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Evaluation of the Future Price of Brazilian Commodities as a Predictor of the Price of the Spot Market

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Abstract

The present work seeks to bring empirical evidence on the efficiency of futures prices as predictors of spot market prices. For this, future and spot prices of live cattle, coffee, corn, soybeans, ethanol, gold and dollars traded in Brazil are considered. To compare the probability of occurrence with the event that actually happened, the score proposed by Brier in 1950 is used. It was observed that the spot and future price curves have the same trajectory and, considering the same date, have similar values. Despite this behavior, when calculating the scores, we found that the lowest was found for live cattle, 0.47, the highest for the dollar, with a value close to 1, and the other assets varied between 0.6 and 0.8. Scores of 1 denote worse predictive powers, it was noted that future prices are not good predictors for the assets considered. These results contribute to filling the gap in the financial literature that seeks to assess the efficiency of futures markets by bringing empirical evidence to Brazilian commodities and using the Brier Score. The findings are also useful for financial market agents who use these assets in their portfolios, producers and principals in the supply chain and policy makers who make decisions involving these commodities.

Keywords: brier score, future prices, prediction, futures markets, Brazilian, commodities

1. Introduction

Since antiquity, we have sought to know and predict the future. Wise men, elders and oracles, among others, had the task of predicting events and, in virtue of this special task, enjoyed prestige and benefits. However, those who used this information for decision-making faced at least two problems. The first was and is to ensure that the expert has shared his best prediction, that is, his best judgment. The second, on the other hand, is the problem of evaluating the forecast. The decision-maker, after the event has passed, needs to have a way of evaluating the quality of the estimates he received (Friedman, 1983).

In general, experts end up making judgments considering other factors. Entrepreneurs underestimate the likelihood of the business going bankrupt, just as investors tend to positively value assets they have in their portfolio. In summary, people rely too much on their previous knowledge and opinions, generating a personal bias and positive illusions (Baron, 2000; Gilovich, Griffin, & Kahneman, 2002).

In this context, predictions are often subjective and some analyses contain only indications of possibilities as being probable, almost certain, or impossible, among others. To quantify these terms, Sherman Kent proposed a solution to associate the indications with the probabilities of the event occurring. Over time, statistical analysis has become increasingly important, especially to provide uncertainty measures and make predictions for the future (Gneiting & Raftery, 2007).

In order to make predictions more accurate, several prediction techniques have been developed. More recently, algorithms based on large amounts of data may have significantly reduced the error of predictions. However, there is still an error associated with the estimate and the need to assess, with hindsight, the quality of the estimates. In addition, mathematical models have several premises, often subjective, and, in particular, they consider that past data is capable of predicting the future. In this sense, studies have pointed out great differences between the predictions and the data observed later (Leitch & Tanner, 1991; Brand & Bessler, 1981; Dorfman & Mcintosh, 1997).

In the agricultural market, uncertainty about future prices, as well as production and consumption levels, are the

biggest obstacles to planning and investment strategies (Brand & Bessler, 1983). In order to protect against possible price volatilities, stock markets trade assets at pre-established prices. Thus, regardless of events that may occur, sellers and buyers eliminate risks by fixing the prices, quantity and terms of future transactions.

However, the future pricing method, despite being determined by supply and demand, needs to be reliable. Thus, the price estimate must have a high probability of happening. In this way, the agents involved will be assured that, in the present, that future price is a fair value. However, commodities futures prices are often criticized for not being informative for forecasting purposes. This is because they apparently do not generate better estimates than a random walk or because they do not consider the increase in global demand (Reeve & Vigfusson, 2011).

With this in mind, the present work seeks to carry out an evaluation of future prices based on the comparison with the spot market prices of assets traded on the Brazilian Stock Exchange - more precisely, live cattle, coffee, corn, soybeans, ethanol, gold and the dollar - in the period from January 2015 to June 2020. For this purpose, a score based on the probability of occurrence of the event is used, as proposed by Brier (1950).

Currently, the Brazilian Federal Government's Minimum Price Guarantee Policy aims to guarantee minimum profitability to rural producers, encouraging them, once planning and investment have been carried out, to produce. Thus, the role of the minimum price policy is to ensure that, since it is already committed to its fixed costs, it will always be more advantageous to produce than to leave the enterprise idle.

In a way, the Federal Government acts as an insurer or the launcher of a put option, in which it guarantees a minimum price to the rural producer for a given product. In other words, when the market price is lower than the pre-established minimum price, the State intervenes and purchases production.

The way to calibrate the magnitude of such prices is to equate them to the variable average costs of production. In microeconomic theory, if the price of a product is above its variable average cost, the producer has an incentive to continue producing, at least in the short term, even if these prices are lower than the average total cost of production, that is, even if production implies a loss.

Naturally, the producer does not have ex-ante accurate information on the sale price of his product and, in most cases, he only has estimates on the productivity to be achieved by his enterprise. Thus, in certain cases, he cannot, with an appropriate margin of error, deduce whether the selling price will be at levels higher than its average variable cost of production.

When acting in the market as guarantor of a minimum price, the Government has a fiscal risk, as it may be obliged to purchase the production, which will incur a state expense. Therefore, considering the federal law approved in 2020 that provides for the economic subsidy to rural producers and agricultural cooperatives, an alternative designed to eliminate the fiscal risk of the National Treasury is the incentive to the derivatives market, in which the State would give a subsidy to the producer. The aforementioned law expresses that the concession of the grant relieves the Government of the obligation to purchase the product, which must be marketed by the private sector.

However, in order to operationalize this alternative, it is necessary that the future price is a good predictor of the spot market price. That is, that the future price is a good estimate of the spot market price on its maturity date and, thus, it can encourage rural producers to opt for the derivatives market for the product they produce.

In addition to the implications of public policies, the results of the work are useful for the financial literature by providing empirical evidence for the application of the score proposed by Brier (1950) to assess the prices of the futures markets of Brazilian commodities, making it possible to assess the level of information future prices have and, consequently, to analyze them as predictors of the spot market.

