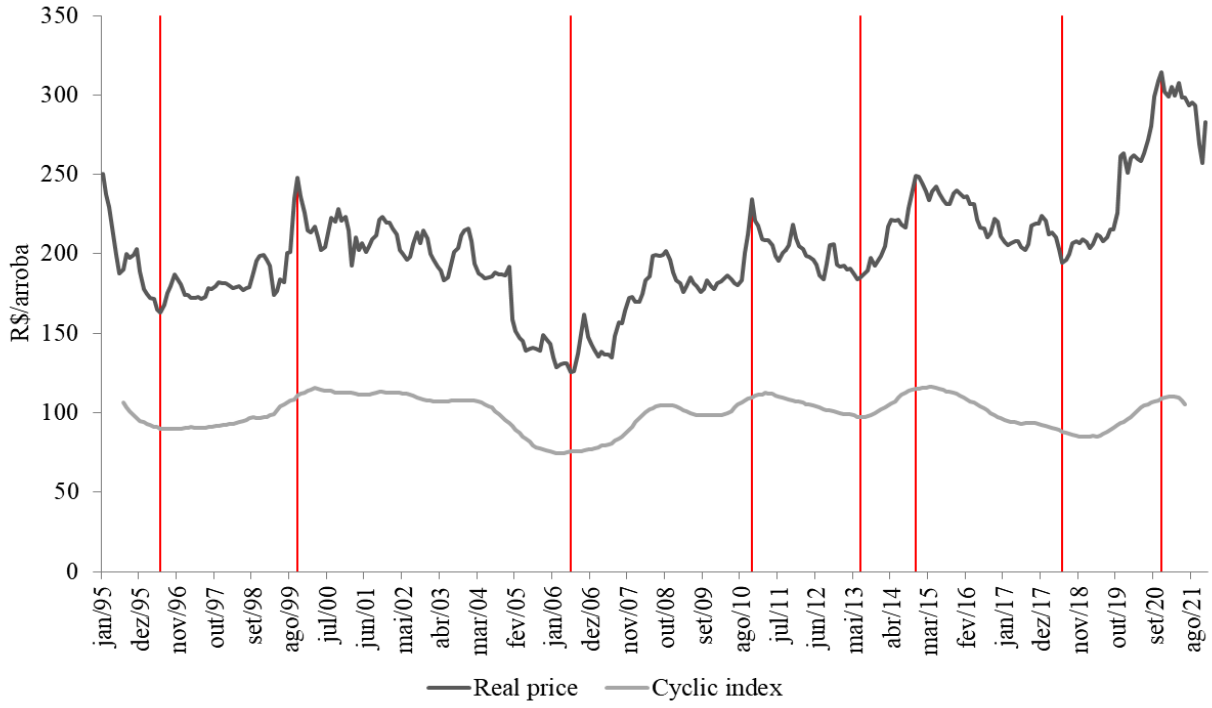

Figure 2. Behavior of fattened cattle price cycles in Pará (1995–2021)

Figure 2 shows three livestock cycles, represented by vertical lines, with different durations, amplitudes and symmetries. A livestock cycle is understood to be the period starting with the lowest price quotation in a period of descending quotations followed by ascending quotations and subsequent decline to a lower value, thus initiating the next cycle (Griffith & Alford, 2002). The shorter vertical lines represent the division between the lows and highs of prices within each cycle.

The first cycle, lasting approximately 10 years, for the period 1996–2006, presented an upswing lasting 3.4 years, and a downswing of 6.7 years, with prices fluctuating between a maximum of R$248.17 and minimum of R$128.79/arroba. Note that the highest real price drops in the analyzed historical series were observed in 2005 and 2006, with averages of R$ 145.16 and R$ 137.31/arroba. This behavior was related to the outbreak of foot-and-mouth disease in the state of Mato Grosso do Sul in 2005, which resulted in restrictions on exports to some European markets, in turn resulting in a greater concentration of meat in the domestic market with consequent devaluation of the price of the arroba of the fattened cattle.

The second cycle (2006–2013) lasted 7 years, with a high phase of 4.5 years, and a low phase of 2.9 years. The rise in prices up to November 2008 was due to the increase in the slaughter of bovine females in the period prior to 2007. As of November 2008, there was a fall in prices paid to the producer, coinciding with the international financial and economic crisis known as the subprime in the North American real estate market (Von Braun, 2008). This crisis negatively affected commodity prices in emerging countries, and foreign demand for Brazilian beef in the main importing countries such as Russia, Venezuela, Iran, Algeria, Egypt, and Hong Kong (Ministry of Economy, Industry, Foreign Trade and Services [MDIC], 2021), causing a surplus of production in the country. The Brazilian domestic market reduced the price of the arroba paid to the rancher with the consequent sending of bovine females for slaughter (Figure 3), further reinforcing the fall in prices. In this cycle, the downward phase in the first 2 years coincided with the effect of the crisis in the Eurozone in 2012 (Lopes et al., 2016), which affected Brazilian beef exports, resulting in a high volume of domestic sales in Brazil (Brazilian Agribusiness Foreign Trade Statistics [AGROSTAT], 2020).

