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Determinants of Corn and Soybean Futures Prices Traded on the Brazilian Stock Exchange: An ARDL Approach

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Abstract

This work aims to understand the determinants of the prices of corn and soybean futures traded on the Brazilian Stock Exchange (B3) based on the influence of international commodity prices on domestic prices. Using a theoretical model developed by Mundlack and Larson (1993) that considers the one-price law hypothesis, we estimate the Autoregressive Distributed Lag (ARDL) bounds test for cointegration (Pesaran et al., 2001), who tested the existence of a long-term relationship between the variables, as well as short-term influences. The database comprises the period from February 2011 to December 2019 and corresponds to the prices of corn and soybean futures contracts traded on the Brazilian Stock Exchange; and corn, soybeans and oil traded on the Chicago Mercantile Exchange, in addition to incorporating in the analysis the Brazilian macroeconomic variables exchange rate, inflation and GDP. The main results showed a long-term relationship between domestic prices, the exchange rate, and international prices negotiated in the United States for both commodities. Soybean prices are mostly affected by international prices in comparison to corn prices. In the short term, we found that soybean prices are affected by trading prices of the same commodity in the United States.

Keywords: Corn, Soybean, ARDL, future markets, derivatives

JEL Classification: Q02, Q14, G13, G12.

1. Introduction

The commodities market has been attracting increasing interest of investors and consequently the literature that investigates empirical finance. This is due to the growth of the financialization of assets in this market, especially after 2000 when US the Congress approved the Commodity Futures Modernization Act (Algieri & Leccadito, 2018). Trading of assets in the futures market can increase the efficiency of markets, and prices in efficient markets will not change drastically when facing external shocks (Zhang, Shi, & Yu, 2018).

According to Fan Wang (2016), in the commodity futures market, agricultural commodities are particularly volatile, which creates challenges for producers and consumers seeking to hedge price risk, and financial market participants, who may seek to diversify multi-asset class portfolios by adding exposure to commodities as part of a statistical approach that can provide insight into the future direction of commodity futures prices. This is of particular value to commercial and financial market participants. Better forecasts of future commodity prices can lessen the risk assumed by companies that use a determined commodity, resulting in lower prices for consumers (Ahumada & Cornejo, 2015).

As presented by Fama and French (2015), in the literature there are two main explanations for the formation of commodity futures prices. On the one hand is the theory that divides futures prices into an expected risk premium and a forecast of the future spot price. On the other hand, is the view that considers storage and explains the difference between contemporary spot and futures prices in terms of the costs of this storage, its forgone interest earnings and a convenience yield on the inventory. Either way, it can be inferred that futures prices have the power to predict future spot prices.

This paper seeks to understand the determinants of corn and soybean futures prices traded on the Brazilian Stock

Exchange, based on the influence of international commodity prices on domestic prices. Our empirical development starts from the theoretical model of Mundlack and Larson (1993), which considers the influence of external agricultural prices on domestic prices. As an empirical part, we use the Autoregressive Model with Distributed Lags (ARDL) presented in Pesaran et al. (2001). In addition to corn and soybean prices traded on the B3, the estimated econometric models also consider corn, soybeans and oil prices traded on the Chicago Mercantile Exchange (CME), Brazilian GDP, the exchange rate of the Brazil's currency (the real, plural reais, R$) against the US dollar and the Brazilian basic interest rate. The data series has monthly frequency and covers the period from February 2011 to December 2020. The results show that the selected models have a long-term relationship, with cointegration in the sense of Pesaran et al. (2001) for the prices of both commodities, with exchange rate and corn traded in the United States exerting long-term influences on corn prices traded in Brazil, while oil prices have an impact in the short term. At the same time, prices for soybeans traded in Brazil are only impacted by prices of soybeans traded in the United States.

These findings are useful for the researchers who investigate the formation of agricultural prices, by providing empirical evidence for future prices of corn and soybeans traded on the Brazilian Stock Exchange, The trends found are also important to producers and traders in the supply chain, to agricultural policymakers, and mainly, financial market investors who use these assets in their strategies.

