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A STUDY ON THE HEDGING OF THE CALF AND THE HEGDE OF LIVE CATTLE IN FUTURES MARKET NEGOTIATIONS AT BM&F

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Abstract: The present study sought to analyze live cattle and calf hedge operations in futures contracts traded on the BM&F from January 2014 to December 2020. From the data and values of trades in contracts traded in this period, taken from the CEPEA/B3, it became possible to carry out some calculations of fundamental Variables for the analysis of the risk inherent to the performance of this type of operations and its effectiveness. It is concluded that hedging operations in futures markets are fundamental for risk management, but these are higher in calf operations compared to similar contracts of the same period for live cattle.
Keywords: futures market, hedge, live cattle, BM&F.

INTRODUCTION

It is notorious the difficulty of beef cattle producers in dealing with uncertain scenarios of price formation in the physical market, primarily in regions where cattle are produced and traded. There is, therefore, the need to protect against constant price fluctuations and for this purpose hedge operations in futures markets are used.

Agricultural derivatives contracts in Brazil are traded on the Commodities & Futures Exchange (well known by the acronym BM&F). These negotiations generate price information by providing a future indication of quotations and, therefore, allow better planning of livestock activity. The derivatives markets, in general, help to minimize the risks of discrepant variations in prices (SCHOUCHANA and PEROBELLI, 2000).

The main objective of risk management in agriculture is to manage potential losses in the negotiation process in the most diverse markets. Hedge operations, in turn, are a strategic price management mechanism that is intended to be achieved in environments of uncertainty in the formation of commercialization prices.

Beef cattle ranching in the country is an activity in which most of its agents are exposed to a high price risk, since the production system is mostly horizontal. Thus, the price of the calf is shown to be a key variable both for ranchers specialized in raising animals, as well as for agents involved in raising/fattening, rearing/fattening and fattening. Since, for these agents, the price of live cattle is not analyzed separately, and the decision-making about whether or not to sell is also made together. It is essential to evaluate the price of the calf since the replacement of the herd is a fundamental factor for the continuity of the activity. Therefore, price risk involves the exchange ratio between live cattle and calves (SCHOUCHANA AND CAFFAGNI, 2001).

In October 2002, BM&F began to offer agents in this system the possibility of negotiating contracts for calves, in addition to live cattle. With the possibility of carrying out protection operations against unwanted calf price movements, in addition to enabling the exchange ratio between live cattle and calf.

With this, the present work aims to analyze the hedging operations of calf and cattle in the futures market (BM&F), for the accomplishment of the study, data extracted from CEPEA were used, referring to all months of the years 2014, 2015, 2016, 2017, 2018, 2019 and 2020. We sought to assess how hedging of calf and live cattle can be effective for trading in futures markets through studies and calculations of some variables that allow the analysis.

MATERIAL AND METHODS

To carry out the present study, a survey of futures prices on the BM&F was carried out in the harvest and off-season, during all months from January 2014 to December 2020, with the primary objective of verifying the differences in the base variance (basis risk) in the period and make calculations that would allow

more in-depth analysis. Some data were also collected from physical quotations of states by CEPEA, and data from exports by SECEX, both extracted from CEPEA.

Based on the data collected, it became possible to calculate the general average basis and the basis risk for hedging operations for live cattle prices, according to the expiration dates of the BM&F live cattle futures contracts.

Hull (2003) defines the difference between the spot prices in the physical market (also known as spot) and those of the futures markets (those that are previously defined and traded for a certain date), as being the Value of the base, the author also highlights the need to assess the risk involved in this relationship in the final result of all hedge operations.

The Base Values for the period (month/year), general average base and base risk, were obtained from the equations and models highlighted below. Hull (2005) establishes the following equation:

$$b_1 = S_1 - F_1$$

Where:

b1 = Value of the base;

S1 = spot price (spot) of live cattle on the physical market;

F1 = futures price on the expiration date of BM&F futures contracts.

To calculate how the base risk differs between the live ox and the calf and between the regions considered, a regression model known as the Ordinary Least Squares Method (OMM) was used, where the base standard deviation in the week of maturity of the contract will be expressed in terms of binary variables. This model can be calculated using the following equation:

$$In(S_{BASIS\,ij}) = \alpha Tipo_i + \sum_{j=1}^{8} \beta_j L_j + u_{ij}$$

Where:

$In(S_{BASIS\,ij})$ = Naperian logarithm of the base standard deviation in the contract expiration week;

$\alpha Tipo_i$ = binary variable to represent whether the animal in question is a fattened ox or a calf. It will assume Value 0, when i refers to the base standard deviation for calf and Value 1, when i relates to the base standard deviation for ox;

L_j = binary variable that indicates the location. The Value will be 1 for a given region j which refers to the base standard deviation and 0 for the other regions;

u_{ij} = error term.