The third cycle (2013–2018), with an approximate duration of 5 years (the shortest cycle duration of the analyzed historical series), presented a high phase of 1.7 years, and a low phase of 3.7 years, and prices ranged from R$187.54 at R$249.40/arroba. During this cycle, in 2017, corruption and fraudulent meats were discovered by the Brazilian Federal Police in an operation known worldwide as Operation Weak Flesh and Bullish, which affected the beef market in general with the suspension of slaughter due to embargoes on Brazilian beef and the distrust of international importers in relation to the quality of Brazilian meat. This generated an internal oversupply and a consequent fall in prices.

The current cycle began in June 2018 and is currently in the high phase, driven by increased exports to China, growth in domestic demand and the high dollar, placing Brazilian beef at a more competitive level in the international market. In the same year, China reached its largest share as a destination for Brazilian exports, accounting for 26.8% of the total. It should be noted that since 2012, China has become an important destination for exports of this commodity, since overturning the ban related to Bovine Spongiform Encephalopathy (Zia et al., 2019).

In 2019, there was a gradual increase in fattened cattle prices, becoming more evident from October onwards. This is due to the cattle off-season period, the fall in the slaughter of females and the additional demand from China for Brazilian beef, after the deficit of animal

protein in this country caused by the involvement of swineherds in an outbreak of African Swine Fever (ASF).

In 2020, with the atypical situation of the coronavirus (COVID-19) pandemic that shook many sectors of the global economy, Brazil experienced a decline of more than 4% in Brazilian GDP, affecting the population's income and changing the routine and consumption habits of Brazilians in general. Despite this, beef exports, mainly to China, Hong Kong (Special Administrative Region of China) and Egypt, increased enormously (MDIC, 2021). The increase in exports was related to the rise in prices in international markets (Fligenspan et al., 2015). Following the devaluation of the Brazilian currency against the US dollar, Brazilian beef has become more competitive in the international market, stimulating exports and generating a shortage of this commodity in the domestic market, raising the price of the arroba.

In addition, there was a drop in the supply of finished cattle for slaughter, caused by the large retention of females in the current livestock cycle for the production of replacement animals, stimulated by the high prices of calves. In 2021, the price of the arroba of the fattened cattle showed a downward trend in the short term until the month of November of the same year, with a subsequent increase in price.

The average monthly real prices of the current cycle fluctuated between R$196.49 and R$314.58/arroba, until December 2021. The average duration of the livestock cycle in the state of Pará in the analyzed period was approximately 7 years. According to Couto (1996) and Mendes & Padilha Junior (2007), the duration of the livestock cycle varies between 5 and 7 years, with an average duration of 4 years, during which production adapts to price conditions offered, with stocks of animals in the field being adjusted according to market demand.

According to historical data from time series of agricultural prices, a decline in real prices of products is expected as a result of technological advances and new production techniques implemented in the sector that reduce the age of slaughter and improve reproductive indices (Mendes & Padilha Junior, 2007; Wedekin, 2017). This behavior of falling prices of the arroba of cattle, in the long term, was not observed in the present study. The price of cattle can vary more or less systematically over time, but may be affected further by other variables. Thus, trend estimation aims to identify the general long-term price movement.

The real prices paid to beef cattle producers in Pará, from January 1995 to December 2021, showed an upward trend, with the test of the angular coefficient of the regression equation proving the existence of this upward behavior of prices. In the analyzed period, there was a real increase of 40.29% in the value of the arroba of the cattle. The historical average value of the arroba price of fattened cattle in Pará, from January 1995 to December 2021, was R$ 201.81/arroba.

There are clear up and down swings in the prices of the arroba of fattened cattle. These variations are mainly due to changes in the quality of pastures and production efficiency (Lanfranco & Castaño, 2017). The price fluctuations that occur in the short term, that is,

intra-annual, are related to factors that affect the supply of the product, such as the climate, the quality and supply of pasture, prices of inputs, health, and animal welfare.