The work has five more sections. In section 2, we present a brief review of the literature related to the topic; in section 3 we describe theoretical model and data characteristics; section 4 presents the econometric method used; section 5 presents and discuses the results; and section 6 concludes.

2. Theoretical Reference

Until the early 2000s, commodity prices behaved differently from typical financial assets, they had few price co-movements with equities and with each other, in contrast to the price dynamics of typical financial assets, which carry a premium only for systematic risk and are highly correlated with market indices and with each other, indicating that commodity markets were partially segmented from external financial markets (Tang & Xiong, 2010). As a result, investors increasingly came to trust the diversification effect that commodities could bring to their portfolios (Aboura & Chevallier, 2014).

According to Pereira, Ribeiro and Securato (2012), investors can also use commodities - as real goods with economic value in the supply chain - as a safe means of preserving capital, since they are assets that maintain their inherent value regardless of their quotation and can be used as value benchmarks in periods of inflation or economic crises that cause momentary distortions in the relative value of currencies.

As can be seen in Büyüksahin and Robe (2014), since Friedman in 1953 a large body of work has investigated whether the trade composition of an activity and those who trade it are important for asset pricing. Since the 2000s, the commodities market has been steadily growing, with increasing commodity market activity by hedge funds, commodity index traders and other financial agents. However, Blocher, Cooper, and Molyboga (2016) argued that research has been less focused on how investors should incorporate commodities into diversified portfolios, an important issue considering that the global capital allocated to commodities in 2016 was approximately 330 billion dollars.

These commodity markets experienced significant growth in trading volume, variety of contracts, and range of underlying and derivative contracts during the period. As a result, market participants also became increasingly sophisticated in identifying and exercising operational contingencies embedded in delivery. of contracts. For all these reasons, there is widespread interest in models for pricing and covering claims and contingents linked to commodities, on the grounds that future curves for commodities differ from those for stocks or bonds (Routledge et al., 2000).

Financial advisers have suggested that individuals include commodities in their personal asset allocation, and this increased interest in commodity investments at the start of the millennium, combined with the poor performance of passive market indices, makes qualified investors more interested in evaluating the performance of active managers of commodities funds (Blocher, Cooper, & Moyboga, 2016). The common perception is that the popularity of investing in commodities resides precisely in the fact that, from a theoretical point of view, commodities constitute an alternative asset class, so it is expected that the correlation of their returns with those of traditional asset classes is expected to be small or even negative in relation with assets that belong to traditional asset classes such as stocks and bonds. This is because the factors that drive commodity prices are distinct from those that determine the value of stocks and bonds, another reason for their popularity is the possibility of using them to hedge against inflation (Daskalaki & Skiadopoulos, 2011).

This belief has allowed investment banks to successfully promote commodity futures as a new asset class for prudent investors, and as a result, various commodity index-based instruments have attracted billions of dollars of investment from institutional and retail individuals. The growing presence of index investors has precipitated a fundamental process of financialization among commodity markets, whereby commodity prices have become more correlated with financial asset prices and with each other (Tang & Xiong, 2010).

Many traders and investors face restrictions in their choices of trading strategies, but with them facing fewer restrictions they should lessen price discrepancies and improve risk transfers between markets. As hedge funds become less investor-restricted, increased activity in hedge funds could strengthen links between markets. Commodity return co-movements are positively related to the extent of participation in the commodity market by speculators in the financial sector as a whole and hedge funds in particular (Büyükşahin & Robe, 2014), since futures trading is a valuable activity that increases market efficiency, improves price discovery, increases the depth of information and contributes to the functioning of the market (Algieri & Leccadito, 2018).

As a result of the financialization process, the price of an individual commodity is no longer simply determined by its supply and demand. Commodity prices are also determined by a whole range of financial factors, such as aggregate risk appetite for financial assets, and investment behavior of investors in diversified commodity indices. On the one hand, the presence of these investors can lead to a more efficient sharing of commodity price risk, while on the other hand, the rebalancing of portfolios can affect the volatility of prices from outside to commodity markets and also to different products (Tang & Xiong, 2010).

