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Factors Defining Prices of Finished Cattle in Mato Grosso Contrasted Within Brazil's Pricing Structure

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Abstract

Due to the socioeconomic importance of beef cattle production in Brazil, there are several studies that have been dedicated to the analysis of cattle price formation. The research herein introduces advances in the formulation of these prices by including logistics and industry concentration variables. We aimed to analyze the "prices paid" behavior for male cattle destined for slaughter in the state of Mato Grosso versus other Brazilian states and to evaluate the main factors that influence prices to producers. To this end, several Brazilian databases on price registration were analyzed using regression models. From the mid-1990s onwards, the price paid for cattle presented a scenario of more stable and less variable prices. In all Brazilian states, there was an alignment of prices with the Cepea Indicator, except in the Northeastern states. In Mato Grosso, the Cepea Indicator alone represented more than 90% of the cattle pricing phenomenon. Other factors that contributed to the formation of the price of live cattle in the state were: the distance from São Paulo state, the period of the year, the number of available cattle in the influence region, and slaughterhouse concentration. In the state of Mato Grosso, the Cepea Indicator showed greater discounts when compared to other Brazilian states; therefore, the use of indicators to assess the price paid for live cattle helps to reduce the asymmetry of information between farmers and industry.

Keywords: agricultural economics, beef cattle, livestock, price formation

1. Introduction

Prices are fundamental indicators of a market economy. They tend to signal the scarcity and availability of products and reflect the structure of the markets (Inoua & Smith, 2022). Competitive markets tend to have prices capable of covering the production agents' production costs and reducing economic profit margins, even tending to zero, when they

approach perfect competition. More concentrated markets can generate prices above when contrasted with the competitive price (when thinking about selling) or below (when thinking about buying). In the case of this study, the transaction in question is between cattle breeders offering cattle for slaughterhouses.

Despite the diversified supply of beef cattle, slaughterhouses have undergone a profound process of industrial concentration (Ermgassen et al., 2020; Moita & Golon, 2014), so that three main business groups account for 27% of the market composed of 521 companies in Brazil, with the largest company in the sector having 15% of the national market (establishment with state and federal inspection). This context brings a central theme to this production chain: the price paid for the cattle for slaughter. In addition, Brazil holds an expressive market in the beef cattle supply chain, having the largest commercial herd and beef exporter worldwide (Ermgassen et al., 2020). In this context, the State of Mato Grosso gains visibility for being the largest beef exporting state in Brazil and for having the largest numbers of head destined for beef production (Vale et al., 2019). Thus, the issue of the price paid to the Mato Grosso producer can influence the entire production chain of the sector in the state due to its economic importance, and it can influence the price of other animal categories and modes of commercialization, as most suppliers of cattle for slaughter also trade between farms (Malafaia et al., 2021; Carvalho et al., 2021; Ermgassen et al., 2020; Santos et al., 2019; Vale et al., 2019).

The price of finished cattle is defined by market conditions and, in effect, imposes different strategies on producers and the agroindustry processors to protect themselves from price volatilities (Martinez et al., 2021; Carvalho & Felema, 2021; Marquezin & Mattos, 2014). The market is characterized by being of the unregulated type, i.e., it is governed by the free market through the laws of supply and demand and for the most part the negotiations in the spot market, where immediate transactions are on a day-to-day basis between cattle producers and slaughterhouses (Carvalho & Felema, 2021; Martinez et al., 2021; Pascoal et al., 2011). There is a scarcity of research on this theme due to the complexity of the macroeconomic aspects involved in this production chain (Silva & Ferreira, 2016). Previous research had focused on using price forecasting based on the values of future contracts (Brester et al., 2022; Schoroeder et al., 2019; Amarante et al., 2018) or using price analysis according to seasonal or cyclical changes in Brazilian beef cattle (Santos et al., 2019; Pereira et al., 2018). Still, there is a gap in available detailed data on trade relations between slaughterhouses and producers in Brazil (Carvalho et al., 2021).

Given this, the objective of this study was to analyze the prices of live cattle destined to slaughterhouses in the State of Mato Grosso and Brazil at large and to evaluate the main factors that influence the price paid to the producer. For this, a statistical analysis was created of the price paid for finished cattle that entailed a range of Brazilian data sources, and for Mato Grosso, some variables were tested that can influence the price paid to the cattle producer.

1.1 Theoretical Foundation

Brazilian beef cattle production can be divided into four stages: i) inputs; ii) production

(cow-calf operation, breeding, and fattening); iii) processing industry (slaughterhouses); iv) services. The price quotation in "arrobas" (one "arroba" is equivalent to 15 kg of live weight and represented by "@") takes place between stages 2 and 3 (Shikida et al., 2016). Studies indicate that although the price of arroba involves stages 2 and 3 of the production cycle, its value directly impacts other segments of the chain, making the study of its variables relevant for understanding Brazilian beef cattle (Amarante et al., 2018; Mattos et al., 2009; Bacchi, 1999). The actions involved in pricing cattle in Brazil are considered unstable (Amarante et al., 2018). Prices can be influenced due to interferences such as variations in international demand and supply, seasonality, weather, and competition with other agricultural commodities (Payne et al., 2019). These factors lead the formation of prices to have irregular, cyclical, and seasonal characteristics (Carvalho & Felema, 2021).