In addition to this introduction, the work has four more sections, in which the second section presents the theoretical basis on the judgment of forecasts, in addition to showing how future pricing of assets is carried out. In the third section, the database and the estimation method used are detailed. In the fourth section, data analysis and score calculations are reported to assess the pricing of each asset. Finally, in the last section, the final considerations are made based on the results obtained.

2. Theoretical References

2.1 Literature Review

For many decades, the literature investigating economics and finance has sought to understand how future markets act and what their effects are on markets and on the well-being of society as a whole. As with almost everything else in the social sciences, the results are often controversial and several authors can find even more diverse evidence. As stated in Kawai (1983), regulators, media and farmers claim that a futures market offers individual

trader ample opportunities for speculation, leading to unjustified price levels and unnecessary price volatility. However, most economists argue that speculation results in better allocation of commodities over time and reduces the frequency and breadth of price fluctuations.

Thus, the futures market stabilizes the spot price, consolidating its long-term spot rate and reducing its average in which, even with extreme cases being considered, the long-term distribution response to the spot price should not be very different of future prices (Turnovsky, 1983). They also play an important role in price discovery, recording and transmitting information from the real economy, reacting more quickly to new or unexpected information than the underlying spot market (Baldi, Peri, & Vandone, 2011) and are often described as having the important social function of facilitating the transfer of commodity price risk (French, 1986).

In cases where an individual is faced with price and production risk, the resulting revenue risk is their primary concern, then the futures market provides insurance against that price risk to individuals or companies producing the commodity. When the income-elasticity of demand is higher (lower) than the relative risk aversion index of consumers and the price-elasticity is lower (higher) than unity, the future price is lower (higher) than the price expected sight in equilibrium (Britto, 1984). Thus, the great value of futures markets comes from this ability to predict cash prices at a specified future date and thus provide agents with a means of managing the uncertainty associated with trading a particular commodity (Kellard et al., 1999).

With the agricultural commodity futures exchange providing a centralized market environment - where farmers and other market participants can find out the prices of commodities for futures delivery and risk-averse people can transfer price risk to those willing to bear it (Anto, Suresh, & Garima, 2015), Kawai (1983) states that the future market stimulates production due to the existence of insurance, increases the level of expectation of supply and, thus, reduces the level of spot prices expected in the long run, thus concluding that the general welfare of society increases due to the introduction of a futures market.

Specifically, there is a vast literature on the assessment of predictions of these futures markets, seeking to analyze the behavior of futures prices and assess whether there is information that can serve as a predictor of the spot price. However, it is important to note that there may be nothing for the futures market to predict, as with the current spot price being equal to the true expectation of the future spot price, the futures market cannot provide a better forecast (French, 1986).

Kellard et al. (1999) explain that in an efficient commodity market, the futures price will be an optimal forecast of the spot price at contract termination, in the sense that it will be wrong with an unpredictable zero-mean random error where, in its simplest form, the efficient markets (HEM) hypothesis can be reduced to the joint hypothesis that agents are - in an aggregated sense - endowed with rational and risk-neutral expectations in which future prices are an impartial estimator of the future spot price.

In their article on predictive power, premiums, and commodity storage theory, Fama and French (1987) assess two common views about future prices in this market. Storage theory explains the difference between the futures price and the spot market price in terms of interest lost in stocking the product, the costs involved in this process, and an inventory yield. The second view divides the future price into an expected premium and a forecast of the spot price. Among the conclusions of the study, it was possible to infer that futures prices have the power to predict, on their expiration date, the spot market prices on that date.

Although the future price contains the risk premium, the performance of predictions does not significantly improve with the control of this factor for the estimates, that is, the estimate given by the asset's future price exceeds, but by a small margin, the forecast given by a random walk (Reeve & Vigfusson, 2011). To reach this conclusion, Reeve and Vigfusson (2011) adopted an econometric approach, where the difference between the spot market price and its future price was regressed in terms of a constant, a slope factor between the price estimate and the present price is an error. They also concluded that when commodities are storable, spot prices reflect current supply and demand conditions, as well as expectations for these conditions in the future, because market agents can arbitrate between the current spot price and the future price. Consequently, futures trajectories are relatively stable, with no indication of dysfunction on the part of the futures markets.

Stein (1976) explains that there are two components of the net marginal costs of maintaining futures contracts, being the marginal storage costs and the marginal convenience yield, which is negative in the carrying cost. As the convenience yield is a measure of the advantage - for the producer, processor or wholesaler - of having readily available stocks, it depends on the total amount of assets held - protected and unhedged, where the marginal convenience yield is negatively related to the total amount of inventories held, the net marginal maintenance costs increase with the total amount of inventories held.

Theissen's (2012) results corroborate that the futures market generally captures new information faster than the spot market and the ones by Baldi, Peri and Vandone (2011) denote that in times of crisis and, in particular, in strong phases price rise, the spot market also becomes a major player in the price discovery process price.

The Granger non-causality estimated by Anto, Suresh and Garima (2015) indicate the presence of one-way Granger causality of futures prices for commodity spot prices, while the findings of Nicolau and Palomba (2015) indicate that the dynamic interactions between spot and futures prices depend on each commodity, but both prices are always co-integrated because the time series share a common path. Evidence suggests that futures and spot prices are cointegrated with a long-run slope unit coefficient, the long-run equilibrium condition being maintained, while there is evidence of short-run inefficiencies (Kellard et al., 1999).

Anto, Suresh, and Garima (2015) found that the causalities of futures market prices in relation to the spot market are significant for commodities, both in positive and negative components, showing that negative shocks from futures markets are having more impact on price the spot market than positive shocks, that is, market participants are giving more weight and responding more quickly to negative shocks than to positive ones.

Protopapadakis and Stoll (1983) emphasize the importance of studying commodities individually because it is possible to obtain information about the efficiency and degree of integration of international markets because, in efficient markets, the international arbitrage of commodities implies that, for a standard commodity, prices in two markets expressed in a common currency they do not differ and the existence of futures markets allows an arbitrator to block a certain return from buying the commodity in one country and selling it at a later date in another country.