With all these changes, profit-maximizing harvest decisions increasingly rely on price projections because virtually no cultivation restrictions are imposed by the latest agricultural legislation, which means that the accuracy of crop price projections is becoming more important, with agricultural producers and companies demanding price forecasts that are more specific regarding product, location and time (Zhang, Xi, & Yu, 2018). Commodities will gain even more importance globally in the future, since demand for agricultural products will grow alongside the growth of population, with the development of commodity markets playing an important role in economics and politics (Lübbers & Posch, 2016).

According to Ye et al. (2018), the literature contains extensive evidence of close relationships between commodity prices and macroeconomic variables such as GDP growth, money supply, interest rates, exchange rates and inflation. This is because commodity futures contracts are inherently forward-looking and incorporate investors’ expectations of future commodity returns, so they are expected to contain investors' expectations of the future macroeconomic environment, with demand for commodities largely driven. by economic activity, with strongly correlated commodity prices and general price indices. Lübbers and Posch (2016) also reported numerous studies that demonstrated that macroeconomic factors such as the real interest rate, exchange rate and hedging pressure affect commodity pricing.

Ahumada and Cornejo (2016) argued that commodities included in the World Bank Food Price Index for the period 1990-2013 (on a monthly basis) showed price correlations well above 0.60 and even 0.85 for some subsets, which motivated them to explore whether the accuracy of predictions for a subset of these commodity prices could be improved by taking into account their cross-dependence. The authors used corn, soybeans and wheat to predict their prices against each other and found that the cross-dependence between the three commodities was beneficial for forecasting purposes.

Parallel to this, Lübbers and Posch (2016) explained that researchers used factor models to understand commodity markets as early as Pindyck and Rotemberg (1988), and showed that unrelated raw commodity prices have a persistent tendency to move together, even in periods of exceptional macroeconomic variables such as inflation, interest rates and exchange rates.

Gülerce and Ünal (2017) related agricultural prices to oil prices, since the inputs for production and harvest of agricultural products - such as fertilizers, pesticides and fuel for machinery and equipment - are based on petroleum, and consequently the increase in the cost of agricultural production due to fuel consumption is reflected in the price of agricultural products. Oil prices also influence transport costs, so agricultural products grown in dispersed rural areas are also affected by transport costs.

In this respect, according to Ibrahim (2015), by affecting energy-intensive inputs, such as fertilizers and fuel, and influencing transport costs, changes in oil prices directly affect food production costs and prices. With rising costs of global food production, food import bills rise in times of rising oil prices for food importing countries and consequently exert upward pressure on domestic food prices.

Furthermore, biodiesel - which is mainly produced from soybeans - and bioethanol - largely produced from corn

- are considered technological alternatives to conventional fuels - such as diesel and gasoline - with an increase in the production of biofuels leading to an increase in agricultural commodity prices. Thus, a commodity formation model is needed that considers that corn and soybeans have become part of the energy matrix and will be priced to a certain extent interdependent with the price of oil (Pereira, Ribeiro, & Securato, 2012).

The last argument, involving the exchange rate issue – is due to the fact it is widely accepted that the ups and downs of commodity prices are mainly caused by fluctuations in global demand that are associated with unexpected changes in real global economic activity (Kilian & Zhou, 2018). Since the United States is the largest exporter of agricultural commodities and many commodity markets are denominated in US dollars, the devaluation of the dollar in certain periods raised the price of commodities in dollars (Roberts and Schlenker, 2010), while the appreciation of the dollar had the opposite effect.

In addition, in the United States the prices are quoted through the Chicago Board of Trade (CBOT) (Bento, Tabaso, & Araújo, 2016), making it important to understand the relationship between world prices and local prices to assess how exposed countries - especially developing ones - are to fluctuations in international food prices. In this same vein, it is also important to understand the impacts of exogenous price shocks on food security, which is associated with the availability of food in these nations (Abidove & Labuschagne, 2014).