Several factors have been related to pricing of feeder cattle, among them, the cattle's expected price, inputs price, live weight of animals, herd size, sanitary conditions, carcass quality, and market conditions (Schroeder et al., 2018; Harborth et al., 2010). In a study in the United States that evaluated feeder cattle prices, the day of the week the negotiation took place, the sales volume, classification, and average weight were the main factors of change in the price paid in cash (Boyer et al., 2022). This was also observed in the analysis of factors that affect the steer-heifer price, emphasizing that weight significantly alters the price paid in breeding categories (Halich & Burdine, 2014). The price of feed inputs has been negatively correlated with feeder cattle prices (Bina et al., 2022). In addition, factors such as seasonality have also been significant for the formation of prices for cattle and for feed inputs such as corn and soybeans (Bina et al., 2022; Burdine et al., 2014; Halich & Burdine, 2014).

Among the factors that can influence a market, a relevant aspect is the concentration through oligopolies, oligopsonies, or monopolies[1] present in the various sectors of agricultural production chain (Panagiotou & Stavrakoudis, 2017; Moita & Golon, 2014). Consolidation has allowed companies to impose significant price concessions on farmers and consumers, as few industries are involved in the processes of selling agricultural inputs and purchasing agricultural production (Woodall & Shannon, 2018). In Brazilian beef cattle, there is a clear trend towards verticalization and concentration of the slaughterhouses (Moita & Golon, 2014), especially in states with many cattle, such as Mato Grosso (Carvalho et al., 2021).

Since the mid-1990s, Brazilian beef cattle have undergone intense modernization in production and organization systems (Malafaia et al., 2021; Abrahao, 2020). The slaughterhouse sector has also undergone considerable changes (Moita & Golon, 2014). In addition to the global trend of consolidation, in Brazilian slaughterhouses there was also significant public funding (especially between 2006 and 2014) (Moita & Golon, 2014).

A study carried out by Urso (2007), which analyzed the concentration of the Brazilian slaughterhouses market using Information Theory, concluded that there is an influence of industry on acquisition cattle price. The study also developed a complimentary analysis of the structure of cattle price formation, having identified São Paulo as a price-forming region for all the country. Another central result of the study was the corroboration of the hypothesis that the slaughterhouses would have more information on the futures market than the other

agents.

Using the Herfindahl-Hirschman Index (IHH), the relationship between the slaughterhouses and farmers in the largest meat-producing regions in Brazil was evaluated (Amorim Neto, 2009). The study concluded that the industry was moderately concentrated in the states of Mato Grosso do Sul, Mato Grosso, and Goiás and highly concentrated in the states of São Paulo and Minas Gerais; however, the application of an econometric model to the logic of profit maximization by the companies (Schroeter's Model) did not present results that would allow the author to conclude that the slaughterhouses exercise market power in any of the regions surveyed.

2. Method

Data referring to the price of finished cattle, in carcass "arrobas" (one arroba equivalent to 15 kg of carcass), were collected in the following databases: "Indicador do Boi Gordo Cepea / B3" (Cepea); Agricultural Economics Institute (IEA) of the São Paulo State Department of Agriculture; Emater RS; Paraná State Department of Agriculture (SAA); Mato Grosso Institute of Agricultural Economics (Imea); National Supply Company (Conab). All prices were deflated by the IGP-DI (General Price Index – Internal Availability) and prepared by the Getúlio Vargas Foundation (FGV), for the month of December 2018, to eliminate the inflation effect.

The period of analysis was different between the states, due to the availability of data, which were divided into 6 categories: i) State of São Paulo (Cepea, Iea, Conab) period from January 1998 to April 2018; ii) Southern States (Paraná and the Rio Grande do Sul), (Cepea, Conab, Emater RS, Paraná State Department of Agriculture, SAA) period from July 1997 to July 2018; iii) the Southeastern States except for São Paulo (Espírito Santo and Minas Gerais), (Cepea, Conab) period from December 2004 to December 2018; iv) Midwestern States (Goiás, Mato Grosso, and Mato Grosso do Sul), (Cepea, Conab, Imea) period from May 2005 to November 2018; v) Northeastern States (Ceará, Alagoas, Bahia, Pernambuco, and Paraíba), (Cepea, Conab) period from October 2015 to December 2018; vi) Northern States (Tocantins, Pará, and Acre), (Cepea, Conab) period from October 2012 to October 2018. It was decided not to include 2019 prices because of the large Chinese demand because of the crisis in the domestic supply of meat through which the country has passed. Also, it was also decided not to include the years 2020 and 2021 because of the new coronavirus pandemic effect (Covid-19).