Long-term price fluctuations are caused by increases or decreases in the supply of animals for slaughter (Bragança & Bueno, 2010). The supply of bovine males tends to be relatively steady over the year whereas the supply of females tends to be concentrated in the first and last quarter of the year (Vaz et al., 2014). Therefore, the supply of females for slaughter is a major determining factor in the behavior of the livestock cycle. They can be destined for the production of calves, capital goods, or for slaughter, whereby they are transformed into raw material for the meatpacking industry/consumer goods.

The retention or slaughter of bovine females is determined by the current market situation and future prospects. The variation in the quantity of beef produced from the slaughter of females is an important driver of the price of fattened cattle (Wedekin, 2017) and in the domestic market, the behavior of prices paid for the arroba of fattened cattle is linked to the slaughter of the females (Santos et al., 2019a).

The evolution of prices and percentage of slaughter of bovine females in the analyzed period is shown in Figure 3.

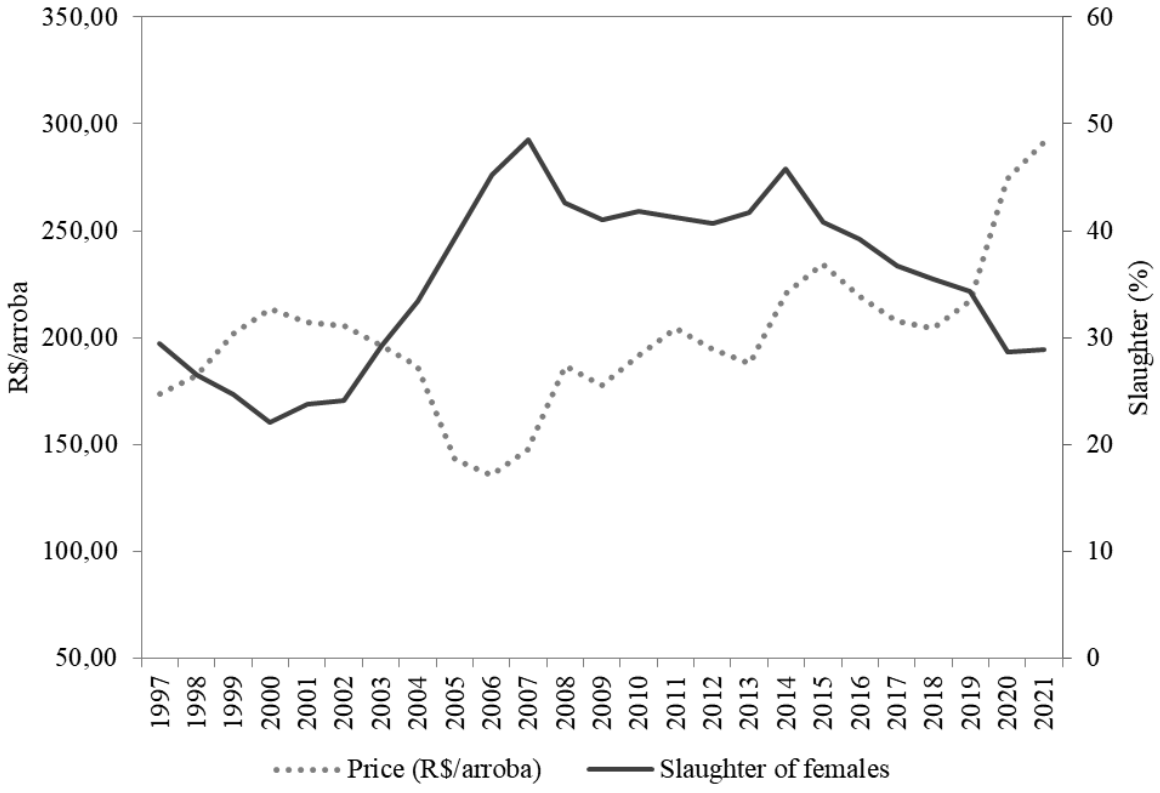

Figure 3. Growth in the price of fattened cattle and in the slaughter rate of females in relation to the total number of cattle in the state of Pará (1997–2021)

The lowest average annual prices were observed in 2005, 2006, and 2007, at R$145.16, R$137.31, and R$149.36/arroba, respectively, which marked the lowest points of the livestock cycle (Figure 2) in the analyzed period. In the same period, these low points

coincided with the highest slaughter rates of bovine females, at 34.20%, 45.23% and 48.49%, respectively. The highest percentage slaughter in the historical series from 1997 to 2021 was in 2007. Santos et al. (2019a) described a similar behavior for the livestock cycle in the Brazilian Amazon.

