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# SOYBEAN MARKET IN PARANÁ, HEDGING USING FUTURES AND OPTIONS CONTRACTS IN BRASIL BOLSA BALCÃO - B³

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## Abstract

In this study, it is analyzed the importance and the possible utility of futures contracts and option contracts with financial settlement for hedging purpose, in soybean commodity, for region of Paraná, Brazil. We collected historical data regarding the applications of those two financial instruments in different commodities markets, the historical variability of the soybean price and its social-economic and importance for the region under analysis. The historical data about the use of these financial instruments, in different types of agricultural commodities, has proven the efficiency of those tools to mitigate the impacts of the unpredictability on price levels. Our findings suggest that both the futures contracts, in their different forms, and the option contracts are a possible alternative for efficient risk management for the soybean market in the Paraná region.



**Key-words: Risk Management, *hedging*, Futures contracts, Options contracts, soybean**


### Introduction

Brazil is the second largest producer of grains, bran and soybean oil in the world, being responsible for the supply of 35%, 26% and 26% of world demand, respectively. The country's main trading partner is the Chinese market, which accounts for 43% of global grain demand and 18% of soybean oil consumption. Brazil accounts for 25% of this supply, the rest of the national production being exported mainly to the Netherlands, France, Iran and India (Goldsmith, 2008; Marques, Mello & Martines 2006).

Due to the fact that exports are concentrated in one country (China), the Brazilian market becomes vulnerable to risks on the part of the producer, such as fluctuations in the price of the commodity, exchange rate fluctuations, fluctuations in the price of direct and indirect inputs, among others. This reinforces the need for efficient tools for mitigation and risk management (Demarchi, 2012).

Given the importance of soybean production for the Brazilian and Paraná economy, the present paper aims to carry out a review of the state of the art on the efficiency of risk coverage through the use of futures contracts and option contracts as hedging strategy tools for the agents of the soybean chain. From the academic perspective, this paper intends to contribute to a better understanding of the Brazilian agricultural derivatives market, having as main focus the soybean, making possible the realization of future different lines of research to compare different types of commodities in the Brazilian market or for the comparison on the behavior of soybean derivatives in different world markets. In turn, its importance to the market lies in the review of two risk management tools and their possibilities of real application.

In order to reach the objective, the paper was divided in 4 sections, besides the introduction and conclusion, as follows: in section 1 a succinct approach to the economic fundamentals of agricultural commodity prices, futures and option contracts markets. Section 2 briefly describes the soybean production market in the state of Paraná, Brazil. Next, the main pricing techniques for futures and option contracts are discussed in section 3 and section 4 deals with the main possible strategies to be used. It ends with a conclusion, where the opinions of the researchers are presented, resulting from the analysis of the work in question.

## 1. Theoretical framework

### 1.1. Economic fundamentals of agricultural commodity prices

Like other goods and services, the price of agricultural commodities is influenced by internal and external factors to the producing units. Among the internal factors we can mention the degree of technological innovation and the learning curve of the agricultural sector, pest control and harvesting techniques, and the quality of the inputs. In turn, the external factors are the basic costs, logistics, credit policies, inflation levels, climatic problems, seasonality, changes in population habit, among others. Importantly, unlike many other commodities, agricultural commodities historically have a high degree of volatility, which represents a greater difficulty in forecasting prices and consequently an increase in the risks associated with economic activity (Abreu, Medeiros & Werneck, 2003; Horngren, Datar & Foster, 2003; Mankiw, 2008; Varian, 2010).

Figure 1 shows the historical price variation of coffee, corn and soybeans, respectively (Lapp & Smith 1992; Marques, Mello & Martines, 2006).


Figure 1. CBOT historical price series for coffee, corn and soybean

Source: Macrotrends, 2019

From the analysis of the three graphs, it is possible to verify the existence of a high oscillation in the prices of commodities. This variability is one of the risks to which the members of the agribusiness productive chain are exposed and which are related to a multitude of factors, often beyond the influence of an isolated agent of the market, which increases the unpredictability about the possibilities future. For these reasons, it is interesting to manage these types of risks through the use of appropriate tools, such as hedging from futures and option contracts (Marques, Mello & Martines, 2006; CME Group, 2014; Varian, 2010).

Among the main contributions on the studies of the variables of influence on the indices of price in the bulk sector are the studies by Deaton and Laroque (1992). The results indicate that the practice of maintaining commodity inventories is an important factor for the formation and forecasting of prices of these commodities. During the research it was noticed the existence of a non-linear relationship between the behavior in the prices of the analyzed commodities and

the Competitive Storage Model. Another relevant study was that of Lapp and Smith (1992). The authors examined the influence of inflationary indices and the variability in the behavior of the prices of forty-seven agricultural commodities in the United States for the period 1962 to 1987. The results indicated a strong relation between inflation and the variation in prices, as well as the influence of macroeconomic policies (Lapp & Smith,1992).

The Chicago Board of Trade (CBOT), one of the largest commodity exchanges in the world and where the world soybean price is formed and signaled, states that the price calculation for this product is a latent variable whose value is determined by the fundamentals of supply and demand (CME Group, 2014).