Then, the F Test was performed, which is an analysis of variance of the base, testing the null hypothesis that each variable has equality in relation to the variance of the base.

Continuing the study, we sought to transform the futures price series into a stationary series, since it is more effective when working with stationary time series in the construction of forecast models. For this, the ADF test was used on the first difference based on the following equation:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{\rho} \Delta Y_{t-1} + u_t$$

It then moved on to the next step, which was to find the optimal ratio using the methodology proposed by Myers & Thompson (1989), who describe that the optimal hedge ratios can be obtained by estimating the equation:

$$\Delta P_t = \alpha + \delta F_t + \sum_{i=1}^{p} \beta_i \Delta P_{t-1} + \Delta \gamma F_{t-1} + u_t$$

Where:

ΔP_t = spot price of the live ox (calf) in the first difference at the moment: t;

δ = optimal hedge ratio;

ΔF_t = Live cattle futures price on BM&F at

the first difference;

ΔP_{t-1} = spot price of the live ox (calf) in the first difference at the moment: t-i;

ΔF_{t-1} = Live cattle futures price on BM&F at the moment: t-1;

D_i = slope dummy variable to capture differences in hedge ratios between harvest and off-season periods;

u_t = error term.

It is important to highlight that, as the live cattle and calf price series became stationary only in the first difference, the regressions occurred with variations in spot and future prices. To differentiate the hedge ratios between the harvest and off-season periods, the equation was estimated:

$$\Delta P_t = \alpha + \delta F_t + \sum_{i=1}^{p} \beta_i \Delta P_{t-1} + \gamma \Delta F_{t-1} + \gamma D_i \Delta F_t + u_t$$

Where:

ΔP_t = spot price of the live ox (calf) in the first difference at the moment: t;

δ = optimal hedge ratio;

ΔF_t = Live cattle futures price on BM&F at the first difference;

ΔP_{t-1} = spot price of the live ox (calf) in the first difference at the moment: t-i;

ΔF_{t-1} = Live cattle futures price on BM&F at the moment: t-1;

D_i = slope dummy variable to capture differences in hedge ratios between harvest and off-season periods;

u_t = error term.

Finally, the effectiveness calculation was carried out, which in turn was performed through the equation:

$$E = 1 - \frac{Var(h)}{Var(p)}$$

Where:

Var(h) = variance of the revenue of a hedged portfolio in its optimal ratio;

Var(p) = revenue variance not involving hedging transaction.

Through the calculations, it became possible to create TABLEs and graphs that facilitate the visualization and analysis of the data, which provided the basis for this study.

To perform the tabulations and operations, the programs Rstudio and Power BI were used.