Thus, with regard to the gold market, the results of the recursive analyzes by Nicolau and Palomba (2015) show that there is no possibility of a valid forecast between spot and future prices. Moosa and Al-Loughani (1994) analyzed futures and spot market prices for WTI oil and their econometric analyzes indicated that futures prices are biased estimates of spot prices, therefore, they do not generate efficient spot market forecasts.

In relation to soybeans, Baldi, Peri, and Vandone (2011) emphasize that the uncovered price is more related to fundamental patterns, rather than financial trading in futures markets, with the soybean futures market being shallower and thicker than the futures market. of corn. For the currency market, Chen and Gau (2010) suggest that the currency futures market contributes more information when the futures market is more liquid, that price discovery is greater when the spot market is more volatile and when the transaction cost of the spot market is higher, the relative information actions of the spot and futures markets remain unchanged, which suggests that the transaction cost hypothesis does not hold in the foreign exchange markets.

For metallic commodities, Gulley and Tilton (2014) found evidence that during periods when futures prices are above the spot price to cover storage costs and interest on capital, the correlations between changes in spot and futures prices are very close of 1, as well as in contrary scenarios, this correlation decreases, reducing the link between spot and futures prices. The authors also explain that, for situations where investor demand raises the three-month futures price and encourage investors to buy in the spot market and sell forward in the futures market, while covering their futures positions and storing quantities they have bought on the spot market. This intertemporal arbitrage will continue until the price difference between the spot and futures markets returns to a value that only covers storage costs, as a result, up and down movements in the futures price will cause changes in the spot price.

Still on metals, under scenarios of high interest rates, a positive adjusted interest base is observed when future prices are much higher than spot prices, demand and supply shocks produce similar changes in the spot market and in the futures prices when stocks are high and, conversely, when the adjusted interest base is negative - low stocks - spot prices are more sensitive to shocks than futures prices (Fernandez, 2016).

In Brazil, some studies have analyzed the relationship between the futures market and the spot market. Abitante (2008) assessed the efficiency of the futures market as a predictor of the spot market for the live cattle and soybean commodities. The time series showed significant cointegration, which indicates that there is a relationship between the futures and spot markets in the long run. The efficiency indicator proposed in the article was shown to be high for cattle, thus, it can be concluded that the future price can help discover the spot market price.

The ethanol futures market investigated by Quintinho, David, and Vian (2017) revealed to have less pricing power than the spot market, which is responsible for almost the entire long-term price discovery process. This can be explained by the relative concentration of ethanol in the wholesale market, with only a few groups holding a significant share of the market, and by the oligopolistic behavior of distributors. Another reason could be the regulation of ethanol by the Brazilian government and the price and sales policy of Petrobras.

Silva and Takeuchi (2010) proposed an empirical analysis in the sugar market to assess the possibility of arbitrage for the product based on the differences between future and spot prices. The researchers approached the problem through the analysis of time series. They applied the cointegration test and error correction models to assess the existence of a relationship between duly lagged spot and future sugar prices. The results found show a long-term relationship between futures and spot prices and generate weak evidence of inefficiency in the sugar market.

2.2 Future Price Calculation and Scoring Rule from the Probabilities of Occurrence

The formation of the future price of a contract is defined by a consensual value between the buyers and sellers of that asset. However, the closer the maturity date is, the smaller the disparity between the price previously agreed and that observed in the future in the spot market tends to be.

The pricing manual for the Brazilian Merchandise and Futures Exchange addresses the future price and, although its value is determined by supply and demand, it proposes that the calculation of the future price be given by the following equation:

$$FP = SP + CC + UA \quad (1)$$

where FP is future price, SP is spot price, CC is charge cost and UA is uncertainty award. Since the charge cost consists of the cost of storage, transportation, insurance and financing.

It should be noted that the first two terms on the right side of the equation, cash price and shipping cost, are known and do not depend on any estimate from the agents. The third factor, premium for uncertainty, is given by the agents' expectations regarding the market, considering seasonality and trend.

The literature addresses the comparison between the predicted values and those observed in several research fields. There are probably most studies in the area of meteorology. Several scores are proposed to measure the quality of the prediction. Gneiting and Raftery, in 2007, addressed the comparison of four different scores - Brier Score, Logarithmic Score, Zero-One Score and Winkler`s Score, depending on the distribution of the probability function.

There are numerous reasons for evaluating predictions (Jolliffe & Stephenson, 2003). The limits of predictions must be recognized; however, they cannot be disregarded (Tetlock & Gardner, 2015). As a result, Glenn Brier published a seminal article in 1944 (Brier, 1944) and then proposed the construction of a score to identify how good the prediction is compared to the observed value (Brier, 1950).

The idea behind a score to check predictions in terms of probability is that if the event has a certain chance of occurring, it should happen in the same proportion in the future. The figure below shows examples with the variation between a perfect calibration, in which the proportion of occurrence of the event is equal to that predicted and when there is a difference between the estimated probabilities, and the percentage that the event actually happened.