### 1.2. The futures contract market

The formation of the market for futures contracts occurred from the need for a tool to reduce the uncertainties and risks in negotiations of products offered and purchased by farmers and merchants, respectively. Among the risks associated with the negotiation of these products we can mention the price volatility, the quality, the quantity to be delivered, the date and place of delivery, the actual delivery or payment (Carlton, 1984; Hull, 1995).

The solution initially was to carry out the negotiations based on the use of specific contracts between the parties, called Forward Market, in which the seller undertakes to deliver a defined quantity of a product, with a certain place, quality and price pre-defined. In this type of contract the clauses are not standardized, which entails four important consequences, as follows (Telser, 1981; Williams, 1982; Carlton, 1984; Marques et al., 2006):

(i) greater flexibility on the terms agreed between the seller and the buyer;

(ii) higher operating costs, arising from activities that are not the company's objective, such as the preparation of each contract, agreement on the price of each contract, credit analysis functions, legal procedures when failure to comply with the agreement by one of the parts;

(iii) physical delivery of the product is normally performed;

(iv) the need for trust between the signatory parties to the agreement.

The last three are the main points that bring less liquidity to the futures market because of the greater difficulty in selling the contract to a third party stakeholder.

The limitations imposed by the forward market, coupled with the interests of other members of the commodity chain in increasing the predictability of supply and demand, have led to the

emergence of a new type of futures market, organized markets, where contracts are standardized; payment and receipt are guaranteed by a clearing house, and the liquidation at maturity of the contract can be financial or physical delivery of product. The standardization of contracts allows individuals who do not have technical knowledge about the goods sold to participate in this market, since the quality and quantity of the products traded, and the date and form of settlement of the contract are pre-established. In turn, the figure of the clearing and settlement chamber supplies the need to know with whom the agreement is being made, since it becomes the guarantor of the fulfillment of the contractual obligations, being used for this the collection of Guarantee Margins and settings (Telser & Higinbontham, 1977; Telser, 1981; Williams, 1982; Carlton, 1984; Marques et al., 2006; Banco do Brasil, 2019).

The Guarantee Margin is a deposit amount in the form of a bond, required by the scholarships and accepted in the form of currency, Bank Deposit Certificate (BDC), Treasury Direct or shares, in order to guarantee settlement of the contract in case of one of the parties do not fulfill their obligations. The amount required to hedge the risks is calculated daily and is associated with market volatility, and buyers or sellers may be required to deposit more funds, which the market calls the "Margin Reinforcement". After deduction of all uncovered costs arising from the contract, the remaining margin value is returned to the depositor. Complementary to this practice, daily adjustments are amounts paid or received by the parties in accordance with the position taken and the value of the contract at the end of the day. If a futures market participant fails to meet its daily adjustment obligations, the required amount will be paid from the margin (Marques et al., 2006, CME Group, 2019b, ADVFN, 2019). These two characteristics are fundamental for the entry of new agents in the sector, who assume the positions of buyer, seller, hedger or speculator, which guarantees the liquidity of the system. In a simplified analogy, Telser (1981) states that forward contracts are for check, as are futures contracts for money, referring to the confidence and liquidity levels of the negotiations (Telser & Higinbontham, 1977; Telser, 1981; Williams, 1982; Carlton, 1984; Marques et al., 2006; Banco do Brasil, 2019).

To close a position of a future contract, the participant must take a position contrary to the initial, i.e. someone who bought a future contract and want to close the position must sell a contract with the same specifications or equivalent. The standardization of contracts facilitates this negotiation, with the negotiated price normally being the difference. This price difference between contracts is the arbitrage opportunity that market speculators seek to exploit, which generates liquidity to the system (Telser, 1981; Hull, 1995; Ferreira, 2009).

In Brazil, the market for futures and options contracts is governed by the official stock exchange, Brasil, Bolsa, Balcão (B3), which has among its attributions "trading services (stock exchange), post-trading (clearing), over-the-counter registration [...] "(B3, 2019a). The traded commodities are sugar crystal, beef cattle, arabica coffee 4/5, arabica coffee 6/7, anhydrous ethanol, hydrated ethanol, corn, gold, oil and soybeans (B3, 2019b). Table 1 shows the technical characteristics of the future soybean contract traded on the Brazilian stock exchange[1].