Several recent works have investigated corn and soybean commodity prices and their findings should be highlighted. Hao et al. (2021) reported that soybean option prices are more efficient than futures contract prices in predicting soybean prices. Conversely, Yang et al. (2020) concluded that China's agricultural futures markets generally play a more dominant role in the price discovery process as markets mature. Bohmann et al. (2019) investigated whether commodity futures or options markets are important determinants of the price discovery process in the markets for crude oil, natural gas, gold, silver, corn and soybeans. The authors found that increased speculation rather than hedging activity in commodity derivatives was the key driver of price discovery in the respective options markets.

Bala and Abdullahi (2019) found a long-term association between oil prices, exchange rate and food prices in Nigeria, with the exchange rate affecting food prices more than oil prices. Finally, empirical results from Campos (2020) indicate that real interest rates and US soybean, corn and wheat prices have a U-shaped relationship. They also found that if the real interest rates were below the limit of -1.45 and rose by 1%, the prices of agricultural commodities would decline by 8.1%, while if the real interest rates were greater than or equal to -1.45% and were increased by 1%, the prices of agricultural commodities would increase by 3.4%.

3. Model and Data Specification

3.1 Theoretical Model

Our theoretical model is based on the work of Mundlack and Larson (1993), who analyzed the transmission of prices between foreign and domestic markets, in which domestic prices are related to international prices through the Law of One Price. The model proposed here is tailored to explain the price transmission mechanism between the foreign and domestic markets in the short and long terms.

The equation for the domestic price of commodity *i* presented by Mundlack and Larson (1993) is:

$$p_{it} = p_{it}^{*} e_t s_{it} \tag{1}$$

where p_{it} is the domestic price of commodity i in period t, p_{it}^{*} the world price of product, e_t is the nominal exchange rate and, s_{it} is a variable related to tax policy.

Taking the logarithm of equation (1), we write it with capital letters to obtain the linear price model:

$$P_{it} = P_{it}^{*} + E_t + S_{it} \tag{2}$$

According to Mundlack and Larson (1993), one can test the relationship between the domestic prices of each commodity and the international price by estimating the following regression:

$$P_{it} = \beta_0 + \beta_1 P_{it}^{*} + \beta_2 E_t + \varepsilon_{it} \tag{3}$$

The term ε_{it} is included in equation (3) to allow for deviations from this assumption and for effects that are not included in the equation, so we add the constant β_0 in the model to ensure the zero-mean property in the error term ε_{it}. The coefficient β_1 is the elasticity of the domestic price in relation to the world price, called the transmission elasticity; while the coefficient β_2 is the domestic price elasticity in relation to the exchange rate. Eq. 2 can be expressed in terms of Eq. 3 subject to restrictions $\beta_1 = 1$ and $\beta_2 = 1$. A value of 1 implies that changes in world prices are fully transmitted to domestic prices, while a value of 0 implies that no transmission occurs from those variables to domestic prices. As pointed out by Mundlack and Larson (1993), there are several reasons why this elasticity would be different from one. First, omitted variables, specifically tax policy variables (S_{it}), are correlated with the world price. Second, there may be measurement errors in the world price. These errors may reflect the fact that the world price used in a given study differs from the one relevant for the given country. Third, if the economy is closed, the world price is irrelevant.

3.2 Data

Corn price (P_c) and soybean (P_s) data correspond to the closing prices of continuous futures contracts, traded on the Brazilian Stock Exchange. The series were obtained from the Investing website. The Brazilian GDP series (GDP), real/US dollar exchange rate (E), and Brazilian basic interest rate (R) were obtained from the Institute of Applied Economic Research (IPEADATA), a think tank associated with the Brazilian government. We use as proxies for the external prices of soybeans, corn and oil, the closing prices of continuous corn future contracts (P_c^*), soybean (P_s^*) and oil (OIL) traded on the Chicago Mercantile Exchange (CME).

The data frequency is monthly and covers the period from February 2011 to December 2019. Table 1 presents the descriptive statistics of the series considered. The variable (R) is expressed as a percentage, the others are pieces quoted in reais.