In all analyses, the Cepea Indicator was included as a basis for comparison. This choice is because the indicator is widely publicized in the country and is recognized by the industry as the main reference for the finished cattle market in Brazil. To analyze the behavior of regional prices paid for cattle destined to slaughter, econometric and statistical tools were used. For the construction of these analyses, a linear regression was carried out considering as a variable dependent (Y) for each state's average prices obtained from the different sources consulted; the Cepea Indicator was allocated as an explanatory variable (X1) and in some states, where there was availability, a second explanatory variable was allocated (X2) as a dummy (binary type "0/1"), that represented the period considered for analysis after 2008.

The year 2008 was chosen because it is the period immediately after the merger of companies, public financing for the sector, and the expressive growth of three companies in the cattle slaughter sector, indicating a market concentration (indicated in the rest of this text as a post-period-concentration). The inclusion of this dummy variable is a first attempt to observe a change in pricing behavior. This variable was only included in the state models when the series was long enough, i.e., when it started at least before January 2007, in order to have at least 12 months before January 2008.

From the linear regression, the calculations determined were: i) the p-values of the parameters, ii) the probability of the estimated value being equal to zero, i.e., that there was no influence of the Cepea Indicator on the formation of the state price of the cattle, iii) the post-concentration effect (dummy variable =1), iv) coefficient of determination (R^2), which represents how much of the Cepea Indicator effect and the post-concentration effect (when applicable) explain the formation the price of live cattle in the respective state.

Because the data provided by the IMEA for the State of Mato Grosso were quite extensive and complete, in addition to the fact that the difference in the influence of the Cepea Indicator in the formation of the price of live cattle is more expressive than that observed in other states, an attempt was made to better understand the dynamics of price formation in this state. For this, monthly average price data was used for all municipalities in the state, from March 2010 to December 2018, deflated by the IGP-DI/FGV for December 2018. The methodology for regression analysis, coefficient of determination, and standard error were like those carried out at the state level. In addition to this, a more in-depth survey was created by adding the bovine herd in number of heads existing in each municipality (IBGE/Municipal Agricultural Research database), the mapping of the location and slaughtering capacity of slaughterhouses under federal inspection (SIF/MAPA) and state inspection (INDEA), and the distances to Piracicaba in the State of São Paulo (where Cepea is located), and these were also calculated using the displacement by the road network using GoogleMaps®.

In the State of Mato Grosso, an attempt was made to advance further in the possible effects of price formation in order to fill in the gaps that still exist in the analysis of the influence of the structure of the beef slaughterhouse industry on the beef market and on the strategy of companies acting in it. To this end, the monthly municipal price was defined as an independent variable, and the explanatory variables were: i) the Cepea Indicator; ii) the distance from the headquarters of the respective municipality to the city of Piracicaba in the interior of São Paulo, where Cepea is located; iii) a dummy variable (binary type “0/1”) to represent the months of harvest (1 for November to May) and off-season (0 for June to October); iv) the number of cattle herds in the municipality of Mato Grosso; v) the distance from the seat of the municipality to the seat of the nearest municipality that has a slaughterhouse; vi) the slaughtering capacity of the slaughterhouse(s) existing in the municipality closest to the one in question; vii) the number of slaughterhouses (state inspection and federal inspection) in the nearest municipality.

3. Results

Concerning the price paid for male cattle destined for slaughter from the mid-1990s onwards,

Brazilian beef cattle production experienced a scenario of much more stable prices with less variation in amplitude. In October 2019 there was a price peak due to greater demand from the Chinese market, which raised the prices of the arroba to R$ 220. Even with the price peak, this is below the peaks seen at the time of the two oil crises (between R$ 300 and R$ 350) and in the country's persistent macroeconomic crises of the 1980s and 1990s (when the prices exceeded R$ 350 per arroba). Between the two decades, 1997 to 2018, arroba prices fluctuated around R$ 100 and R$ 150, except for brief peaks that exceeded this upper limit, as in early 2011. Prices, therefore, have not only reduced but also fluctuate in narrower ranges of amplitude.

Other studies show that the oscillation in the price of finished cattle is linked to the law of supply and demand, which is present in daily negotiations for the acquisition of this raw material. The law of supply and demand influences values because of the amount of product that is available in each period versus market demand. In this sense, if the supply of live cattle on the market increases, the price will tend to decrease; if the opposite occurs, the price will tend to increase.

Most of the indicators analyzed in this study use the daily price survey among agents in the production chain (producers, slaughterhouses, and traders) in the region covered by the indicator as a methodology. The indicator is calculated using the weighted average of prices concerning the total proportion of animals slaughtered and/or studies of regional markets; therefore, when comparing the Cepea Indicator with the other price indicators paid for cattle at the state level, it is observed that the monthly average prices behave in a very approximate way. In all Brazilian states, this alignment with Cepea was evident, except for the states in the Northeast of the country (Table 1). In Mato Grosso, there were significant discounts on the Cepea Indicator to the other cattle price indicator, so a more specific analysis of prices in this state was carried out. For the Northeast region, the data is recent, which makes it difficult to make conclusions about the behavior of prices.