Table 1

Soybean futures contract with financial settlement

| Soybean futures contract with financial settlement | |
|---|---|
| Trading object | Soybeans in bulk, export type, with the following maximum limits: 14% moisture; 1% foreign material and impurities; 30% of broken; 8% greenish; 8% defective, of which up to 6% of moldy grains, up to 4% of burned and burned grains, up to a maximum of 1% can be allowed; and 18.5% oil content. |
| Trading Code | SFI |
| Contract size | 450 bags of 60kg liquid (equivalent to 27 metric tons). |
| Price | United States dollars per bag, to two decimal places. |
| Minimum price fluctuation | US$0,01. |
| Standard Lot | 1 contract. |
| Last trading day | 2nd business day prior to the month of maturity. |
| Due date | 2nd business day prior to the month of maturity. |
| Months of maturity | March, April, May, June, July, August, September and November. |
| Settlement at maturity | Financial. |

Source: Brasil, Bolsa, Balcão (B3), 2019c

### 1.3. The options market

The options market began in the sixteenth and eighteenth centuries. From this period until the beginning of 1970, the option contract was considered as a kind of betting instrument on market price fluctuation, in which the option buyer limits his loss to the premium paid, while the possible gains would be numerous times higher (Poitras, 2009). This exaggerated belief on the part of

[1] The complete agreement can be consulted at http://www.bmfbovespa.com.br/en/produtos/listados-a-vista-e-derivativos/commodities/futuro-de-soja-com-liquidacao-financeira.htm

the members of this market is justified by the nature of the option contracts, in which the contract holder earns for himself the right, but not the obligation, to buy or sell the goods at a predetermined price, for delivery at a future date, by paying a premium on the acquisition of the contract. The holder of these rights assumes a position known as long and has the possibility to resell them to a new stakeholder, by premium agreed between the parties. On the other hand, the seller of the option contract assumes a position known as short and limits its gains to the value of the premium, while assuming the risk of unlimited losses, since it assumes the obligation to buy or sell the goods for the amount determined in the contract of option if it is executed. For this reason, the issuer of an options contract is required to deposit a guarantee equivalent to that of negotiating future contracts (Mackenzie, 2006; Poitras, 2009).

With the publication in the early 1970s of Black and Scholes's work on option pricing theorems ("Theory of Rational Option Pricing" and the "Black-Scholes Formula"[2], there was a change in the perception of market agents about options contracts, which until then were seen as a betting instrument. Black and Scholes demonstrated how these contracts could be used as a risk management or investment (arbitrage) instrument, in addition to speculation. For the organized option market this change meant the entry of new participants, which led to an increase in liquidity and the consolidation of options as another financial engineering tool (Black, 1975; Donald Mackenzie, 2006; Poitras, 2009).

These types of contracts can be found on different organized exchanges, the largest being in the commodities sector, including soybeans, the CBOT, belonging to the CME Group (CME Group, 2019a). In Brazil these contracts are traded in Brasil, Bolsa, Balcão (B3). Table 2 represents a soybean option with financial settlement negotiated in B3 (B3, 2019d).

[2]Later enhanced and renamed Black-Scholes-Merton Formula.

Table 2

Soybean option contract with financial settlement

| | |
|---|---|
| Trading object | Soybeans in bulk, export type, with the following maximum limits: 14% moisture; 1% foreign material and impurities; 30% of broken; 8% greenish; 8% defective, of which up to 6% of moldy grains, up to 4% of burned and burned grains, up to a maximum of 1% can be allowed; and 18.5% oil content. |
| Trading Code | SFI |
| Option style | American[3]. |
| Contract size | 450 bags of 60kg net (equivalent to 27 metric tons). |
| Price | Option premium, expressed in United States dollars per bag, to two decimal places. |
| Minimum price fluctuation | US$0,01. |
| Standard Lot | 1 contract. |
| Last trading day | Business day before expiration date. |
| Maturity date. | Second business day prior to the month of maturity. |
| Months of maturity | March, April, May, June, July, August, September and November. |
| Settlement | On the maturity date, the exercise of the option is performed automatically by B3, subject to the following conditions:<br>Call option:<br>a) If the result of the difference between the settlement price of the underlying asset and the exercise price, for the principal holder, is positive; and<br>b) The principal does not register in the trading system his intention not to exercise his call on the due date.<br>Put option:<br>a) If the result of the difference between the exercise price and the settlement price of the underlying asset, for the principal holder, is positive; and<br>b) The titular principal does not register in the trading system his intention not to exercise his put on the expiration date. |

source: Brasil, Bolsa, Balcão (B3), 2019d

The possibility of finding these financial instruments in different places is possible because the understanding of what options contracts are homogeneous, as can be seen from the comparison of how scholars and different financial institutions define this concept.

Hull (1995) defines the option contract as

[3] American-style contracts allow the same to be settled at any time prior to its expiration.

> "The options are fundamentally different from forward or futures contracts. An option gives the holder of the option the right to do something. The holder does not have to exercise this right. By contrast, in forward or futures contract, the two parties have the committed themselves to doing something. Whereas it costs nothing (except for the margin requirements) to enter into a forward or futures contract, the purchase of an option requires an up-front payment." (p. 172)

For Banco do Brasil, the option contract "[...] guarantees the 'right' to buy or sell a certain product at a fixed price until a future date, upon payment of a premium, at the time of purchase of the contract. There are no daily adjustments and margin of guarantee. "(Banco do Brasil, 2019). In turn, the Lisbon Stock Exchange states that "There are two types of option contracts: call options and put options. A call option entitles the buyer to acquire the underlying asset, while a put option confers the buyer the right to sell the underlying asset." (Lisbon Stock Exchange, 2019).