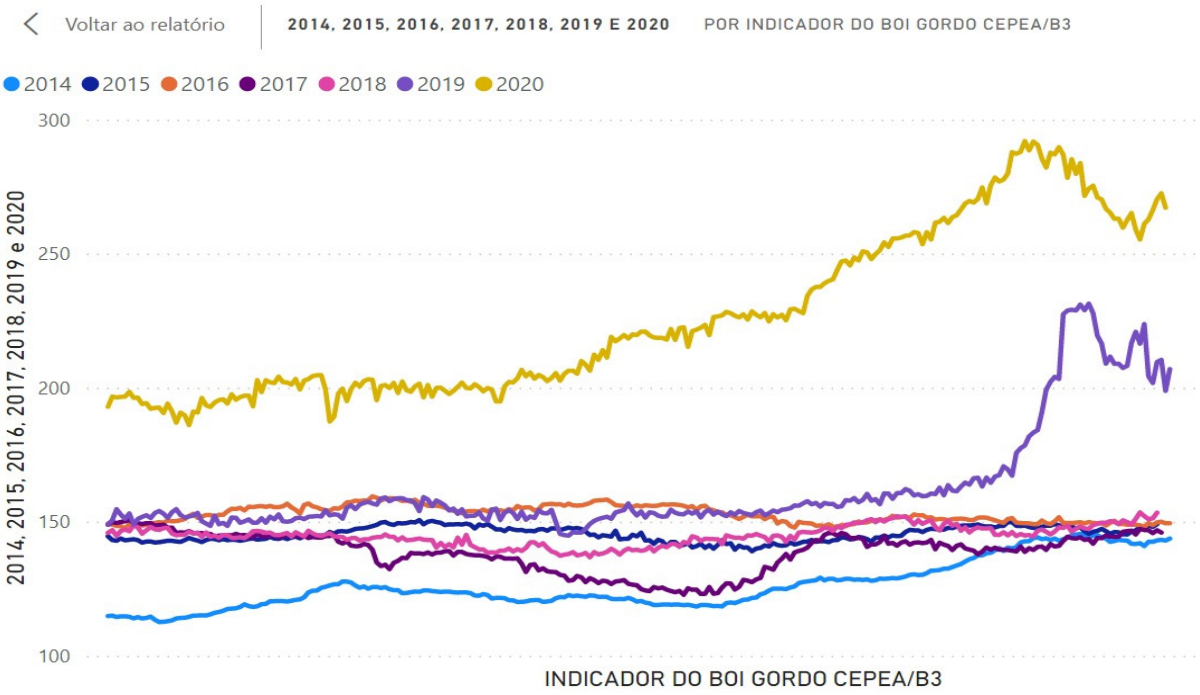
RESULTS AND DISCUSSION

To carry out this research, data were collected on negotiations and sales of calf and live cattle during the period from January 2014 to December 2020. This information was processed, and served as a subsidy for some calculations and tabulations which will be presented below.

The Live Cattle Indicator CEPEA/B3 is an indicator formed by a weighted daily average of prices per arroba in sight of live cattle, it is important to note that the average of the Indicators of the last five working days of each month is used to settle Live cattle futures contracts traded by B3. The first data collected and treated to carry out this work was the CEPEA/B3 live cattle indicator for the years 2014, 2015, 2016, 2017, 2018, 2019 and 2020, as can be seen below (Graphic 1).

From the data collected, it became possible to calculate and tabulate the average value of the base and risk of the base by region. This analysis is extremely important, since it represents the risk of carrying out the hedge of live cattle prices and the hedging of calf prices in the BM&F live cattle futures market. Through these procedures it is possible to observe the difference between these operations. It is important to note that some regions do not have animals and therefore Values were not assigned.

In TABLE 1, where the results of the average value of the base and the base risk associated with the hedging of live cattle and



GRAPHIC 1: Live cattle indicator:CEPEA/B3.

Source: Prepared by the author com dados extraídos de CEPEA/B3.[1]

Region	Average Base Value		Basis risk	
	Calf	Ox	Calf	Ox
Araçatuba	2.01	-0.07	340.53	12.00
Bauru/Marília	2.28	-0.06	7976.13	22.59
Cáceres	1.83	-0.15	1406.38	15.35
Colider	1.63	-0.13	819.20	36.48
Cuiabá	1.86	-0.09	34.03	23.54
Noroeste do Paraná	2.11	-0.11	774.40	17.38
Norte de Goiás		-0.05		
Norte de Minas	1.87	-0.14	720.10	0.74
Oeste da Bahia	5.94			
Presidente Prudente	1.97	-0.11	1513.04	13.89
Rio Grande do Sul	1.96	-0.30	915.20	3.08
Rondonópolis	1.88	-0.17	418.78	3.77
São José do Rio Preto	1.99	-0.09	19.34	7.61
Sorriso	2.07			
Triângulo Mineiro	2.59	-0.10	5302.32	17.07
Vale do Paraíba		-0.05		

TABLE 1 – Value médio e risco de base.

Source: Prepared by the author.

1. More tables on this topic, prepared by the author, can be found at: https://app.powerbi.com/view?r=e yJrIjoiNGZlN zZkODgtYThjMC00N GI0LTgxMTYtYT lmMWNlZTc0NzllIiwidCI6IjE0Y2JkNWE3LW VjOTQtNDZiYS1iMzE0LWNjMGZ jOTcyYTE2MSIsImMiOjh9

hedging of the calf are presented, it can be observed that the average value of the base of the calf is much higher in relation to the Live cattle values in all regions of analysis. It is also observed that the base risk in hedge operations is much higher than the risk associated with hedging live cattle.