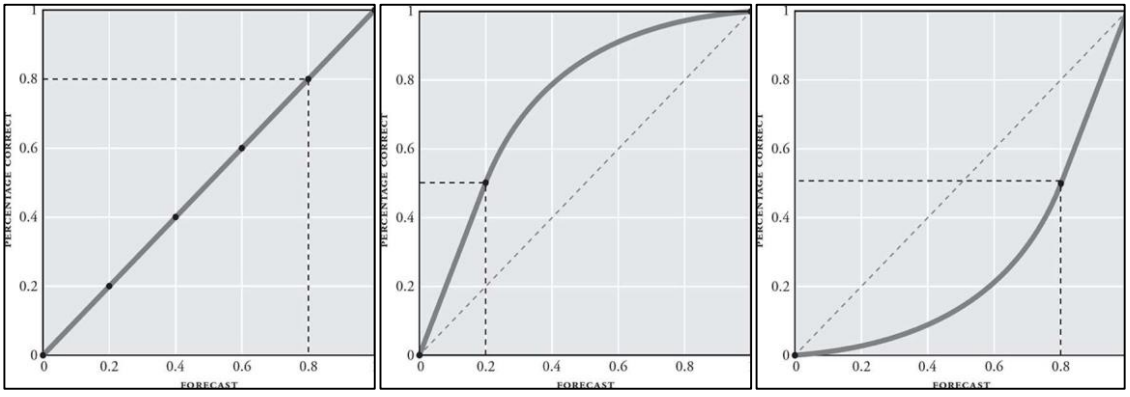

Figure 1. Examples of perfect calibration, underconfident and overconfident when comparing the predicted probability of occurrence and the correct percentage of the event

Source: Tetlock and Gardner, 2015.

The method presented by Brier refers to the verification of climatic predictions (Brier, 1950). The score is obtained from a formula that compares the probabilities of the occurrence of an event and the observation if the event

actually happened. Assuming that f_{ij} represents the probabilities of the event and E_{ij} the observation of the event, the score is defined by:

$$P = \frac{1}{n}\sum_{j=1}^{r}\sum_{i=1}^{n}(f_{ij} - E_{ij})^2 \quad (2)$$

where $\sum_{j=1}^{r} f_{ij} = 1, \text{for } i = 1, 2, 3, \dots, n$. The score varies from 0 to 1, where the maximum value refers to when there is a total disagreement between the predicted value and the one that was observed. While, if the difference between the estimate and the event is small, the score approaches zero.

Note that E_{ij} assumes the values 0 or 1, depending on the occurrence or not of the expected event. Thus, the proposed score refers to a metric in which the prediction is in terms of probability and the observed event is binary.

When the event does not assume dichotomous behavior, the data must be transformed so that they have binomial distribution. One option for handling continuous values is to categorize the data. In a 1972 paper, Von Hostein proposes using a score based on probabilities to verify the prediction in the stock market, considering that the price has little variation, up to 1% difference, variation of 1% to 3% in the price and variation above 3% (Von Holstein, 1972). In order to assess the estimates, the score, when considering several classes, must be composed of a non-linear function (Murphy & Winkler, 1970). In this sense, the scores obtained through the quadratic, spherical and logarithmic functions are more appropriate (Von Holstein, 1972).

Mason (2008) pointed out a problem when the data has a temporal autocorrelation. In order to get around this problem, he suggests performing a block bootstrap before applying other statistical analyses. That is, the data is divided into several blocks and the resampling process is applied to each block.

3. Methodological Procedures

3.1 Data

For the present study, asset price information on the Brazilian Merchandise and Futures Exchange is used. Seven assets were chosen: live cattle, coffee, corn, soybeans, ethanol, gold and dollars.

The spot market prices were collected using data available on the website of the Center for Advanced Studies in Applied Economics of the Higher School of Agriculture Luiz de Queiroz, a unit of the University of São Paulo.

Future prices were obtained from the Investing website, which provides access to asset data on the Brazilian Stock Exchange. The information is made available in the form of a continuous future (CF), calculated as a weighted average of prices with different expiry dates. The weighting is done considering the number of days remaining until the closure of the contract negotiation. The formula below shows the calculation when there are two contracts according to the following formula:

$$CF = F_1 * \frac{T_1}{T} + F_2 * \frac{T_2}{T} \quad (3)$$

So, the price of the continuous future CF of a certain asset is a weighted average between the contract closest to reaching maturity, where T_1 represents the number of days until the expiry of the first contract of the future, T_2 the number of days until the second contract expires, and T the difference in days between T_1 and T_2. Future prices are represented by F_1 for the first contract and F_2 for the second.

The choice of using the continuous future price is due to the advantage of this way to mitigate the distortions that occur during the transition between the months in which maturity is reached. Thus, it facilitates the analysis with a longer term.

3.2 Quantitative Technique

From the price data of the futures and spot markets for each product, the information was visualized and the data were transformed into a time series format.

There was a need to allocate a few values, as there are dates when the spot market operated, but there was no trading on the stock exchange for the futures market. The imputation of these data was performed using the imputeTS package, which considers the time series for the estimate to be attributed in place of the missing value.

To circumvent the problem of autocorrelation, present in time series, a block bootstrap was carried out on the data of the continuous future. In this process, they were simulated and resampled considering blocks of 30, 60, 90, 180 and 360 days.

After applying the resampling process, the confidence interval at 90% and 95% levels was calculated. From this

distribution, it was possible to transform the observed data into binary terms. When spot prices were within the confidence interval, they received a value equal to 1 and, otherwise, 0. Thus, it was possible to calculate the Brier score, using the following formula:

$$P = \frac{1}{n}\sum_{j=1}^{r}\sum_{i=1}^{n}(f_{ij} - E_{ij})^2 \quad (4)$$

The variable f_{ij} corresponds to a confidence level of the interval (90% or 95%), and E_{ij} will receive a value of 1 or 0, depending on whether or not the spot price is contained in the confidence interval.

4. Results

The analysis of the data started with the visualization of the time series of the market for each product. In this way, it is possible to compare the trajectories of future and spot prices in a descriptive way.

When analyzing the spot and future market prices for live cattle, it is noted that the curves have very close values when compared on the same date. The increase observed since the second half of 2019 occurred both in the spot market and in the future prices of the commodity. As can be seen in the Figure 2.