## 2. The soybean market in Paraná

The state of Paraná, located in the southern region of Brazil, is the largest soybean producer in the South region and the second largest producer in the country. During the harvest of 2017/2018 the region accounted for 16.29% of the country's total production of the commodity, with a total value of 116.996 million tons (EMBRAPA, 05/2018).

The soybean complex began in Brazil in the 1960s and was adopted by the state of Paraná 10 years later in 1970. The evolution from good land management, the development and application of new technologies and the search for optimization of production efficiency meant that, almost 50 years after the start of activities, the harvest in the state increased from 0.37 million tons in 1970 to 19.07 million in 2018 (Flaskerud, 2003; Demarchi, 2012; EMBRAPA, 2018). Production in the state comes mostly from small farmers, who seek agricultural credits partly through government programs, but mainly from financial tools, such as the Agricultural Credit Letter (ACL), cooperatives, input suppliers and equipment, and of companies consuming soy and its by-products with the use of forward contracts (OTC) (Bulhões, 2007; Flaskerud, 2003; Marques et al., 2006).

The soybean plantations found in the region can be classified into two types of planting, traditional and organic. In traditional planting, soybeans are used, which can be genetically modified (GMO) or non-genetically modified (N-GMO), synthetic fertilizers and pesticides to improve productivity and control pests. In turn, organic farms are those where chemical

products are not used in the maintenance of soybean plantations, so it is necessary to hire more labor to maintain pest control (Kamali, Meuwissen, de Boer, van Middelaar, Moreira, & Lansink, 2017). The system of organic planting presents, on average, a greater profitability when compared to the traditional system of planting. However, the farmer who opts for this modality is more exposed to the risk, since it has a greater variability in prices. One of the options for the management and mitigation of these risks is the use of hedge tools (Kamali et al., 2017).

For the state's economy, the soybean industry has become an important member of the agribusiness productive chain. Among the directly affected members of the chain we can mention chicken producers, animal feed industry, soy oil extracting industries, milling companies, agricultural cooperatives, transport companies, suppliers of raw material and equipment. In turn indirect impacts can be perceived from social reflexes, improvement in the quality of life of the population, increased search for better educational levels, such as higher education and specialization, especially in areas related to the agro industrial sector (Madureira & Rippel, 2014).

Figure 2 represents the historical series of the soybean grains production in the state of Paraná for the period1995 to 2017. From Figure 2 it is possible to verify the growth in the production volume in the state of Paraná, whose value was tripled in the period of twenty years, which evidences the growth of the sector.

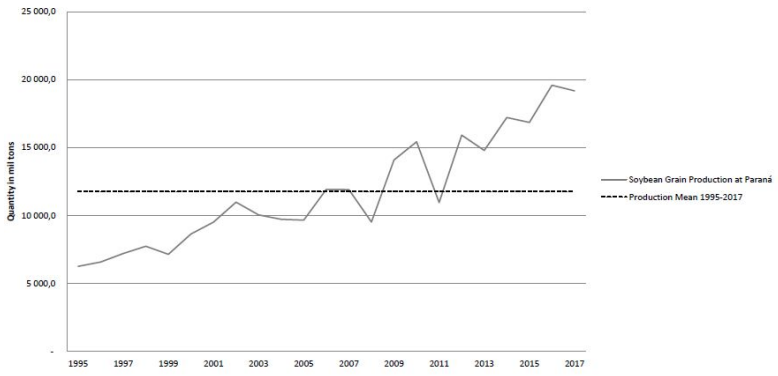


Figure 2. Historical series of soybean production in the state of Paraná (Brazil) from 1995 to 2017.

Source: prepared by the author, based on data from Companhia Nacional de Abastecimento (Conab), 2019 and Banco Central do Brasil, 2019

The figure 3 exhibit the annual price of soybean grains in the state of Paraná for the period of 1995 to 2017. The graph shown in figure 3 allows us to easily visualize the existence of peaks and valleys with different amplitudes. Due to this price variation, associated with the growth of the soybean production sector, the use of risk management instruments may be interesting.