Continuing the study, in order to verify how the base risk differs between the live cattle and the calf and between the analyzed regions, a regression model was estimated by the Ordinary Least Squares Method (MMQO), where the standard deviation of the based on the contract expiration week is expressed as a function of binary variables, reaching the following results:

Variables	Coefficients	t-statistic
Product	-6.034004	-25.106
Araçatuba	-0.007965	-0.031
Bauru Marília	0.072137	0.3
Cáceres	-0.103412	-0.406
Colíder	-0.219988	-0.915
Cuiabá	-0.0803	-0.315
Noroeste do Paraná	0.040583	0.174
Norte de Goiás	0	0
Norte de Minas	-0.076362	-0.3
Oeste da Bahia	1.083098	3.68
Presidente Prudente	-0.036026	-0.155
Rio Grande do Sul	-0.034662	-0.144
Rondonópolis	-0.073683	-0.317
São José do Rio Preto	-0.010521	-0.041
Sorriso	0.03129	0.106
Triângulo Mineiro	0.221685	0.972
Vale do Paraíba	0	0

TABLE 2 – Model results of MQO.

Source: Prepared by the author.

Subsequently, seeking to analyze whether the basis risk differs statistically between the regions studied, hypothesis tests were carried out on the variance of the basis of live cattle and calf in the weeks of expiration of the live cattle contract at the BM&F. For this, the "F" Test was used, where some combinations of Values corresponding to the base risk were tested, as can be seen in TABLE 3.

Only the product variable (animal) and the western region of Bahia proved to be significant. The model was shown to be significant as a whole, F-statistic: 56.25. The adjusted coefficient of determination R^2 explains 95.51% of the base variation.

Variables	F-statistic	p-Value
Product	1143.3725	2.00E-16
Araçatuba	0.0295	0.86406
Bauru Marília	0.7957	0.37562
Cáceres	1.0885	0.3006
Colider	5.4544	0.02257
Cuiabá	0.5906	0.44494
Noroeste do Paraná	0.1807	0.67217
Norte de Goiás	0.0123	0.91197
Norte de Minas	1.5835	0.21269
Oeste da Bahia	154.715	2.00E-16
Presidente Prudente	0.1406	0.70887
Rio Grande do Sul	2.7159	0.10411
Rondonópolis	3.7135	0.05828
São José do Rio Preto	3.0196	0.08693
Sorriso	0.492	0.4855
Triângulo Mineiro	2.9624	0.08991
Vale do Paraíba	0.1458	0.70377

TABLE 3 – Test: F

Source: Prepared by the author.

Continuing, the first unit root test was calculated: ADF test for the Future Price and Spot Price Variables, these are stationary in the first difference. To be stationary the t-statistic must be greater than the Value critical. The t-statistic is the ratio between the deviation of the estimated Value of a parameter from its hypothetical Value and its standard error. This methodology is used to test hypotheses

and determine whether to support or reject the null hypothesis. It is possible to observe through these analyzes that the series are non-stationary. These series were then subjected to transformations to analyze stationarity, using the Dickey-Fuller Augmented Test – ADF, to reach the desired result. The series were shown, according to the test, to be stationary in the first difference.

Tests:	t-statistic	Value – critical		
		1%	5%	10%
ADF (AIC)	-2.6697	-4.04	-3.45	-3.15

TABLE 4 – Level ADF unit root test for futures price.

Source: Prepared by the author.

Tests:	t-statistic	Value – critical		
		1%	5%	10%
ADF (AIC)	-6.0054	-4.04	-3.45	-3.15

TABLE 5 – ADF unit root test at first difference for futures price.

Source: Prepared by the author.

Tests:	t-statistic	Value – critical		
		1%	5%	10%
ADF (AIC)	-2.2601	-4.04	-3.45	-3.15

TABLE 6 – Level ADF Unit Root Test for Spot Price.

Source: Prepared by the author.

Tests:	t-statistic	Value – critical		
		1%	5%	10%
ADF (AIC)	-7.829	-4.04	-3.45	-3.15

TABLE 7 – ADF unit root test at first difference for spot price

Source: Prepared by the author.

The next step was to find the optimal reason for the methodology proposed by Myers & Thompson (1989), that is, to estimate the AR model, through the equations arranged in the methodology of this work.

The objective of estimating these two equations is to find the optimal hedge ratio for the live cattle and the calf. In the equations, the optimal ratio is represented by the coefficient that accompanies the future price.