Table 1. Descriptive statistics of the variables considered

	R	E	OIL	P_c	P_c^*	P_s	P_s^*	GDP
Mean	0.78	2.87	190.61	32.78	1244.42	67.77	3061.46	493088.23
Median	0.80	3.13	184.16	31.14	1198.86	69.25	3140.94	493304.70
Std. Dev.	0.23	0.81	36.31	6.68	205.60	9.88	461.73	77098.72
Min.	0.37	1.56	126.87	23.01	747.34	46.90	2028.75	334982.00
Max.	1.22	4.16	301.79	49.80	1708.00	88.54	4015.94	493304.70

Source: Elaborated by authors.

Figure 1 illustrates the trajectory of the monthly closing prices of continuous corn and soybean futures contracts traded on the Brazilian Stock Exchange during the analyzed period. The data series are original, nominal and quoted in reais. It is possible to notice there was an increase in the prices of both commodities from 2010 onwards, although with some sharp falls and rises on certain dates.

In addition, the correlation between the prices of the two commodities is clear, more precisely 0.67, since they are goods that compete for inputs and arable land for production, and are used to feed humans and livestock, as well as for production of biofuels.

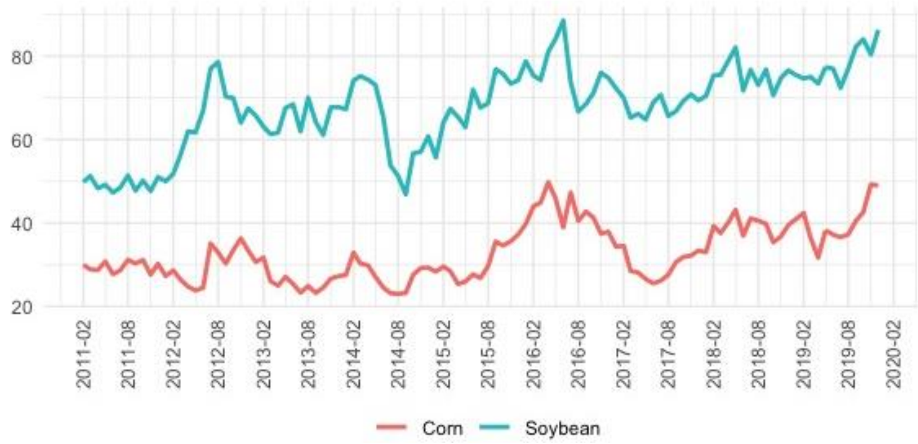

Figure 1. Corn and soybean future price trajectories

Source: Elaborated by the authors.

4. Methodology

4.1 Empirical Model

Starting from the theoretical model presented by Mundlack and Larson (1993), we incorporated in equation (3) the variables domestic interest rate, domestic GDP, oil price and the domestic price of the substitute commodity, in order to take into account other factors that may influence domestic commodity prices. We propose the following model to describe domestic commodity prices:

$$P_{it} = \beta_0 + \beta_1 P_{it}^* + \beta_2 E_t + \beta_3 R_t + \beta_4 GDP_t + \beta_5 OIL_t + \beta_6 P_{kt} + \varepsilon_{it} \quad (4)$$

Where:

P_{it}: is the domestic price of commodity i in t (for corn ($i = c$) and soybean ($i = s$));

P_{it}^*: is the external price of the commodity i in t;

E_t: is the exchange rate in t;

R_t: is the domestic interest rate at *t*;

GDP_t: is the GDP of Brazil at *t*;

OIL_t: is the price of oil at *t*;

P_{kt}: is the price of good *k* that substitutes for commodity *i* at *t*.