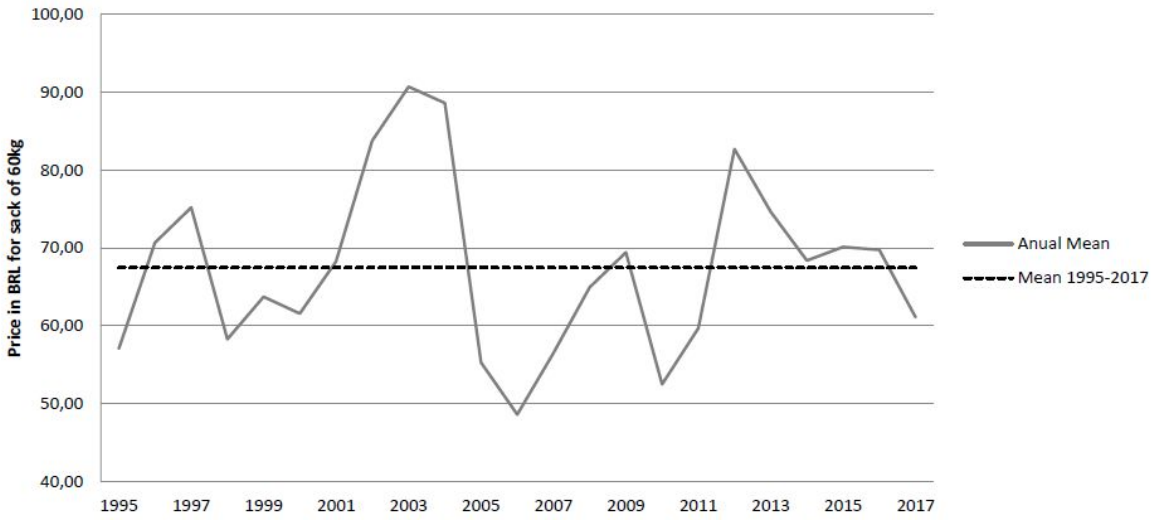


Figure 3. Historical series of soybean grain prices in the state of Paraná (Brazil) from 1995 to 2017.

Source: prepared by the author, based on data from Secretaria da Agricultura e Abastecimento (SEAB-PR), 2019 and Banco Central do Brasil, 2019.

In Paraná, transportation of grain production is carried out mostly through highways, in bulk trucks. The modality used has a direct impact on the basic value for the soybean price, being responsible for approximately 7% of the price paid by the international markets (Silva-Neto, Rocha, Pera & Caixeta-Filho, 2014).

The exchange rate variation should be taken into account for the strategies adopted by the producers of the region and for the clients of that area, in order to mitigate risks and maximize profits, since this variation affects both the sales prices of soybeans and the cost of production inputs (Marques et al., 2006). In the state there are four commodities exchanges registered by the Companhia Nacional de Abastecimento[4] (CONAB). They are non-profit institutions that aim to foster systems and tools that stimulate and improve the commercialization of goods, services

[4] National Supply Company

and rights. These are as follows (BBM, 2019; BCMM, 2019; BCML, 2019; Noticias Agrícolas, 2019):

- Associação Nacional das Bolsas de Mercadorias e Cereais[5]- ANBM;
- Bolsa Brasileira de Mercadorias[6] – BBM/PR;
- Bolsa de Cereais e Mercadorias de Maringá[7] - BCMM;
- Bolsa de Cereais e Mercadorias de Londrina[8] - BCML.

## 3. Soybean futures and options pricing techniques

The analysis of prices for the futures markets has two main analyzes, the technical or graphical analysis and the fundamental analysis. The professionals in this market are based on these two tools, usually using one of them as a basis for decision making and the other as a complementary data source for the confirmation or reanalysis of the decision (Marques et al., 2006).

Users of fundamental analysis are concerned with factors that may influence the price of a stock or commodity, such as the company's financial health, historical supply and demand series, market trends, weather factors, and stock levels. This information forms the basis for the decision of what is to be bought or sold and at what price (Marques et al., 2006; Harrington, 2003). In turn, the technical analysis proposes the forecast of future price trends from the market movements, with the aid mainly of graphical resources. This information forms the basis for deciding when to buy, sell or hold a position in the market and is more appropriate than the fundamentalist analysis when the period analyzed is relatively short (Marques et al., 2006; Harrington, 2003; Lemos, 2017).

Other tools used to try to predict futures and options contracts prices are, for example, the Black-Scholes-Merton Theory of Options (BSM), econometric series, use of financial mathematics, Random Walk Theory, Stock Theory, Put-Call Parity, among others (Ferreira, 2009; Hull, 1995; Deaton & Laroque, 1992; Black, 1975; Marques et al., 2006).

[5] National Association of Stock Exchanges and Cereals
[6] Brazilian Commodities Exchange
[7] Cereals and Commodities Exchange of Maringá
[8] Cereals and Commodities Exchange of Londrina

3.1. Techniques for forecasting prices of soybean futures contracts

The price forecasting techniques of futures contracts have been studied in different business areas, either with the objective of reducing uncertainties and managing risks or by the possibility of gains from the inefficiency of the markets and the possibility of arbitrage. Its importance is relevant mainly in markets with a high degree of randomness and, consequently, uncertainties, such as agribusiness and commodity marketing (Williams, 1982; Bressan, 2003; Poitras, 2009).

Hull (1995, p. 72) demonstrates the equation for commodities of non-investment, with possibility of gains for convenience, as being (equation 1):

$$F = Se^{(r+u-y)T} \quad (1)$$

At where, F: Future price; S: Spot Price; $e$: Neperian number; r: Risk free rate; u: Proportional constant of storage costs brought to zero time; y: Gains for convenience; T: Time

Equation (1) is one of the possible tools for forecasting future soybean prices. Other forecasting possibilities include: (i) the search for information on the fundamentals of the soybean market, such as world supply and demand levels, stock levels, country risk of major producers and consumers of the product, official reports on the soy market and related markets, climatic factors in producing countries, historical series of prices, among other information that the analyst deems relevant (Marques et al., 2006); the use of quantitative tools with the analysis of time series. Among the most well-known models we can mention Integrated Mobile Average Autoregressive (ARIMA), Structural Models, Bayesian Models and Neural Networks Models (Bressam, 2003; Marques et al., 2006). Table 3 provides a summary of the quantitative models previously mentioned.