Table 1. The estimated effect of the Cepea Indicator on the price of live cattle practiced in Brazilian states, obtained by linear regression based on average monthly prices deflated for December 2018; p-values of the parameters; regression determination coefficient (R^2), and post-concentration effect (dummy variable = 1 for as of January 2008).

States	Constant		Cepea Indicator		Post-concentration effect	R^2	N. Observation
/Source of data	Value	p-value	Value[1]	p-value[2]	Value	Value[3]	
RS/ Emater	4.75	0.6128	0.9617	0.0000	Nd	67.2%	120
PR/ Conab	-2.29	0.5610	0.9835	0.0000	Nd	91.1%	139
PR/ SAA	-4.27	0.0536	0.9729	0.0000	2.89	95.5%	258
SP/ Conab	1.08	0.6299	0.9885	0.0000	Nd	97.0%	140

SP/ IEA	-2.98	0.0479	1.0046	0.0000	0.71	97.9%	252
MG/ Conab	2.06	0.5497	0.9261	0.0000	-3.02	92.4%	158
ES/ Conab	23.78	0.0000	0.6838	0.0000	10.26	80.2%	169
GO/ Conab	-3.87	0.0883	0.9688	0.0000	-2.83	97.0%	164
MS/ Conab	1.74	0.6506	0.9217	0.0000	Nd	90.6%	138
MT/ Conab	9.17	0.2402	0.8364	0.0000	Nd	82.2%	65
MT/ Imea	-4.64	0.2092	0.9097	0.0000	Nd	91.5%	132
BA/ Conab	59.66	0.0005	0.6342	0.0000	Nd	51.6%	37
AL/ Conab	91.98	0.0003	0.4765	0.0033	Nd	20.4%	36
PE/ Conab	24.78	0.1247	0.9134	0.0000	Nd	72.2%	31
PB/ Conab	135.05	0.0000	0.1862	0.0769	Nd	51.6%	37
CE/ Conab	29.57	0.0296	0.7434	0.0000	Nd	32.7%	141
TO/ Conab	5.85	0.3652	0.8533	0.0000	Nd	85.3%	36
PA/ Conab	74.91	0.0000	0.4219	0.0000	Nd	52.9%	36
AC/ Conab	153.57	0.0000	-0.1000	0.1454	Nd	3.10%	39

Note. R$/@: One @ = 15kg carcass weight. Values in Brazilian Reais. Nd= Not available.

[1] This parameter, when multiplied by the Cepea Indicator, results in the estimate of the price practiced in the respective state if its p-value indicates that the parameter differs from zero.

[2] It is the probability that the estimated value is equal to zero, i.e., there was no influence of the Cepea Indicator on the formation of the state price of live cattle. The lower its value the better the estimate.

[3] This coefficient represents the extent to which the effect of the Cepea Indicator and the post-concentration effect (when applicable) explain the formation of the price of live cattle in the respective state.

For the State of Mato Grosso, the price regressions comparing the estimated effect of the Cepea Indicator on the price of cattle in the municipalities of Mato Grosso obtained p-values

tending to nullity with coefficients of determination above 90%. Therefore, not only for the state but also when considering its municipal prices, there is the ratification that the Cepea Indicator alone accounts for more than 90% of the phenomenon of setting prices paid for cattle in Mato Grosso (Table 2).

Table 2. The estimated effect of the Cepea Indicator on the price of live cattle in Mato Grosso's municipalities, obtained by linear regression from monthly average prices between March 2010 and December 2018 and deflated for this last month; regression determination coefficient (R^2), standard error, and minimum and maximum effect values