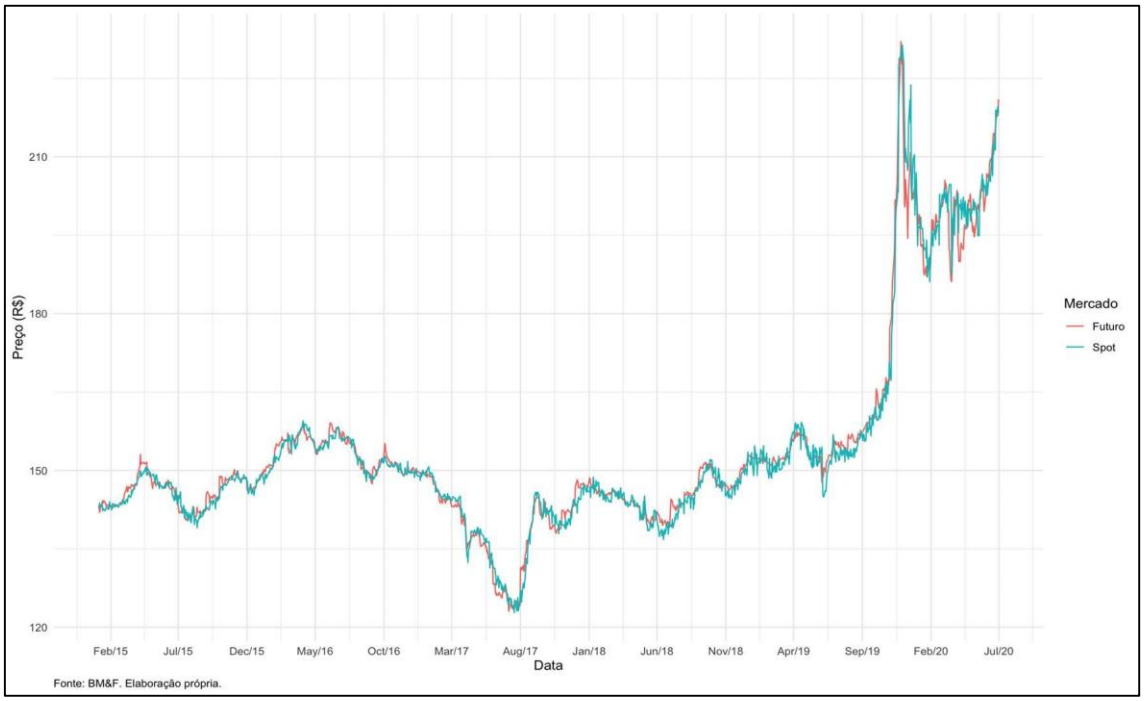

Figure 2. Price of live cattle in the spot and futures markets in the period from January 2015 to June 2020

Source: Elaborated by authors.

In the coffee market, it is observed that the futures market is constantly above the spot market in the analyzed period. However, it is observed that the curves have the same behavior; that is, when there is a change in spot prices, the futures market also presents a change in the same direction. As can be seen in the Figure 3.

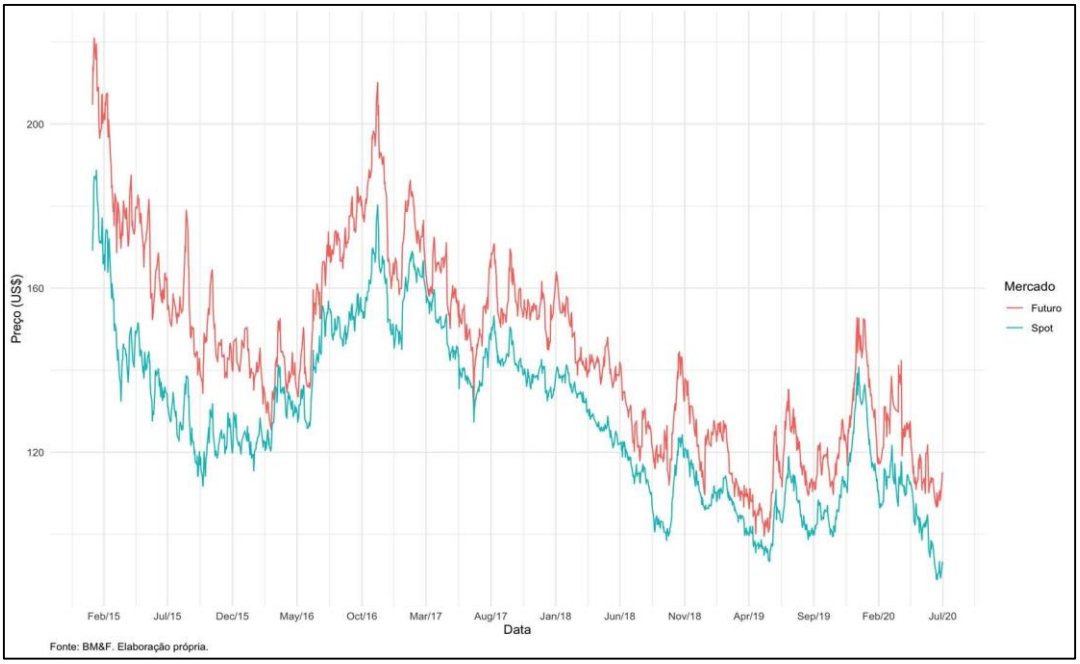

Figure 3. Coffee prices in the spot and futures markets in the period from January 2015 to June 2020

Source: Elaborated by authors.

The curves of the spot and futures markets for corn show similar trajectories, with a slight detachment of prices observed in short periods. However, for most of the time analyzed, prices for the product, both spot and future, were close. As can be seen in the Figure 4.