Table 3

Summary with the possible quantitative models to estimate the price of soybean futures contracts

| Model | Main Features |
|---|---|
| Autoregressive - Integrated - Moving Average (ARIMA) | It is based on the premise that it is possible to perform modeling to predict a non-stationary time series. In order to do this, we perform non-stationary process differentiations, the inclusion of an autoregressive component and the inclusion of a moving average component |

| Model | Main Features |
|---|---|
| Linear Dynamic Structural | This model allows new information to be incorporated into the calculated parameters, adjusting the time series to the new scenario. The parameters are the trend, the cycle, the seasonality and an irregularity component, calculated from the likelihood function. |
| Linear Dynamic Bayesian | Analogous to the Linear Dynamic Structural model, with the difference that the parameters are calculated from iterative methods. The main characteristic of this model is the adaptation of the series to stochastic shocks (abrupt variations in mean and variance). |
| Artificial Neural Networks (ANR) | Non-parametric models involving learning algorithms. Its purpose is to simulate human neural networks, with the aim of replicating behavior patterns over a time series. |

Source: prepared by the author, based on Bressam (2003)

Bressam (2003), states that the results indicate a potential for practical application of quantitative models, especially the predictive capacity of the Dynamic Structural (or Classical) Model.

### 3.2. Price forecasting techniques for soybean options contracts

Analogous to the motives that drive the development of tools to increase the accuracy of price forecasting for futures contracts, option market professionals look for models and analyzes with greater predictive power than the premium value of an option (CME Group, 2014).

The premium value of options contracts is formed from two main components, called Intrinsic Value and Time Value. The Intrinsic Value corresponds to the amount that can be acquired from the exercise of the option, that is, the difference between the exercise price and the spot price. In turn, Time Value (also called Bet Value) is calculated from the expectation of market movements, with parameters such as the volatility of underlying assets and risk-free interest rates, and the time to expiration of the option (time to maturity of the option). Therefore, the main factors affecting the prices of commodity options contracts are: (i) Supply and Demand of the option contracts; (ii) Spot price of the underlying asset; (iii) Exercise price of the option; (iv) Time to expiration of option; (v) Volatility in the price of the underlying asset (CME Group, 2014; Ferreira, 2009; Hull, 1995; Marques et al., 2006). Table 4 presents a summary of the premium value of the options, intrinsic value and time value.

Table 4

Price value of options and their components

| Variable | Definition | Calculation Form | Example |
|---|---|---|---|
| Intrinsic Value | Value resulting from the difference between the exercise price of an option (X) and the underlying assets' spot price (S). | max (S-X; 0) for Call<br>max (X-S; 0) for Put | An option contract for the purchase of a soybean bag for $10.00. The spot price of a sack of soybeans at this time is $12.00. Therefore, the intrinsic value of this option contract is $2.00 ($12.00 - $10.50). |
| Time value | Value resulting from the expectation of market agents on the future value of the asset. The time value decreases to the value 0 (zero) on the option's maturity date and its value is maximum, for each time t, when the option is At-the-Money (ATM). | Statistical tools for calculating the probability of a favorable scenario, taking into account the standard deviation, price variation, interest rate and time to maturity of the option. One such tool is the Monte Carlo Simulation Method (MMC) | An option contract for the purchase of a soybean bag for $10.00, with the possibility of exercise only on the maturity date, is being traded for $10.50 on the stock exchange. The spot price of a sack of soybeans at this time is $9.00. Since the spot price is less than the exercise price of the option, the intrinsic value is zero. Therefore, the time value of this option agreement is $0.50 ($12.00 - $10.50). |
| Option Price | Also called the option premium, it is the value that the buyer of an option contract pays to the issuer of this agreement to obtain the right, but not the obligation, to buy the asset for a certain price. Its value is the sum of two components, the intrinsic value and the time value | Option Price = Intrinsic Value + Time Value | An option contract for the purchase of a soybean bag for $10.00, with the possibility of exercise only on the maturity date, is being traded for $10.50 on the stock exchange. The spot price of a sack of soybeans at this time is $10.20. The intrinsic value is $0.20, while the time value of this option contract is $0.30. |

Source: elaborated by the authors, based on CME Group, 2014 ; Hull, 1995; and Ferreira, 2009

From the calculation of the intrinsic value of an option, it is possible to classify its position. Hull (1995, p.181) uses three main classifications:

- In-The-Money (ITM): when the immediately exercise of this option will generate a positive cash flow for its holder;

- *At-The-Money (ATM)*: when the immediately exercise of this option will generate a neutral cash flow to its holder;
- *Out-Of-The-Money (OTM)*: when the immediately exercise of this option will generate a negative cash flow to its holder.