4.2 Autoregressive Distributed Lag (ARDL) Cointegration Analysis

To investigate the relationship between commodity prices, we used the autoregressive model with distributed lags ARDL (ARDL bounds testing approach of cointegration) developed by Pesaran et al. (2001), Pesaran (1997), Pesaran and Shin (1999) and Pesaran et al. (2001). The ARDL model for equation (4) can be expressed as:

$$X_t' = (P_{it}^*, E_t, R_t, GDP_t, OIL_t, P_{kt})$$

$$Z_t = (P_{it}, P_{it}^*, E_t, R_t, GDP_t, OIL_t, P_{kt})' = (P_{it}, X_t')'$$

$$\Delta P_{it} = \beta_0 + \theta_0 P_{it-1} + \theta_1 P_{it-1}^* + \theta_2 E_{t-1} + \theta_3 R_{t-1} + \theta_4 GDP_{t-1} + \theta_5 OIL_{t-1} + \theta_6 P_{kt-1} + \sum_{j=1}^{p} \psi'_j \Delta Z_{t-j} + \delta' \Delta X_t' + \nu_t \quad (5)$$

Where Δ is the first difference operator and ν_t is the model error. Model identification is based on the AIC, BIC (SC) and HQ information criteria.

The first step is to test a long-term relationship (cointegration) between the variables. The null hypothesis for "no cointegration" between the variables in equation (5) is:

$$H_0: \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = 0$$

which is tested against the alternative hypothesis:

$$H_1: \theta_0 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq 0$$

If the estimated value of the F-statistic exceeds the critical value of the upper limit, the null hypothesis is rejected, in which case a long-term relationship – cointegration – is established between the variables of the time series. If the F-statistic is less than the critical value of the lower bound, the null hypothesis was not rejected. If the value of the estimated F-statistic is between the lower limit and the upper limit, it cannot be inferred whether or not there is cointegration, since the integral degree of integration of the variable is unknown.

If there is evidence of cointegration between the variables, we can represent the long-term equation in level as:

$$P_{it} = \beta_0 + \beta_1 P_{it-1}^* + \beta_2 E_t + \beta_3 R_t + \beta_4 GDP_t + \beta_5 OIL_t + \beta_6 P_{kt} + \varepsilon_{it} \quad (6)$$

The next step is to estimate the coefficient of the long run relationship (Eq.6) identified in the first step. Finally, we employed the Error Correction Model (ECM) version of modified ARDL to investigate the short run dynamic relationships. The ARDL specification of the short-run dynamics can be derived by constructing an ECM of the following form:

$$\Delta P_{it} = \beta_0 + \sum_{j=1}^{p} \phi_j \Delta P_{it-j} + \sum_{j=0}^{q_1} \gamma_j \Delta P_{it-j}^* + \sum_{j=0}^{q_2} \delta_j \Delta E_{it-j} + \sum_{j=0}^{q_3} \alpha_j \Delta R_{t-j} \sum_{j=0}^{q_4} \varphi_j \Delta GDP_{t-j} + \sum_{j=0}^{q_5} \rho_j \Delta OIL_{t-j} + \sum_{j=0}^{q_6} \sigma_j \Delta P_{kt-j} + \psi ECT_{t-1} + \xi_t \quad (7)$$

Where the error correction term (ECT) in $t-1$ is defined as:

$$ECT_{t-1} = P_{it-1} - \beta_0 - \beta_1 P_{it-1}^* - \beta_2 E_{t-1} - \beta_3 R_{t-1} - \beta_4 GDP_{t-1} - \beta_5 OIL_{t-1} - \beta_6 P_{kt-1} \quad (8)$$

and ψ is the coefficient of the ECT that captures the speed of adjustment to long-term equilibrium.

5. Results

5.1 Unit Root Tests

After performing the descriptive analysis described in section 3.2, the price series were seasonally adjusted, deflated and their logs were taken. In addition, the exchange rate was log-transformed. Even if the ARDL approach for cointegration is used regardless of whether the variables are stationary at level, I(0), or at first difference, I(1), it is necessary to perform unit root tests to ensure that no series is being considered. stationary in second difference, I(2), since the presence of a variable I(2) makes the F-statistics computed to test the cointegrations invalid (Ibrahim, 2015).

In order to establish the order of integration of the series, the ADF, DF-GLS, PP and KPSS unit root tests were used. The results, presented in Table 2, showed that, with the exception of the inflation series, all the series considered had a unit root. However, none of the series was integrated with order 2, I(2), since they become stationary when we removed the first difference.