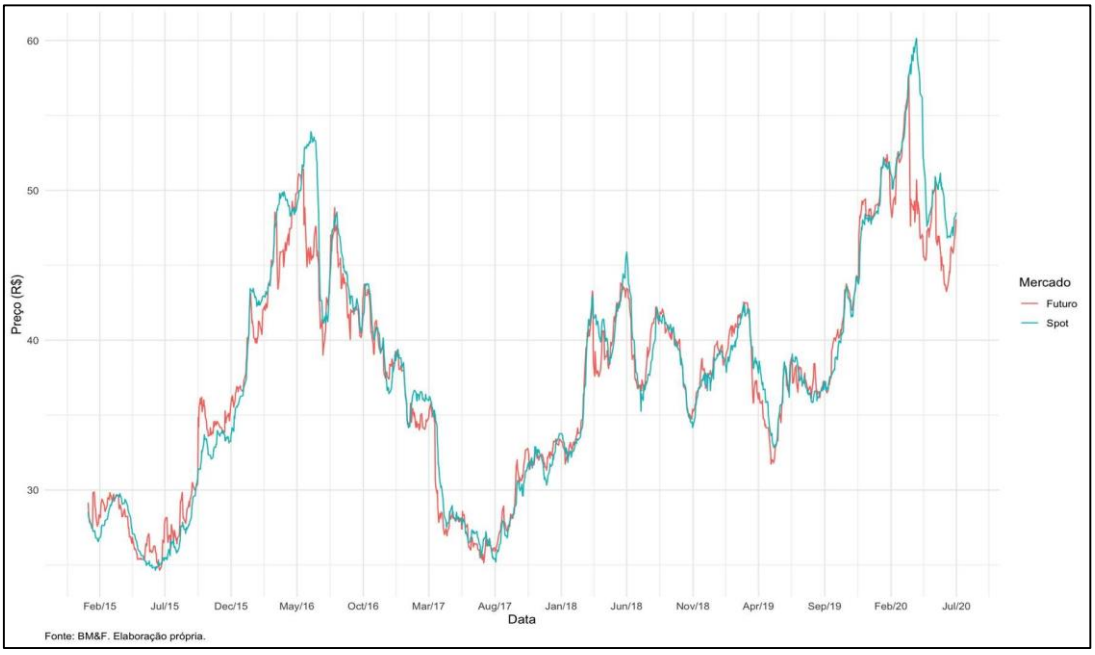

Figure 4. Corn prices in the spot and futures markets in the period from January 2015 to June 2020

Source: Elaborated by authors.

For soybeans, spot prices, in almost the entire period analyzed, were higher than those observed in the futures market. However, as with the products described above, the behavior of market curves is similar. As can be seen in the Figure 5.

Figure 5. Soybean prices in the spot and futures markets in the period from January 2015 to June 2020

Source: Elaborated by authors.

In the ethanol market, spot and future prices have similar trajectories. However, at the end of 2016, there was a change in future prices, with a sharp drop. In 2017, however, the curve returned to the same level as the spot market. As can be seen in the Figure 6.

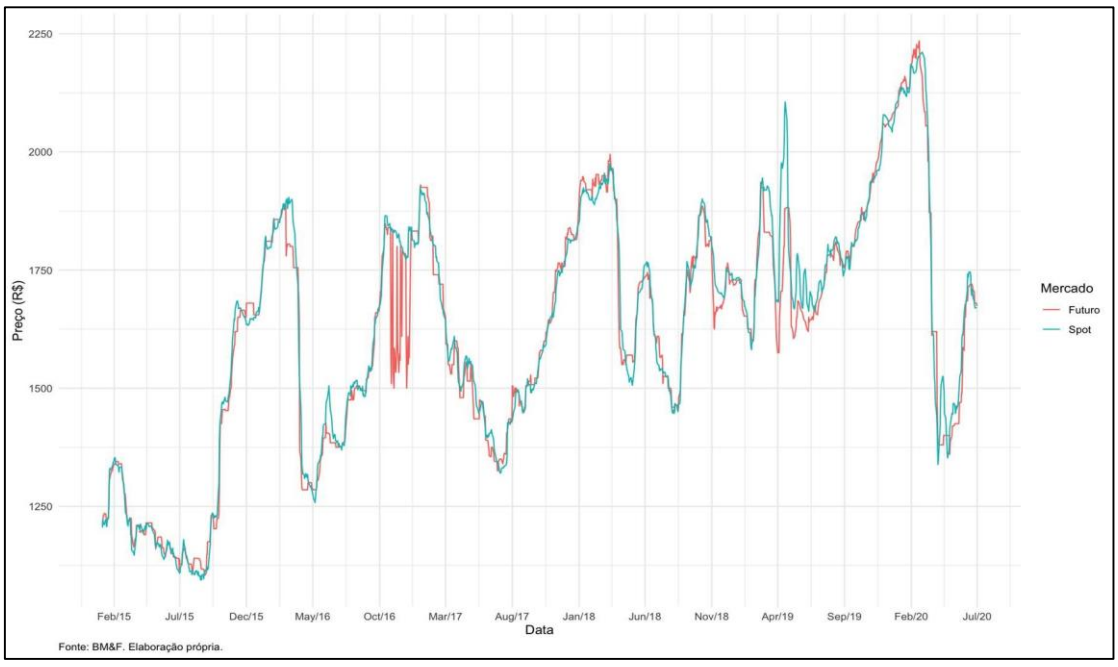

Figure 6. Ethanol price in the spot and futures markets from January 2015 to June 2020

Source: Elaborated by authors.

Spot and future gold prices have similar behaviors and very close values in both markets. Thus, for the same date, the pricing of the futures market follows the price observed in the spot market. As can be seen in the Figure 7.