Mato Grosso's municipalities	Cepea Indicator	Determination Coefficient	Standard Error	Indicator minus/plus standard error	
		R^2		Minimum	Maximum
Juruena	0.8033	91.2%	0.0242	0.7791	0.8275
Santa Rita do Trivelato	0.8139	89.7%	0.0268	0.7871	0.8407
Novo Mundo	0.8172	90.8%	0.0253	0.7919	0.8425
Brasnorte	0.8217	90.7%	0.0256	0.7961	0.8473
Nova Mutum	0.8237	89.2%	0.0279	0.7958	0.8516
Carlinda	0.8246	90.9%	0.0254	0.7992	0.8500
Nova Guarita	0.8248	91.2%	0.0250	0.7998	0.8498
Alta Floresta	0.8251	90.8%	0.0255	0.7996	0.8506
Lucas do Rio Verde	0.8257	90.2%	0.0265	0.7992	0.8522
Ipiranga do Norte	0.8259	91.2%	0.0249	0.8010	0.8508
Terra Nova do Norte	0.8259	91.3%	0.0249	0.8010	0.8508
Guarantã do Norte	0.8260	91.1%	0.0251	0.8009	0.8511
Paranaíta	0.8260	90.8%	0.0255	0.8005	0.8515
Peixoto de Azevedo	0.8260	91.2%	0.0250	0.8010	0.8510
Castanheira	0.8264	91.0%	0.0253	0.8011	0.8517
Marcelândia	0.8270	91.2%	0.0250	0.8020	0.8520
Matupá	0.8274	91.3%	0.0249	0.8025	0.8523
Nova Ubiratã	0.8277	90.9%	0.0252	0.8025	0.8529
Nova Maringá	0.8291	89.8%	0.0272	0.8019	0.8563
Nova Monte Verde	0.8291	91.5%	0.0246	0.8045	0.8537
Nova Canaã do Norte	0.8305	91,4%	0.0248	0.8057	0.8553
Juara	0.8308	91.0%	0.0255	0.8053	0.8563
Colíder	0.8311	91.3%	0.0250	0.8061	0.8561
Sorriso	0.8312	90.9%	0.0256	0.8056	0.8568
Porto dos Gaúchos	0.8314	90.9%	0.0256	0.8058	0.8570
Cotriguaçu	0.8324	92.0%	0.0239	0.0885	0.8563
Nova Santa Helena	0.8324	91.4%	0.0248	0.8076	0.8572
Itaúba	0.8325	91.5%	0.0247	0.8078	0.8572
União do Sul	0.8325	91.8%	0.0241	0.8084	0.8566
Itanhangá	0.8329	90.6%	0.0261	0.8068	0.8590
Apiacás	0.8329	91.2%	0.0252	0.8077	0.8581

Nova Bandeirantes	0.8330	91.2%	0.0252	0.8078	0.8582
Rondolândia	0.8331	92.0%	0.0240	0.8091	0.8571
Juína	0.8335	90.9%	0.0257	0.8078	0.8592
Tabaporã	0.8338	91.4%	0.0249	0.8089	0.8587
Colniza	0.8342	91.6%	0.0246	0.8096	0.8588
Tapurah	0.8345	90.3%	0.0267	0.8078	0.8612
Vera	0.8351	91.6%	0.0246	0.8105	0.8597
Sinop	0.8358	91.5%	0.0248	0.8110	0.8606
Novo Horizonte do Norte	0.8362	91.2%	0.0253	0.8109	0.8615
Santa Carmem	0.8368	91.6%	0.0274	0.8121	0.8615
Cláudia	0.8380	91.8%	0.0244	0.8136	0.8624
Feliz Natal	0.8409	91.9%	0.0244	0.8165	0.8653
Aripuanã	0.8435	91.6%	0.0249	0.8186	0.8684
São José do Rio Claro	0.8505	88.5%	0.0298	0.8207	0.8803
Gaúcha do Norte	0.8553	92.2%	0.0242	0.8311	0.8795
Glória D'Oeste	0.8577	91.2%	0.0260	0.8317	0.8837
Lambari D'Oeste	0.8580	91.7%	0.0251	0.8329	0.8831
Mirassol D'Oeste	0.8591	92.4%	0.0257	0.8334	0.8848
Figueirópolis D'Oeste	0.8597	91.0%	0.0263	0.8334	0.8860
Indiavaí	0.8597	91.0%	0.0263	0.8334	0.8860
Curvelândia	0.8598	91.7%	0.0252	0.8346	0.8850
Santa Terezinha	0.8601	91.4%	0.0257	0.8344	0.8858
Cáceres	0.8606	91.6%	0.0253	0.8353	0.8859
São José dos Quatro Marcos	0.8614	91.4%	0.0258	0.8356	0.8872
Vila Rica	0.8615	92.5%	0.0240	0.8375	0.8855
Reserva do Cabaçal	0.8616	91.4%	0.0258	0.8358	0.8874
Vale de São Domingos	0.8618	90.8%	0.0267	0.8351	0.8885
Rio Branco	0.8620	91.5%	0.0255	0.8365	0.8875
Jauru	0.8623	90.9%	0.0266	0.8357	0.8889
Porto Esperidião	0.8627	91.0%	0.0265	0.8362	0.8892
Salto do Céu	0.8635	91.6%	0.0255	0.8380	0.8890
Santa Cruz do Xingu	0.8640	93.0%	0.0230	0.8410	0.8870
Araputanga	0.8653	91.1%	0.0264	0.8389	0.8917
Cocalinho	0.8660	92.9%	0.0232	0.8428	0.8892
Porto Estrela	0.8672	91.9%	0.0250	0.8422	0.8922
Canabrava do Norte	0.8678	93.1%	0.0229	0.8449	0.8907
Tangará da Serra	0.8678	91.8%	0.0253	0.8425	0.8931
Porto Alegre do Norte	0.8687	93.1%	0.0230	0.8457	0.8917
Confresa	0.8689	93.3%	0.0227	0.8462	0.8916
Denise	0.8694	91.8%	0.0253	0.8441	0.8947
Nortelândia	0.8694	91.8%	0.0253	0.8441	0.8947
Nova Olímpia	0.8697	91.8%	0.0252	0.8445	0.8949
Barra do Bugres	0.8704	91.9%	0.0252	0.8452	0.8956