Table 2. Unit root tests of the series

Serie	ADF [(1)]	DF – GLS	KPSS	PP
ir	-2.36	-0.57	0.18	-4.92
Δir	-2.88	-2.544	0.46	-188
er	-2.23	0.475	0.0804	-2.29
Δer	-4.00	-1.308	0.135	-79.9
oil	-2.33	-1.226	0.203	-18.5
Δoil	-6.82	-4.876	0.0302	-87.6
P_c	-2.34	0.203	0.171	-5.86
ΔP_c	-4.80	-3.905	0.239	-126
P_c^*	-2.84	-0.353	0.113	-10.8
ΔP_c^*	-5.30	-3.197	0.202	-119
P_s	-2.00	0.821	0.217	-4.55
ΔP_s	-5.18	-3.917	0.198	-114
P_s^*	-2.41	0.314	0.179	-7.41
ΔP_s^*	-4.99	-3.405	0.181	-113
gdp	0.3761	-3.155	0.0397	0.15
Δgdp	-6.43	-1.820	0.0309	-119

*Note.*The series are in logarithm, with the exception of ir and er.

(1) Applied to test equations with intercept. Significance of 5% by the Modified Schwartz model.

(2) Applied to test equations with intercept. Significance of 5% by the Modified Schwartz model.

(3) The null hypothesis of the KPSS test is stationarity of the series. We used the estimation method of Bastlett Kernel with Newey-West Bandwidth and the Modified Schwartz model.

(4) For the PP test we used the estimation method of Bastlett Kernel with Newey-West Bandwidth and the Modified Schwartz model.

* , **, *** denote rejection of the null hypothesis at 10%, 5% and 1% and 1% significance, respectively.

After verifying the stationarity of the series that had a unit root, we chose the best models to be tested, based on the Akaike lag selection criterion (AIC). Considering the corn commodity, the selected model contains a lag in the price of corn traded in Brazil, a lag in the interest rate and a lag in the exchange rate, with the other variables being considered only contemporaneously, that is, $p = (1, 1, 1, 0, 0, 0, 0)$.

For the soybean commodity, the Akaike lag selection criterion (AIC) selected the model containing three lags in the variables price of soybean traded in Brazil and interest rate, one lag in oil prices, and three lags in oil prices and soybean prices traded in the United States, with the other variables entering the model only contemporaneously, that is, $p = (3, 3, 0, 0, 1, 3, 0)$.

In subsection 5.2, the results for corn and soybean future prices on the Brazilian Stock Exchange are presented.

5.2 Corn and Soybean Futures Prices

The results of estimates for future prices of corn and soybean traded in Brazil are shown in Table 3. We present the short-term and long-term coefficients, Wald's F-test and Pesaran's (2001) limit test, expressed through the t-test.

Table 3. Estimates for corn and soybean prices

	Dependent Variables:	
	P_c ARDL	P_s ARDL
P_{it-1}	-1.0117 ***	-2.2645 ***
	(0.0808)	(0.2159)
R_{t-1}	0.0426	0.0140
	(0.0337)	(0.0203)
E_t	-	-0.084978 ***
	-	(0.0166)
E_{t-1}	-0.0981	-
	(0.0727)	-
GDP_t	-0.1042	-0.1661
	(0.3762)	(0.1296)
OIL_t	-0.0829	-
	(0.0887)	-
OIL_{t-1}	-	0.04887
	-	(0.0372)
P_{it}^*	0.4756 ***	-
	(0.113035)	-
P_{it-1}^*	-	2.2867 ***
	-	(0.2348)
P_{kt}	0.3294 **	0.0099
	(0.1364)	(0.0333)
ΔP_{it-1}	-	0.6544 ***
	-	(0.1616)
ΔP_{it-2}	-	0.1858 **
	-	(0.085043)
ΔR_t	-0.0043	0.0104
	(0.0231)	(0.0079)
ΔR_{t-1}	-	0.0073
	-	(0.0129)
ΔR_{t-2}	-	0.0136
	-	(0.0082)
ΔE_t	-0.0332	-
	(0.049761)	-
ΔOIL_t	-	-0.0379
	-	(0.0301)
ΔP_{it}^*	-	0.9645 ***
	-	(0.0457)
ΔP_{it-1}^*	-	-0.6412 ***
	-	(0.1658)
ΔP_{it-2}^*	-	-0.1634 *
	-	(0.0913)
$Const$	0.0014	-0.0056 **
	(0.0065)	(0.0022)
Observtions	107	107
R^2	0.7381	0.9525
Adjusted R^2	0.7133	0.9437
F Wald test	36.593 ***	19.617 ***
t test:	-12.511 ***	-10.487 ***
Inferior Limit I (0)	-3.43	-3.43
Upper Limit I (1)	-4.99	-4.99
Alternative hypothesis and null values for both tests:		
Possible cointegration		
K	6	6
T	1000	1000
LM test	0.2722	1.0036
Durbin-Watson test	2.0562	2.1043