A fall in the price of fattened cattle induces the supply of bovine females for slaughter. The liquidity of the stock of females increases the supply of cattle at slaughter and causes prices to fall even further. This generates a low number of animals for replacement and termination, which becomes apparent 2 to 3 years later and leads to an increase in prices. Faced with rising prices, ranchers tend to retain females for calf production, to ensure a long-term supply of fattened cattle (Wolf et al., 2019). In this way, a new livestock cycle begins again.

Our analyses revealed the higher supply of females for slaughter during the first quarter of the year, a behavior that coincided with the culling period of females that did not become pregnant during the mating season, whether by natural or artificial means. It is important to mention that, in general, in Brazil, the breeding season for cattle in pasture-raising systems starts from October, period in which there is a greater offer of pastures and of good nutritional quality, which provides adequate conditions for the reestablishment of the reproductive activity of cattle. After carrying out a pregnancy diagnosis, it is possible to identify females that have reproductive failures, that is, those that have not become pregnant, and are then sent for slaughter.

As for the seasonal variations of fattened cattle prices, Table 2 shows that average seasonal indices below 100 occurred between the months of February and August, with increases above 100 from September to January. It can be inferred that the first period corresponds to the cattle harvest, when prices of the arroba fattened cattle are lower, and the second period refers to the off-season in the Brazilian Amazon region (Santos et al., 2019a), when prices are higher.

We observed that, in periods when there is usually a lower supply of cattle for slaughter (off-season), prices tended to increase. The highest prices of fattened cattle were in the interval between the months of September and December, while in the descending phase of prices (harvest), the lowest quotations were observed in the months of May, June, and July. The peak of prices below the average occurred in June (96.29%) and the peak of high prices occurred in November (105.48%), with an amplitude of price variation throughout the year of 9.19%.

Table 2. Seasonal Index (SI) of the arroba price of fattened cattle commercialized in Pará (1995–2021)

Months	Seasonal			Standard Deviation	CV (%)
	LL	ISAZ	UL		
January	97.83	100.54	103.25	2.71	2.69
February	98.74	101.85	95.63	3.11	3.15
March	95.27	98, 27	101.28	3.00	3.06
April	95.06	98.18	101.31	3.12	3.18
May	94.11	97.25	100.39	3.14	3.23
June	92.82	96.29	99 .76	3.47	3.60
July	94.11	96.89	99.67	2.78	2.87
August	95.83	98.65	101.46	2.81	2.85
September	97.68	101.38	105.09	3.70	3.65
October	100.23	104.64	109.04	4.41	4.21
November	101.85	105.48	109.10	3.62	3.44
December	100.19	103.63	107.06	3.44	3.32

Note: LL = Lower limit; UL = Upper limit.

Santos et al. (2019a) observed a similar behavior in a study in the Brazilian Amazon, with a sharp drop in prices in June and an increase in November. Lemes et al. (2017) also reported that the high price peak occurred in November in a study in Mato Grosso do Sul. Margarido et al. (1996) and Carvalho & Felema (2022) observed the same behavior in the state of São Paulo.

The coefficients of variation of the average monthly values of the arroba of the cattle showed greater variability in prices in the second half of the year, with a maximum variation of 4.21% in October, and a minimum of 2.69% in January. However, there was greater variation in price quotations in the period of high prices, and less in the period of low prices. This behavior is due to the seasonality of forage production, since extensive livestock farming is dominant in Brazil, that directly influences the supply of fattened cattle, thus defining the harvest and off-season periods.

The seasonality of forage production is a factor that represents one of the main causes of changes in the supply of food for cattle throughout the year, directly affecting the supply of these animals to the meatpacking industry.

According to our analysis of seasonal indices, in the period from September to January the rancher is likely to sell his product (fattened cattle) at a price above the annual average (100%

basis). The months from February to August present greater risk to the producer as the prices of fattened cattle may be much lower than those achieved historically. When the upper limit (UL) is above average, the commercialization of the arroba of the fattened cattle is favorable to the producer and unfavorable to the buyer (meatpacking industry); the opposite is also true. Historically, prices are 7.1 percentage points below average in June and 9.1% above the average for the year in November. This does not mean that in the following year, prices will definitely be the lowest and highest in June and November, respectively.

Our analysis is important for the economic agents involved in beef cattle production, as it suggests the most favorable moments of sale/purchase of the fattened cattle. For the producer, in particular, it guides decision making regarding the best period to offer the animals for slaughter, taking into account the months that present greater or lesser risks of obtaining the lowest prices or the highest prices.