Poconé	0.8705	91.8%	0.0253	0.8452	0.8958
Pontes e Lacerda	0.8710	90.7%	0.0271	0.8439	0.8981
Santo Afonso	0.8710	91.9%	0.0251	0.8459	0.8961
Santo Antônio do Leste	0.8710	91.9%	0.0251	0.8459	0.8961
Nobres	0.8711	91.9%	0.0252	0.8459	0.8963
Nossa Senhora do Livramento	0.8715	92.1%	0.0249	0.8466	0.8964
Nova Marilândia	0.8715	91.8%	0.0254	0.8461	0.8969
Campinápolis	0.8716	93.0%	0.0233	0.8483	0.8949
Acorizal	0.8718	92.0%	0.0251	0.8467	0.8969
Alto Paraguai	0.8718	91.8%	0.0253	0.8465	0.8971
Arenápolis	0.8720	91.8%	0.0253	0.8467	0.8973
Diamantino	0.8726	91.9%	0.0253	0.8473	0.8979
Jangada	0.8728	92.0%	0.0250	0.8478	0.8978
Cuiabá	0.8737	92.2%	0.0248	0.8489	0.8985
Várzea Grande	0.8737	92.2%	0.0248	0.8489	0.8985
Água Boa	0.8738	92.8%	0.0237	0.8501	0.8975
Serra Nova Dourada	0.8740	93.3%	0.0228	0.8512	0.8968
Alto Boa Vista	0.8744	93.2%	0.0231	0.8513	0.8975
Novo Santo Antônio	0.8746	93.4%	0.0227	0.8519	0.8973
Nova Nazaré	0.8747	93.2%	0.0230	0.8517	0.8977
Rosário Oeste	0.8747	92.0%	0.0251	0.8496	0.8998
Nova Xavantina	0.8753	93.1%	0.0231	0.8522	0.8984
Bom Jesus do Araguaia	0.8754	93.5%	0.0224	0.8530	0.8978
Conquista D'Oeste	0.8756	91.5%	0.0259	0.8497	0.9015
Chapada dos Guimarães	0.8762	92.0%	0.0251	0.8511	0.9013
Canarana	0.8763	92.8%	0.0238	0.8525	0.9001
Santo Antônio do Leverger	0.8772	92.1%	0.0251	0.8521	0.9023
São José do Xingu	0.8773	93.5%	0.0226	0.8547	0.8999
Campo Verde	0.8789	91.6%	0.0259	0.8530	0.9048
Vila Bela da Santíssima Trindade	0.8791	91.4%	0.0263	0.8528	0.9054
Alto Taquari	0.8792	93.1%	0.0234	0.8558	0.9026
Nova Lacerda	0.8794	91.5%	0.0262	0.8532	0.9056
Campo Novo do Parecis	0.8799	91.5%	0.0262	0.8537	0.9061
Nova Brasilândia	0.8828	92.7%	0.0241	0.8587	0.9069
Barão de Melgaço	0.8836	91.9%	0.0255	0.8581	0.9091
São José do Povo	0.8849	92.3%	0.0246	0.8603	0.9095
Ribeirão Cascalheira	0.8877	93.6%	0.0226	0.8651	0.9103
Itiquira	0.8885	92.4%	0.0248	0.8637	0.9133
Paranatinga	0.8886	92.7%	0.0243	0.8643	0.9129
Luciára	0.8891	92.8%	0.0241	0.8650	0.9132
Alto Garças	0.8895	92.9%	0.0240	0.8655	0.9135
Sapezal	0.8895	91.6%	0.0263	0.8632	0.9158
Pedra Preta	0.8906	92.5%	0.0248	0.8658	0.9154