Variables	Coefficients	t-Value	P Value
Constant	1.20396	0.226	0.82174
ΔP_{t-1}	-0.62554	-7.154	4.00E-10
ΔF_t	0.90149	2.4	0.01879
ΔF_{t-1}	1.13505	3.04	0.00322

TABLE 8 – Great reasons for fattened ox.

Source: Prepared by the author.

It is observed that the optimal hedge ratio is: 0.90149. All Variables are significant except the constant.

Variables	Coefficients	t Value	P Value
Constant	-14.1604	-1.577	0.118943
ΔP_{t-1}	-0.61786	-7.175	4.10E-10
ΔF_t	1.05805	1.792	0.077106
ΔF_{t-1}	1.46507	3.716	0.000385
D ΔF_t	0.18966	0.247	0.805421

TABLE 9 – Optimal ratio for live cattle (harvest and off-season).

Source: Prepared by the author.

In this case the optimal hedge ratio is: 1.05805. Significant variables, except constant and the harvest and off-season dummy.

Variables	Coefficients	t-Value	P Value
Constant	-4.2158	-0.145	0.88505
ΔP_{t-1}	-0.3874	-3.261	0.00165
ΔF_t	20.5151	11.812	< 2e-16
ΔF_{t-1}	8.1175	2.602	0.01109

TABLE 10 – Optimal reason for calf.

Source: Prepared by the author.

With respect to the calf, the optimal hedge ratio is: 20.5151. All Variables are significant except the constant.

Variables	Coefficients	t Value	P Value
Constant	75.60064	2.354	0.02115
ΔP_{t-1}	-0.49511	-4.964	4.13E-06
ΔF_t	7.17176	2.778	0.00689
ΔF_{t-1}	14.06369	5.142	2.06E-06
D ΔF_t	18.48221	5.967	7.19E-08

TABLE 11 – Optimal ratio for calf (harvest and off season).

Source: Prepared by the author.

With regard to the optimal ratio (for calf in season and off-season) the hedge is: 7.17176. All variables are significant.

Finally, the calculation of the effectiveness of the operation was carried out, which can be observed in the following TABLES:

overall effectiveness	Harvest effectiveness	Effectiveness between seasons
0.147613328	-0.254017019	0.267243573

TABLE 12 – Effectiveness for Calf.

Source: Prepared by the author.

overall effectiveness	Harvest effectiveness	Effectiveness between seasons
-0.0695066	-0.119136351	-0.03059089

TABLE 13 – Effectiveness for OX.

Source: Prepared by the author.

CONCLUSIONS

The trading of live cattle and calf futures contracts on the BM&F and the use of hedging tools are ways to manage risk with regard to unexpected price drops, but these operations can also mean losses in cases of price increases. and, therefore, before opting for this type of operation, it is important that the investor evaluates some variables and knows how this type of market behaves. The present study was a research that sought to evaluate live cattle and calf hedge operations in spot and futures markets. To carry out the research, data from January 2014 to December 2020 were used.

Live cattle contracts have been traded on the Brazilian Stock Exchange for many years, and calf contracts began to be traded on the BM&F as of October 2002 and, prior to this date, ranchers specialized in the stages of raising, rearing/fattening, rearing/fattening and fattening had as an alternative only the performance of cross hedge operations in the BM&F live cattle futures market, as a way of protecting themselves from adverse variations in calf prices.

In this study, the risk of carrying out hedge operations for both live cattle and calves was evaluated and compared. It was possible to conclude through this research that the calf hedge presented a base risk significantly higher than that seen in the live cattle hedge, however the average value of the calf base was also significantly higher. Through the regression model using the Ordinary Least Squares Method (MMQO), it was possible to observe that the base standard deviation in the contract maturity week is expressed as a function of binary variables, comparing the base risk of the calf and the live cattle, demonstrating that there is still a significant divergence between the underlying risks of the two operations.

With regard to the estimation of the optimal hedge ratio and hedge effectiveness, it must be noted that these are tools that aim to contribute to protection against the risks of price fluctuations in the sale of live cattle in the physical market, and it was observed that In terms of the first difference for spot price, the tool proved to be effective for both products (live cattle and calf).

With this, it is possible to conclude that the use of hedging tools (both for live cattle and for calves) is effective for risk management and the commercialization of futures contracts is an excellent alternative for ranchers. It is also added that, in the case of the calf, the low

risk is shown to be high in relation to the live cattle, which may be related to its recent entry into the portfolio of futures contracts traded on the BM&F, which makes the live cattle have more historical data and investor experience, which allows for more assertive and secure trading.

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