The seasonal behavior of prices throughout the year is mostly a reflection of the type of system adopted in livestock farming. The state of Pará has a predominantly extensive system that depends on weather conditions. As a result, beef cattle prices in the first half of the year are lower than those in the second half of the year. A similar price behavior was found by Viana et al. (2013), Lemes et al. (2017), Santos et al. (2019a), and Santos et al. (2022b) in beef cattle in the states of Paraná and Mato Grosso do Sul, in the Brazilian Amazon, and in the state of Rondônia.

4. Conclusions

Our analyses revealed an upward trend in fattened cattle price quotations from January 1995 to December 2021. Annual seasonality was observed in prices, with a reduction in prices in the first half and an increase in the second half of the year, corresponding to the fattened cattle harvest and off-season, respectively.

The existence of a long-term cyclical period in quotations was found, with an average duration of 7 years, which can be attributed to different internal and external factors that result in price variations and their long-term durations.

Our study provides useful information capable of supporting decisions made by the different agents in the livestock production chain. In addition, it contributes to the understanding of the dynamics of this important agricultural market in Pará, the competitiveness of which has helped position Brazil among the main producers and exporters of beef in the world.

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References

AGROSTAT, Brazilian Agribusiness Foreign Trade Statistics (2020). Available from https://indicadores.agricultura.gov.br/agrostat/index.htm

Almeida, C. A., Coutinho, A. C., Esquerdo, J. C. D. M., Adami, M., Venturieri, A., Diniz, C. G., ... & Gomes, A. R. (2016). High spatial resolution land use and land cover mapping of the Brazilian legal Amazon in 2008 using Landsat-5/TM and MODIS data. *Acta Amazonica*, *46*(3), 291-302. https://doi.org/10.1590/1809-4392201505504

ANUALPEC, Brazilian Livestock Yearbook – ANUALPEC (2021). Instituto FNP, AGRA FNP Pesquisas LTDA, São Paulo, SP.

Barkley, A. (2019). *The economics of food and agricultural markets*. Manhattan, NY: New Praire Press.

Bolfe, L. E. (2018). *Visão 2030: O futuro da agricultura brasileira* (Coord.). Brasília, DF: Embrapa.

Bragança, R. C., & Bueno, N. P. (2010). O Ciclo pecuário no Brasil: Uma análise usando a metodologia da dinâmica de sistemas. *Revista de Economia e Agronegócio*, *8*, 199-220. https://doi.org/10.25070/rea.v8i2.166

Carvalho, M. L. P. D., & Felema, J. (2022). Projeção do preço da arroba do boi gordo no estado de São Paulo utilizando modelos lineares dinâmicos. *Revista de Economia e Sociologia Rural, 60.* https://doi.org/10.1590/1806-9479.2021.249166

Couto, M. T. (1996). *Ciclos de preços na pecuária de corte*. Preços Agrícolas, Piracicaba, n. 118, p. 2-5.

Dias-Filho, M. B. (2012). *Desafios da produção animal em pastagens na fronteira agrícola brasileira.* Embrapa Amazônia Oriental 34p. (Documentos, 382).

Fafchamps, M., & Gavian, S. (1997). The determinants of livestock prices in Niger. *Journal of African Economies*, *6*(2), 255-295. https://doi.org/10.1093/oxfordjournals.jae.a020928

FAO, Food and Agriculture Organization of the United Nations - FAO. (2020). Available from https://www.fao.org/faostat/en/

Ferraz, J. B. S., & Felício, P. E. (2010). Production systems–An example from Brazil. *Meat science*, *84*(2), 238-243. https://doi.org/10.1016/j.meatsci.2009.06.006

FGV, Fundação Getúlio Vargas – FGV. (2020). Available from: http://fgvdados.fgv.br

Fliessbach, A., & Ihle, R. (2020). Cycles in cattle and hog prices in South America. The Australian *Journal of Agricultural and Resource Economics*, *64*, 1167-1183. https://doi.org/10.1111/1467-8489.12392

Fligenspan, F. B., Cunha, A. M., Lélis, M. T. C., & Lima, M. G. (2015). As exportações do Brasil nos anos 2000: evolução, market share e padrões de especialização a partir de distintas agregações setoriais. *Indicadores Econômicos FEE*, *42*(4), 41-56. https://revistas.planejamento.rs.gov.br/index.php/indicadores/article/view/3502/3539

Florindo, T. J., Medeiros, G. I. B., Costa, J. S., & Ruviaro, C. F. (2015). Competitividade dos principais países exportadores de carne bovina no período de 2002 a 2013. *Revista de Economia e Agronegócio, 12.* https://doi.org/10.25070/rea.v12i1,2,3.240

Franses, P., Dijk, D., & Opschoor, A. (2014). *Time Series Models for Business and Economic Forecasting* (2nd ed.). Cambridge, UK: Cambridge University Press.