São Félix do Araguaia	0.8910	93.0%	0.0239	0.8671	0.9149
Juscimeira	0.8913	92.4%	0.0248	0.8665	0.9161
Jaciara	0.8917	92.5%	0.0247	0.8670	0.9164
São Pedro da Cipa	0.8923	92.6%	0.0246	0.8677	0.9169
Primavera do Leste	0.8924	92.8%	0.0242	0.8682	0.9166
Dom Aquino	0.8926	92.6%	0.0246	0.8680	0.9172
Rondonópolis	0.8928	92.7%	0.0245	0.8683	0.9173
Tesouro	0.8938	93.1%	0.0236	0.8702	0.9174
Campos de Júlio	0.8942	91.9%	0.0258	0.8684	0.9200
Poxoréo	0.8944	92.8%	0.0242	0.8702	0.9186
Alto Araguaia	0.8953	92.9%	0.0241	0.8712	0.9194
Comodoro	0.8958	91.9%	0.0259	0.8699	0.9217
Ponte Branca	0.8962	93.4%	0.0233	0.8729	0.9195
Ribeirãozinho	0.8965	93.3%	0.0234	0.8731	0.9199
Guiratinga	0.8975	92.6%	0.0247	0.8728	0.9222
Araguaiana	0.9153	93.4%	0.0238	0.8915	0.9391
General Carneiro	0.9159	93.1%	0.0242	0.8917	0.9401
Novo São Joaquim	0.9197	93.0%	0.0245	0.8952	0.9442
Pontal do Araguaia	0.9197	93.1%	0.0243	0.8954	0.9440
Barra do Garças	0.9198	93.1%	0.0243	0.8955	0.9441
Torixoréu	0.9237	93.2%	0.0243	0.8994	0.9480
Planalto da Serra	0.9651	90.3%	0.0300	0.9351	0.9951

Source of data: Imea; parameters estimated by the authors.

The results reinforce the discount pattern applied to the Cepea Indicator to purchase cattle in the State of Mato Grosso. Municipalities located in the northern region of the state suffer greater discounts, as was the case in Juruena, where the discount exceeded 20%. In municipalities in the Southwest of the State, which are closer to consumer markets (represented in this study as the State of São Paulo), discounts are lower, approaching 10%.

Although the statistical results to represent municipal prices as a function of the Cepea Indicator alone have already been quite adherent, we tried to go further in this study and include other possible price-forming effects. The analysis of the other factors that can influence the price of cattle in the municipalities of Mato Grosso (14,946 price observations) showed a coefficient of determination of the regression (R^2) of 91.44%, with p-values below 0.0001 (Table 3). The Cepea Indicator alone contributed with 86.75% of the final price of live cattle in Mato Grosso. The values and signs of the estimated parameters show that: i) the greater the distance to the state of São Paulo, the lower the prices to farmers in Mato Grosso; ii) in the seasonal period, prices are lower; iii) the higher the availability of cattle in the region, the lower the prices; iv) the longer the distance from the farm to the nearest slaughterhouse, the lower the prices; (v) the higher the processing capacity of the slaughterhouses in the region, the higher the prices; and vi) the higher the number of slaughterhouse in the region, the higher the prices paid to farmers. In summary, despite being logical (from the empirical point of view and the market experience) and significant (from the

point of view of statistical representativeness), all the observed influences are modest concerning the Cepea Indicator effect plus the logistic effect (distance to Sao Paulo).

Table 3. The estimated effect of variables that determine the price of live cattle practiced in the municipalities of Mato Grosso, obtained by linear regression from deflated monthly average prices between March 2010 and December 2018, deflated by the IGP-DI; p-values of parameters

Variables	Variable unit	Effect value	p-value of the effect[1]
Constant	-	8.871529	0.0000
Cepea Indicator	R$/@	0.867505	0.0000
Distance from Piracicaba	Kilometers	-0.003307	0.0000
Season = 1 (November to May) / Off season = 0 (June to October)	-	-0.632207	0.0000
Herd of cattle in the municipality	Number of heads	-0.000001	0.0000
Distance to the nearest slaughterhouse municipality	Kilometers	-0.007031	0.0000
Slaughter capacity of the nearest slaughterhouse	Number of head per year	0.000001	0.0001
Number of slaughterhouses in the municipality (SIF + SIE)	Number of slaughterhouses	0.246539	0.0000

Note. Data source: Municipal prices: IMEA; Cattle herd: PPM/IBGE, 2018; Distances: Google Maps; slaughter capacity: author'' estimate based on SIF and SIE data deflated by IGP-DI-FGV for December 2018. [1] It is the probability that the estimated value is equal to zero, i.e., that there was no influence of the respective variable on the formation of the municipal price of live cattle. The lower its value the better is the estimate. The regression determination coefficient (R^2) was equal to 91.44%; number of observations = 14,946 (141 municipalities x 106 months).

Prices in the live cattle market are influenced by seasonal, cyclical, and irregular factors. Seasonality is characterized by the availability of pastures, from January to July. The (multi-year) cycle, on the other hand, is approximately six years, which is an important component for defining the long-term evolution of prices (Medeiros et al., 2006; Bressan & Lima, 2002). In a study conducted in the State of Rio Grande do Sul, climatic factors such as "El niño" and "La niña" influenced the prices paid to live cattle more than economic variables, showing that in the state there is a dependence of cattle farming on climatic and external to the activity (Pereira et al., 2018); however, in this study, some phenomena, in addition to seasonality and climate, may have influenced the behavior of live cattle prices.