Note. * , **, *** denote rejection of the null hypothesis at 10%, 5% and 1% and 1% significance, respectively.

Source: Elaborated by the authors.

As can be seen in Table 3, there is a possibility of cointegration between the selected model and corn future prices traded on the Brazilian Stock Exchange, which would denote a long-term relationship between these prices and the considered model. Through the results, we identified the long-term influence of international corn prices, impacting by 0.47 at a 1% significance level on local prices.

In addition, domestic soybean prices exert a 0.37 influence on domestic corn prices. This is due to the characteristics shared between the two crops, such as competition for arable land, for example, and corroborates the findings of Ahumada and Cornejo (2016) that the incorporation of competing commodities would improve forecasting models. The adjusted R^2 of the estimated model explains 71.33% of the price formation.

As can also be seen in Table 3, it is possible there is cointegration between the selected model and the future prices of soybeans traded on the Brazilian Stock Exchange, which would denote a long-term relationship between these prices and the model considered. As in the case of corn, external soybean prices exert a long-term influence if a lag month is considered. In this case, local prices are impacted by 2.28% by international prices.

Considering the short term, this impact is 0.96 at a significance level of 1%, which would possibly validate the law of one price proposed by Mundlack and Larson (1993) since its coefficient is close to unity. With a one-month lag, external prices exert a short-term influence of -0.64 at 1% significance, where with a two-month lag this influence falls to -0.16 at 10% significance.

For soybean prices, the exchange rate of the real against the dollar exerts a long-term influence on the prices of soybeans traded in Brazil, having an impact of -0.08 at a significance level of 1%, which coincides with the results of Roberts and Schlenker (2010), who found that that the devaluation of the dollar tends to raise the price of commodities in dollars.

Through the adjusted R^2 of the estimated model, we verified that it explains 94.37% of the formation of future prices of soybeans traded on the Brazilian Stock Exchange and its comparison with the formation of corn prices traded there indicates how much soybean is more dependent on the international market than corn.

6. Conclusions

This research seeks to understand the determinants of the formation of the future prices of corn and soybeans traded at the Brazilian Stock Exchange by the degree of influence of external prices on domestic commodity prices. Therefore, the study used monthly closing prices of the continuous future contracts of these assets from February 2011 to December 2019.

To test the long-term relationships between the variables, it was used the Autoregressive Distributed Lag (ARDL) bounds test for cointegration (Pesaran et al., 2001). The empirical results showed a long-term relationship between domestic prices, exchange rates, and the international prices negotiated in the United States for both commodities. Furthermore, we observed that soybean prices are most affected by their international price in comparison to corn prices, hence, denoting greater integration in global supply chains. Lastly, in the short term, we found that soybean prices were affected by trading prices of the same commodity in the United States.

These findings are useful for researches interested in asset price formation, by providing evidence for corn and soybean futures contracts traded in Brazil, along with investors and portfolio managers who use commodities in their strategies, producers and agents in the supply chain, formulators of public policies related to the food, agricultural and energy sectors. As a suggestion for future research, the investigation of the formation of these prices from the perspective of computable general equilibrium models can be considered.

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