Freitas Junior, A. M., & Barros, P. H. B. (2021). A expansão da pecuária para a Amazônia legal: externalidades espaciais, acesso ao mercado de crédito e intensificação do sistema produtivo. *Nova Economia, 31*, 303-333. https://doi.org/10.1590/0103-6351/5064

Gaio, L. E., Castro Junior, L. G., & Oliveira, A. R. (2005). Causalidade e elasticidade na transmissão de preço do boi gordo entre regiões do Brasil e a Bolsa de Mercadorias e Futuros (BM&F). *Organizações Rurais & Agroindustriais, 7*, 282-297. http://revista.dae.ufla.br/index.php/ora/article/view/187

Goodwin, J. W. (1999). *Agricultural Price Analysis and Forecasting.* New York, NY: Wiley John Wiley and Sons.

Griffith, G. R., & Alford, A. R. (2002). *The US Cattle Cycle and its Influence on the Australian Beef Industry*, Australasian Agribusiness Review, University of Melbourne, Department of Agriculture and Food Systems.

Gujarati, D. N. (2004). *Basic Econometrics* (4th ed.). NY: The McGraw-Hill.

Harris, P., Lanfranco. B., Lu, B., & Comber, A. (2020). Influence of geographical effects in hedonic pricing models for grass-fed cattle in Uruguay. *Agriculture, 10*(7), 299.

IBGE, Brazilian Institute of Geography and Statistics – IBGE. (2022). Municipal livestock research. Available from http://www.sidra.ibge.gov.br

IBGE, Brazilian Institute of Geography and Statistics - IBGE. Agricultural Census (2017). Available from https://sidra.ibge.gov.br/acervo#/S/CA/A/40/T/Q

IMAZON, Institute of Man and the Environment of the Amazon – IMAZON. (2015). Pecuária na Amazônia: Tendências e Implicações para a Conservação Ambiental. 2015. Available from https://imazon.org.br/pecuaria-na-amazonia-tendencias-e-implicacoes-para-a-conservacao-ambiental/

Isaac, F. I., & Souza, J. G. (2010). Efeitos da política cambial sobre as exportações de carne bovina brasileira. *Archivos de Zootecnia, 59*, 73-79. https://scielo.isciii.es/pdf/azoo/v59n225/art8.pdf

Kamienski, J. D. (2006). *The factors influencing the price of beef, an econometric study*. University of Northern Iowa. https://scholarworks.uni.edu/pst/22

Lanfranco, B. A., & Castaño, J. P. (2017). Hedonic Pricing of Grass-Fed Cattle in Uruguay: Effect of Regional Resource Endowments. *Rangeland ecology & management, 70*(5), 549-559. https://doi.org/10.1016/j.rama.2017.04.001

Lemes, L. H. B., Souza, C. C., Guidolin, D. G. F., Reis Neto, J. F., Dias, R. O., Faria, D. B., ... Vieira, A. B. (2017). Sazonalidade da pecuária de corte de Mato Grosso do Sul. *Informe Gepec, 21*(2), 164-181. https://doi.org/10.48075/igepec.v21i2.16966

Lopes, P. F., Costa, D. F., Melo Carvalho, F., & Castro Júnior, L. G. (2016). Desempenho econômico e financeiro das empresas brasileiras de capital aberto: um estudo das crises de 2008 e 2012. *Revista Universo Contábil, 12*(1), 105-121. https://proxy.furb.br/ojs/index.php/universocontabil/article/view/5143

Malafaia, G. C. (2013). *As interações entre os agentes da cadeia produtiva da pecuária de corte no Brasil: implicações para a sustentabilidade*. Campo Grande, MS: Embrapa Gado de Corte.

Margarido, M. A., Kato, H. T., Bueno, C. R. F., & Junior, E. C. (1996). Análise dos impactos das cotações do dólar paralelo e do índice pluviométrico sobre os preços do boi gordo no estado de São Paulo. *Revista Brasileira de Economia, 50*(2), 255-278. https://bibliotecadigital.fgv.br/ojs/index.php/rbe/article/view/667/8036

Martinelli, L. A., Naylor, R., Vitousek, P. M., & Moutinho, P. (2010). Agriculture in Brazil: impacts, costs, and opportunities for a sustainable future. *Current Opinion in Environmental Sustainability, 2*(5-6), 431-438. https://doi.org/10.1016/j.cosust.2010.09.008

Mathews Junior, K. H., Hahn, W. F., Nelson, K. E., Duewer, L. A., & Gustafson, R. A. (1999). *U.S. Beef Industry: Cattle Cycles, Price Spreads, and Packer Concentration, Market and Trade Economics Division.* Economics Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1874.