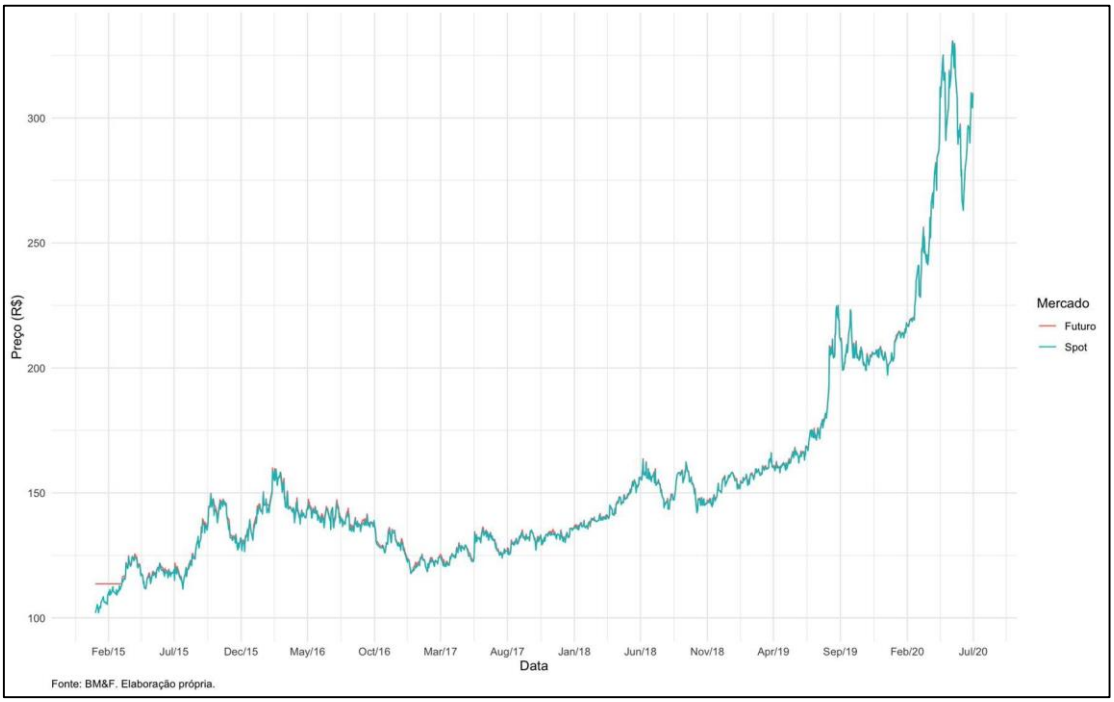

Figure 7. Gold prices in the spot and futures markets from January 2015 to June 2020

Source: Elaborated by authors.

Like gold, the spot market and the futures market of the dollar have similar behaviors and, considering the same date, have very close values. As can be seen in the Figure 8.

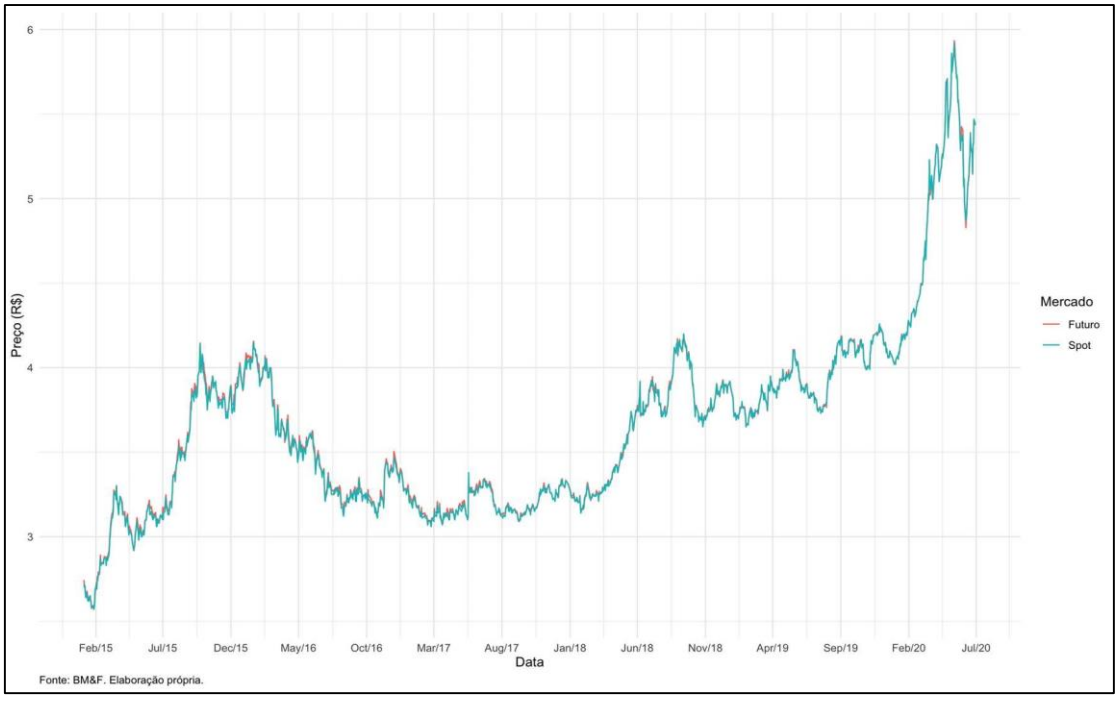

Figure 8. Dollar price in the spot and futures markets from January 2015 to June 2020

Source: Elaborated by authors.

After descriptive analysis, resampling by blocks was carried out, considering one hundred simulations in each group, for future prices. Several periods were tested as a parameter: 30, 60, 90, 180 and 360 days. The Table 1

shows the result of the block bootstrap. Note that the application of the technique resulted in a very small bias; that is, the process did not cause bias when compared to the average of the original distribution and that obtained by the bootstrapping process.

Table 1. Results of the block bootstrap according to the markets and the period considered for blocking

	Period covered by the block bootstrap									
	30 days		60 days		90 days		180 days		360 days	
Asset	Bias	Std. error	Bias	Std. error	Bias	Std. error	Bias	Std. error	Bias	Std. error
Live Cattle	0.0	2.4	0.0	3.1	0.0	3.1	0.0	2.1	0.0	2.1
Coffee	0.0	3.3	0.0	4.5	0.0	5.4	0.0	6.5	0.0	4.2
Corn	0.0	1.0	0.0	1.4	0.0	1.5	0.0	1.8	0.0	1.6
Soybeans	0.0	0.2	0.0	0.3	0.0	0.3	0.0	0.4	0.0	0.3
Ethanol	0.0	36.9	0.1	49.5	-0.1	54.3	-0.2	56.1	-0.1	58.4
Gold	0.0	6.2	0.0	8.4	0.0	9.8	0.0	13.0	0.0	15.9
Dollar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Elaborated by authors.