Usually the OTM options are cheaper than the ITM and ATM options, since their intrinsic value is zero, leaving only the time value. Consequently, an OTM option for a commodity with a high degree of volatility may generate greater profits for speculators (Ferreira, 2009).

Thus, since the intrinsic value corresponds to the difference between the exercise price and the market price at a given time t, and is known, then the time value of the option remains to be calculated. For this, methods and models were developed from different areas of knowledge, such as mathematics, physics, economics, finance, psychology, among others (Ferreira, 2009).

Among the main techniques we can highlight the Black-Scholes-Merton models, Cox binomial tree, Ross and Rubinstein, Hull-White, Wiggins, Stein-Stein, Heston, Eisenberg-Jarrow, Bates multiple factors, Heston- Nandi. In addition to the models mentioned above, option market analysts have the possibility of using computational resources such as Monte Carlo Simulation, Neural Networks, Hybrid Neural Networks and Monte Carlo Simulation, Dynamic Linear Models and Analysis of Historical Series (Black, 1975; Buliali, Fatichah, & Susanto, 2009; Ferreira, 2006; Ferreira, 2009; Hull, 1995; Jabbour & Liu, 2005).

## 4. Risk Management and Hedging Strategies with Futures and Options

Risk management and the degree of exposure that companies, individuals and governments are willing to assume is a subject of study in different areas of research, with the aim of improving the predictability of future events and decision-making. The forms of risk analysis depend on the period to be analyzed. In a general way, it can be said that for short-term forecasts, the future will be a reflection of past events; for medium-term forecasts the forecast is based on the experience, probability of occurrence and simulation of scenarios; for the long-term forecast are analyzed the fundamentals of the object of study (Almeida, 2011; Moreira, 2009).

After the risk analysis, the manager must take a position. Committee of Sponsoring Organizations of the Treadway Commission - COSO - (2007), segments the response in relation to risk in five categories, according to table 5.

Table 5

Risk response

| Risk response | Definition |
|---|---|
| Avoid | Discontinuation of the activities that generate the risks. Avoiding risks may involve discontinuing a product line, declining expansion into a new geographic market, or selling a division. |
| Reduce | Measures are taken to reduce the likelihood or impact of the risks, or even both. Typically, this procedure covers any of the hundreds of business decisions on a day-to-day basis. |
| Share | Reducing the likelihood or impact of risks by transferring or sharing a portion of the risk. Common techniques include acquiring insurance products, performing headline transactions, or outsourcing an activity. |
| Accept | No measures are taken to affect the likelihood or degree of impact of the risks. |

Fonte: *COSO*, 2007

In agribusiness risks can be classified into four groups, as follows (CME Group, 2014; Marques et al., 2006; Moreira, 2009):

- Financial risk - this is the risk of currency fluctuations, interest rates (national and international) and liquidity to honor short-term commitments. The management of this risk class can be carried out from an ideal structure of assets and liabilities, and the use of futures contracts and options;
- Institutional risk - is due to the uncertainties related to the policies imposed by the governments that reflect in the operation of production and distribution. Agricultural credit policy, health regulations, and import and export policies are examples of this type of risk. In general, the members of the agribusiness production chain do not have direct means to manage it;
- Production risk - is related to the uncertainty arising from the variables that affect the level of productivity, and are usually unpredictable. The main variables of this type of risk are climatic variations, pests, diseases and natural disasters. Management can include the use of genetically modified (GMO) seeds to resist diseases, pests and climatic variations and the use of technologies for natural disaster prediction;
- Market risk - is associated with the variability in the prices of products and services in the agribusiness production chain, such as the sales value of soybeans, the purchase cost of agricultural pesticides or the cost of transporting the beans. Goldsmith (2008), in his work on the production and processing of soybeans in Brazil, states that "*Month-to-month variability in prices and the level of correlation among prices are primary sources of*

*uncertainty for processors. Soybean oil prices are 60% more variable from month to month than soybean meal, and 20% more variable than soybeans*“(p. 793). To reduce risk exposure, one of the available tools is the use of hedging.

Within the four risk classifications, two are subject to right control by the parts through the use of futures and options contracts in their different forms in order to conduct hedging transactions. The hedge in turn is defined as a risk hedging operation against the fluctuation of prices, interest rates, currency fluctuations, etc., in which is the cash flow is predetermined. Its effectiveness is determined by offsetting the variations between exercise prices and spot prices (Comissão de Valores Mobiliários, 2009).

In agribusiness, when a hedge transaction is carried out, there is a risk transfer of the spot market price for the base risk. For this reason, it is important to have data on the historical basis of the region under analysis in order to improve the accuracy of forecasting future commodity prices and to perform more effective risk management (CME Group, 2014; Franco, Neto & Machado, 2016; Maia & Aguiar, 2010; Marques et al., 2006).