MDIC, Ministry of Economy, Industry, Foreign Trade and Services - MDIC. (2021). Available from http://comexstat.mdic.gov.br/pt/home

Meiners-Mandujano, R., & Alves, V. E. L. (2018). Disputas territoriales en la sabana tropical brasileña (cerrado): los campesinos agroextractivistas y el agronegócio en Maranhão y Tocantins. *Boletín de la Asociación de Geógrafos Españoles,* (76), 391-413. https://doi.org/10.21138/bage.2527

Mendes, E. C., & Gomes Junior, E. (2021). Movimento de expansão agropecuário: uma análise histórica do seu desenvolvimento na Região Sudeste paraense. *Revista Política e Planejamento Regional, 8*(1), 42-60.

Mendes, J. T., & Padilha Junior, J. B. (2007). *Agronegócio: uma abordagem econômica*. São Paulo, SP: Pearson Prentice Hall.

Mintert, J., Schroeder, T. C., & Marsh, T. (2001). *Factors affecting beef demand.* Kansas Agricultural Experiment Station Research Reports. https://doi.org/10.4148/2378-5977.1744

Mundlak, Y., & Huang, H. (1996). International comparisons of cattle cycles. *American Journal of Agricultural Economics, 78,* 855-868

Neves, E., & Couto, M. T. (1999). Confinamento de bovinos de corte: condicionantes econômicos e instrumentos de apoio à tomada de decisão. In Peixoto, A. M., Moura, J. C., & Faria, V. P. *Bovinocultura de corte: fundamentos da exploração racional* (3rd ed.). Piracicaba, SP: FEALQ.

Newbold, P., Carlson, W. L., & Thorne, B. M. (2019). *Statistics for business and economics*. (9th ed.). Pearson.

Norwood, F. B., & Lusk, J. L. (2008). *Agricultural Marketing and Price Analysis*. Upper Saddle River, NJ: Pearson Prentice Hall.

Petry, T. (2015). *Spotlight on Economics: The Cattle Cycle Revisited*. Agriculture Communication, North Dakota State University.

Petry, T. (2019). *Producing and marketing high-value calves.* Technical Bulletin. North Dakota State University Extension, NDSU, Fargo, ND.

Ramos, D. G. S., Oliveira, F., Freires, L., Neves Neto, J. T., & Braga, I. A. (2017). Cadeia Produtiva da Carne Bovina no Brasil. *Revista Interação Interdisciplinar, 1*(1), 229-244.

Rodrigues, M., & Silva, D. C. C. (2016). Crédito rural e produção agropecuária no Pará. *Revista de Administração e Negócios da Amazônia, 7*, 105-119. https://doi.org/10.18361/2176-8366/rara.v7n3p105-119

Rosen, S., Murphy, K. M., & Scheinkman, J. A. (1994). Cattle Cycles. *Journal of Political Economy, 102*, 468-492. https://www.jstor.org/stable/2138619

Rozenberg, I. M. (2006). *O sistema internacional de unidades-SI* (3th ed.). São Paulo, SP: Instituto Mauá de Tecnologia.

Sachs, R. C. C., & Pinatti, E. (2007). Análise do comportamento dos preços do boi gordo e do boi magro na pecuária de corte paulista, no período de 1995 a 2006. *Revista de Economia e Agronegócio, 5*, 329-351. https://doi.org/10.25070/rea.v5i3.108

Santos, M. A. S., Lourenço Júnior, J. B., Santana, A. C., Homma, A. K. O., Andrade, S. J. T., & Maciel, A. G. (2017). Caracterização do nível tecnológico da pecuária bovina na Amazônia Brasileira. *Revista de Ciências Agrárias Amazonian Journal of Agricultural and Environmental Sciences*, *60*(1), 103-111.