The food crises In 2007/2008 and 2010/2011 increased the prices of Brazilian beef due to the increased demand for food being greater than the capacity of the production chain to supply products. Factors such as the dollar exchange rate, speculation on commodity prices, demand for biofuels, international trade policies, climate problems in grain-producing regions, and increased logistical prices have been attributed to the increase in the price of Brazilian

commodities, including beef (Araujo et al., 2020).

The available literature explores the price dynamics of agricultural products traded internationally, and there is much less work on the behavior of prices in the local market, especially in developing countries such as Brazil (Carvalho & Felema, 2021; Mueller and Mueller, 2016; Araujo et al., 2020). For the live cattle price market, most national and international papers address prices in the futures market (Schroeder et al., 2019; Coffey et al., 2018; Geman et al., 2015; Marquezin and Mattos, 2014; Bressan and Lima, 2002). In an American study comparing spot market prices and live cattle futures market prices, it was concluded that they are co-dependent and that both markets are important for the pricing of live cattle (Schoeder et al., 2019). In addition, American data show that there is great variation in the factors that influence the price of live cattle in different regions of the United States and that there is a need to define hedgers to better understand the dynamics and conditions of each market (Coffey et al., 2018).

In a study conducted on finished cattle prices in Brazil that used dynamic linear models, it was observed that the variables with the highest correlation with the price paid to the farmer for the live cattle were: i) calf's price; ii) the exchange ratio between finished and unfinished cattle; iii) the amount of slaughtered cattle in the country, and iv) the import of beef by China (Carvalho & Felema, 2021). This demonstrates that the price paid to cattle for slaughter influences the entire production chain and further emphases the importance of measurement and studies on the price behavior of these commodities (Osaku, 2019).

In Brazil, there are many producers distributed throughout the national territory, while slaughterhouses are large and few and concentrate their plants in states with larger number of cattle and in São Paulo, the largest consumer region. This predisposes the structure of an oligopsony on the part of the industry and, therefore, has the potential to exert market power over the farmers (Moita and Golon, 2014). This fact was observed in this study where the largest producer state, Mato Grosso, and states with few distributions center plants (mainly in the Northeast region) obtained prices with discounts higher than those observed in other states. In other Brazilian states, the Cepea Indicator and the other indicators evaluated in this study show similar behavior, emphasizing that, regardless of the methodology for analysis, the price indicators of cattle for most Brazilian states correspond to reality.

The results also reveal other important aspects from the point of view of a competitive analysis. One of them is that there is no significant bonus for the ranchers who are closer to the slaughterhouses. Another important result is the influence of the slaughter capacity of the municipality with the closest slaughterhouse, which in turn is somehow associated with the scale of the slaughter plant and the number of plants. The greater the poll's slaughtering capacity, the higher were the prices paid, even though in absolute terms they were in the range of cents per arroba.

The State of Mato Grosso is an important supplier of cattle in Brazil, currently representing 13.9% of the national production of cattle (Vale et al., 2019). Thus, the results of this study showed that the Cepea Indicator alone responded to more than 80% of the state's live cattle price formation. In a study conducted by Pascoal et al. (2011), the formation of live cattle

prices in Brazil complied with the laws of supply and demand, although the authors noticed market powers concentrated in large slaughterhouses that were strategically located in producing regions had more power to set prices. An American study tested the hypothesis that the information provided by the USDA could impact the livestock production market and found that for the price of cattle, the USDA reports had little statistically significant impact, with the volatility of future cattle prices increasing less than twice in the evaluated tests, but the authors point out that this trend is recent in the market, and is probably due to the fact of the changes in the market structure with rapid consolidations and verticalization observed in the American industry (Isengildina-Massa et al., 2021). The results obtained in the American industry and the results of the present study may thus indicate a forecast of the evolution of prices paid by cattle in Brazil since there is a recent trend of consolidation and verticalization of the Brazilian slaughterhouses.

4. Conclusion

In most Brazilian states, live cattle price indicators obtained similar results. Thus, the use of live cattle price indicators helps to reduce the asymmetry of information between cattle producers and the slaughterhouses and probably contributed to reducing price volatility and amplitude.

In the State of Mato Grosso, the Cepea Indicator presented greater discounts when compared to other States. The Cepea Indicator and the distance from the municipality to the State of São Paulo together accounted for a large part of the effect on prices in Mato Grosso. The results also reinforce the standard of the discount applied to the Cepea Indicator to practice the purchase of live cattle in the state. Municipalities further north of the state suffer the greatest discounts and municipalities further south of the state suffer lower discounts due to the proximity of the consumer market. All other variables evaluated in the study were significant and presented expected logical effects, but in a smaller dimension than the first two variables.

The results of this study highlight the importance of conducting studies on the pricing of cattle for slaughter in Brazil and the influence that the slaughterhouses can have on these prices.

Notes

Note 1. Oligopoly: competition among few sellers; and Oligopsony: competition among few buyers (Rogers & Sexton, 1994). Monopoly: The dominance of a single supplier over the supply of a product or service that has no substitute (Panagiotou & Stavrakoudis, 2017).

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