In the case of soybeans, the spot market price is defined by two components, the future price indicated by CBOT and the physical price in the producing region. The price calculated for the physical market is "the future price adjusted by variables such as freight, handling, storage and quality as well as local supply and demand" (CME Group, 2014, p. 11). The difference between these prices is called the base value, as shown in equation (2) (Hull, 1995; Marques et al., 2006).

$$\text{Base value} = \text{Spot price} - \text{Future price} \quad (2)$$

Based on the concepts presented by Franco et al. (2016) and CVM Resolution 604 (CVM, 2010), in order for a risk management operation based on the use of agricultural commodity hedge to be effective, a better quality is and the choice of the appropriate strategy.

In order to minimize the exposure of market agents to risk, the degree of hedge effectiveness is associated with the strategy adopted, which in turn depends on factors such as the type of commodity traded; the stock exchange on which contracts are made; price analysis methodology and the region of production, the latter being responsible for the base risk (CME Group, 2014; Ferreira, 2006; Hull, 1995; Tauser & Cajka, 2014)

The change in the value of the base can be characterized in two distinct ways, the strengthening or the weakening. In the first case the local price increases in relation to the future price, favoring the sellers. Similarly, the second case is when the local price decreased

in relation to the future price, favoring buyers (Hull, 1995; CME Group, 2014; Marques et al., 2006; Maia & Aguiar, 2010).

Several studies on different types of commodities have been developed with the objective of verifying hedging efficiencies and different analysis tools. In the coffee sector, we highlight the work of Fileni, Marques and Machado (1999), in which researchers found a risk reduction, from the use of hedging, of 75% for the Triângulo Mineiro region, 80% for the Alto da Paranaíba and a low effectiveness in the coverage of risk for the region of Zona da Mata, all located in Brazil.

For the soybean market the studies of Maia and Aguiar (2010) showed the importance of knowing the producer region, since the baseline risk index presented values between 0.20 and 1.51, according to the observed location. The index was calculated from the ratio between the standard deviation and the average of the monthly base variations, and serves as an indicator of effectiveness in the hedging application.

From the data on which commodity and region the hedge will be carried out, it is necessary to choose which tool will be used to calculate the optimal Hedge Ratio (OHR). This indicator shows the theoretical proportion between spot contracts and futures contracts (or option contracts) that a hedger must maintain in its portfolio to hedge against price volatility (Black, 1975; Marques et al., 2006). Baillie and Myers (1991) suggest the use of the Bivariate Generalized Autoregressive Conditional Heteroskedastic (BGARCH) to calculate the OHR of six different commodities, with emphasis on the soybean cultivars, which presented a 57% reduction of variance for the case studied. Haigh and Holt (2000) compute the OHR from the GARCH Multivariate method (MGARCH), comparing its effectiveness with the ordinary least squares (OLS) and seemingly unrelated regressions (SUR) methodology for commodity freights. The results indicate a superiority of the MGARCH method over OLS and SUR, even when including operating costs for hedge correction.

Alizadeh, Nomikos, and Pouliasis (2008) evaluate the hedging effectiveness from the relationship between OHR and the "market state" with the aid of MGARCH and the Markov Transactional Regime model in a study of three petroleum-derived commodities. The results indicate a significant improvement for most cases, being a viable and advantageous option for the hedger. Lien, Shrestha and Wu (2016) developed a study of OHR from the segmentation and quartile estimation as an alternative to the most used methods, such as the Minimum Variance. The results obtained, after analysis of twenty different commodities, suggest that traditional Hedge Ratio techniques are more effective for long periods. In the case of

agricultural commodities, such as soybean, the results are inconclusive, sometimes being more efficient and sometimes less efficient than the minimum variance method.

In the studies on live cattle market, the recent work of Pinho, Araujo Júnior and Camargos (2017) on the OHR analysis for futures markets and its effectiveness from six models stands out. The results indicate a low optimal hedge ratio for daily series. However, for the monthly series, the BEKK model presented the best performance for variance reduction and optimization of the Sharpe Index.

After knowing the commodity, the region of production and choosing the methodology of analysis of the OHR that best suits that reality, the hedge must choose which strategy will be used. Among the most common are (CME Group, 2014; Hull, 1995; Marques et al., 2006; Taušer & Čajka, 2014):

- Use of forward contracts;
- Maintenance of a portfolio containing forward contracts, spot contracts and inventory;
- Reversal of position in the futures market (simultaneous buying and selling of similar futures contracts);
- Purchase of options contracts.

## Conclusion

The present paper aimed to evaluate the importance of the use of risk management tools for the members of the soybean complex production chain in the state of Paraná, Brazil. The financial instruments chosen for analysis were futures contracts and option contracts with financial settlement. In order to perform the analysis, data were collected regarding the historical variability of the commodity price and its economic and social importance for the region.

The data indicate the existence of sharp peaks and valleys for the price variation, which characterizes one of the types of risk to which the agents of this market are exposed, especially the market risk. The literature on the use of these financial instruments on soybean and other agricultural commodities has shown the efficiency of these tools to mitigate the impacts of the unpredictability on price levels.

Therefore, both the futures contracts, in their different forms, and the option contracts proved to be a possible important alternative for efficient risk management. For future work, it is suggested to evaluate the efficiency of these instruments for the soybean commodity in the region surveyed.

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