Then, the confidence intervals were calculated at the 90% and 95% levels. Thus, it was possible to calculate the score proposed by Brier, comparing whether the observed values were within the range or not. From the score, it is verified how good an estimator the future price is for the spot price, as seen in the Table 2.

Table 2. Brier score for products according to the period used for bootstrapping

	Period covered by the block bootstrap									
	30 days		60 days		90 days		180 days		360 days	
Asset	CI 90%	CI 95%	CI 90%	CI 95%	CI 90%	CI 95%	CI 90%	CI 95%	CI 90%	CI 95%
Live Cattle	0.62	0.66	0.47	0.68	0.67	0.71	0.61	0.64	0.61	0.64
Coffee	0.70	0.76	0.70	0.76	0.73	0.79	0.69	0.75	0.72	0.79
Corn	0.68	0.74	0.70	0.75	0.72	0.77	0.69	0.74	0.70	0.76
Soybeans	0.72	0.77	0.72	0.78	0.75	0.70	0.70	0.75	0.71	0.77
Ethanol	0.72	0.79	0.73	0.79	0.74	0.81	0.73	0.80	0.73	0.80
Gold	0.70	0.75	0.68	0.73	0.68	0.73	0.75	0.82	0.74	0.80
Dollar	0.81	0.90	0.81	0.90	0.81	0.90	0.81	0.90	0.81	0.90

Source: Elaborated by authors.

The results show that futures market prices, in general, cannot be understood as good estimators of spot market prices when considering such assets, as in the case of oil studied by Moosa and Al-Loughani (1994). In addition, there is no recurrence in the ability to forecast prices in relation to the maturity of contracts, but evaluating the results for all commodities with the highest confidence index - 95% - the period in which the best forecast occurs is 30 days, followed by 60 days, 180 days, 90 days and 360 days, meeting the conclusions that the predictions improve in the long term obtained by Kellard et al. (1999).

With this, and considering the statements of Protopapadakis and Stoll (1983) about the importance of studying commodities individually and Nicolau and Palomba (2015) that the interactions between prices depend on each commodity, we will analyze the results for each one of them. separate.

Obtaining a good advantage over the others, live cattle is the commodity traded on the Brazilian stock exchange in which the futures market has the greatest capacity to forecast spot prices, with its score varying - when considering the confidence index 95% - from 0.64, for 180 and 360 days, to 0.71, for 90 days. These results are consistent with the findings of Abitante (2008), where live cattle futures and spot prices have long-term co-integration and their efficiency indicator was shown to be high.

After cattle, the commodity with the best score is corn, followed by soybeans, which Abitante (2008) also stated that there is long-term cointegration between spot and futures prices. These results are consistent with those of Baldi, Peri and Vandone (2011) who stated that the soybean market is shallower and thicker than the corn market, being determined more by fundamental rather than financial standards.

The score for corn varies from 0.74, in 30 and 180 days, to 0.76, in 360 days, while soybean has its score ranging from 0.7, in 90 days, to 0.78, in 60 days. The pair of grains with prices that have a correlation of 0.88 and very similar characteristics, as they are used to feed humans, herds and for the production of biofuels, have their future prices predicting spot prices better than the commodities coffee, gold, ethanol and dollar, respectively.

With regard to coffee, its score varies from 0.75, in 180 days, to 0.79, in 90 and 360 days. Gold that, as stated in Nicolau and Palomba (2015) does not have the possibility of valid forecasts between spot and futures prices, has its score ranging from 0.73, in 60 and 90 days, to 0.82, in 180 days. Ethanol futures prices have their score ranging from 0.79, in 30 and 60 days, to 0.81, in 90 days.

This poor performance in spot price discovery may be due to the concentration of ethanol by the wholesale market and the oligopolistic behavior adopted by distributors, in addition to the pricing policy exercised by Petrobras (Quintinho, David and Vian, 2017), the Brazilian state-owned fuel company. The worst result occurs, among those observed, for the dollar, whose score is close to 1, being for all periods analyzed at 0.9 for the 95% confidence index, as was considered for other commodities.

5. Conclusion

When viewing the time series of the spot and futures markets, it was noted that for all the products analyzed, the curves have the same trajectory. In most cases, when the observation is made on the same date, spot and future prices are very close. Thus, apparently, there is a strong correlation between spot and futures markets; however, it is not possible, descriptively, to verify if there is a causal relationship.

In order to apply the Brier score (1950), which compares the probabilities of occurrence with the event that actually happened, the confidence interval of the simulations obtained by the block bootstrap process was calculated. This process is appropriate when it comes to time series and adopts a period for grouping and, subsequently, resamples the data.

The resampling process did not cause any bias and, therefore, the execution of the simulation proved to be adequate, with the generated data mirroring those that actually occurred. The Brier score showed that future prices are not good predictors of the values observed in the spot market. The score value is greater than 0.5 for all products and, in many cases, it is close to 1, which indicates total disagreement between the forecast and the actual event.

There is also a difference between the analyzed assets. The dollar had the worst performance, while the other products showed closer results, with the score ranging from 0.6 to 0.8. Fattened cattle is the commodity with the lowest score, so it is the one where the future price best predicts the spot market price. Among the parameter simulations for blocking the bootstrapping process, several different periods were tested. It appears that the longer the period for grouping the time series, the higher the score, showing a worsening of the future price as a predictor of the spot price.

Although there is no indication that future prices are able to satisfactorily predict the values found in the spot market, it was observed that the trajectories of the curves are similar. In addition, when considering the same date, the values are very close. It is likely that storage costs are negligible and, thus, the spot market value moves close to the futures market, because if they are different, the agents could arbitrate, taking advantage of these price differences.

As a continuation of this work, it is suggested that the same assets be analyzed, but traded in other countries to verify the predictive capacity. Another possibility may be the application of other techniques, such as time series, in order to assess the cross-correlation between markets and whether there is a causal relationship between them.

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