Santos, M. A. S., Lourenço Júnior, J. B., Santana, A. C., Homma, A. K. O., Martins, C. M., Andrade, S. J. T., & Silva, A. G. M. (2018). Quantitative analysis of the beef cattle industry in the state of Pará, Brazil. *Semina: Ciencias Agrarias, 39*, 747-756. https://doi.org/10.5433/1679-0359.2018v39n2p747

Santos, M. A. S., Lourenço Júnior, J. B., Santana, A. C., Homma, A. K. O., Martins, C. M., Rebello, F. K., ... & Silva, A. G. M. (2019a). Production behavior and prices of beef cattle in the Brazilian Amazon. *Semina:Ciencias Agrarias, 40*, 1639-1651. https://doi.org/10.5433/1679-0359.2019v40n4p1639

Santos, M. A. S., Rebello, F. K., & Santana, A. C. (2012). A política de crédito rural no Estado do Pará: distribuição espacial e concentração das aplicações no período 2000-2010. *Revista em Agronegócio e Meio Ambiente, 5*(3). https://doi.org/10.17765/2176-9168.2012v5n3p%25p

Santos, M. A. S., Santana, A. C., Homma, A. K. O., Bezerra, A. S., & Lourenço Júnior, J. B. (2019b). Economic efficiency of cattle production in the Brazilian Amazon. *International Journal of Food and Agricultural Economics, 7,* 293-301. https://doi.org/10.22004/ag.econ.296758

Santos, W. M., Costa, J. S., Santos, M. A. S., Rebello, F. K., Nery, M. M., Soares, B. C., & Loureiro, J. P. B. (2022b). Production and Price Cycles in Beef Cattle in Rondônia State, Brazilian Amazon, *Journal of Economics, Management and Trade, 28*(11), 7-18. https://doi.org/10.9734/jemt/2022/v28i1130456

Santos, W. M., Santos, M. A. S., Lopes, M. L. B., Martins, C. M., Soares, B. C., Loureiro, J. P. B., ... & Lourenço Júnior, J. B. (2022a). Socioeconomic, Environmental, and Institutional Determinants of Cattle Ranching in the State of Pará, Brazilian Amazon. *Journal of Agricultural Studies, 10*(3), 100-117. https://doi.org/10.5296/jas.v10i3.19758

Sousa, C. C. (2005). Evolução e sazonalidade dos preços e da relação de troca do boi gordo e do bezerro no estado de São Paulo. *Informações Econômicas, 3*(10), 32-41.

Souza, R. S., Viana, J. G. A., & Bortoli, A. (2006). Tendência histórica de preços pagos ao produtor na pecuária do Rio Grande do Sul, Brasil. *Ciência Rural, 36,* 1511-1517. https://doi.org/10.1590/S0103-84782006000500026

Souza, R. S., Wander, A. E., Cunha, C. A., & Medeiros, J. A. V. (2012) Competitividade dos principais produtos agropecuários do Brasil: vantagem comparativa. *Revista de Política Agrícola, 21,* 64-71. https://seer.sede.embrapa.br/index.php/RPA/article/view/97/71

Toledo, Y. I. M., & Santiago, M. M. D. (1984). Análise do comportamento de preços na pecuária bovina, Estado de São Paulo, 1970-83. *Informações Econômicas, 14,* 21-28.

Vaz, F. N., Pascoal, L. L., Pacheco, P. P., Vaz, R. Z., Vargas, F. V., Soccal, D. C., & Maysonnave, G. S. (2014). Fatness beef cattle purchase transaction study in a abattoir firm in the Rio Grande do Sul State. *American International Journal of Contemporary Research, 4*(9), 165-171. http://www.aijcrnet.com/journals/Vol_4_No_9_September_2014/19.pdf

Viana, J. G. A., Moraes, M. R. E., Dorneles, J. P., & Damboriarena, L. A. (2013). Avaliação do comportamento dos preços da pecuária de corte do Rio Grande do Sul no Período 2000-2011. *Revista em Agronegocio e Meio Ambiente, 8,* 523-542. https://doi.org/10.17765/2176-9168.2015v8n3p523-542

Von Braun, J. (2008). Food and financial crises: Implications for agriculture and the poor. *International Food Policy Research Institute, 20*. https://doi.org/10.2499/0896295346

Wedekin, I. (2017). *Economia da pecuária de corte: Fundamentos e o ciclo de preços* (1st ed.). São Paulo, SP: Wedekin Consultores.

Wolf, M. L., Borges, L. D., & Oliveira, T. E. (2019). Carne bovina: relações de preços. In Barcellos, J. O. J. et al. (Eds.), *Bovinocultura de corte: cadeia produtiva e sistemas de produção* (2nd ed.). Guaíba, RS: Agrolivros,

Zia, M., Hjort, J. H., & Valdes, C. (2019). *Brazil Once Again Becomes the World's Largest Beef Exporter, USDA Agricultural Projections to 2028*, Washington, D.C. https://www.ers.usda.gov/amber-waves/2019/july/brazil-once-again-becomes-the-world-s-largest-beef-exporter

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