



RISK ANALYSIS MODEL AND AGRICULTURAL DERIVATIVE MARKET USE

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ABSTRACT

This research aims to build conceptual guidelines regarding price risk management through the agricultural derivatives market. Specifically, to identify the common price risk management methods and strategies employed, the risk analysis models of derivative markets, and the barriers to agricultural risk management. This is an integrative review, the search for literature on the models of risk management analysis of agricultural derivatives started by listing the largest possible number of keywords on the topic, in the Scopus and Web of Science. Forty-five publications were found meeting the pre-established criteria that served as the basis for this research. Based on the literature review, we list the main information on the subject and we also propose a theoretical model for analyzing the market risks of agricultural derivatives. Still, it was possible to notice that among the methodologies for measuring market risk, Value at Risk (VaR) stands out. We exemplify and demonstrate the existence of several statistical analyzes and mathematical models, as well as software available for the management of price risks. It is concluded that strategies with the futures and options market, even though they are the most efficient for risk management, lack incentives to become practical.

Keywords: market risks; forward market; future market; options market; hedge



1. INTRODUCTION

The idea of risk is associated with an event that implies some loss or damage and that can occur with some probability. It implies the existence of some uncertainty, but, unlike the latter, the term "risk" emphasizes the loss or negative part of the uncertainty. Sometimes, these two terms are used as differentiated: risk implies knowledge of some probabilities associated with an uncertain event, while uncertainty is applied to situations in which the probabilities are not known (Antón et al., 2013).

Agricultural production has particular characteristics when compared to other economic activities. One of the most striking is the extent and nature of the risks to which it is exposed since it includes biological processes subject to weather, pests, and diseases. In addition, the primary activity is also subject to risks inherent in other sectors, such as price fluctuations, political instability, and difficulty in accessing credit (Finger & Waquil, 2013).

Unlike others, the agricultural sector is known for presenting constant variations in product prices, due to exogenous factors, related to production, climate forecasts, exchange rates, internal consumption, and availability of related goods, with the need for means of protection against these variations (Calegari et al., 2012).

On the other hand, the major problem in the sector today concerns the property management process, the managerial incapacity of these companies, organizational weakness, and the presence of very ingrained practices and customs. Some authors have found that decisions are often made based on feeling and without planning, that is, improvised.

The way in which producers finance the purchase of inputs for production is another factor that generates extra costs and uncertainties. The input companies, through barter operations, sell inputs in exchange for future production, with the help of a futures contract, an interesting mechanism for financing production.

In relation to the market, agricultural derivatives help producers to manage their businesses, making them more secure. Obviously, the adoption of risk management for companies is essential, whether they are linked to agricultural production, commerce, industry, distribution, financial institutions, or agribusiness.

It is also worth noting that the management of rural properties is essential for business continuity, and the adoption of risk management is vital for the profitability and success of projects.



It is well known that agriculture has always been exposed to a wide spectrum of risks. More volatile agricultural and input prices, climate change, ongoing discussions about the future of agricultural policies, increasing difficulty in finding skilled agricultural workers, and growing criticism of modern intensive agriculture by the general public and the mass media are just some of the risks that farmers need to face. Therefore, risk management has become highly relevant in agriculture, and understanding the types of risks and their management in an interconnected way is essential.

In this context, this article aims to build conceptual guidelines regarding price risk management through the agricultural derivatives market. The objectives of this study are, therefore, to review the existing literature to identify (1) the common price risk management methods and strategies employed, (2) the risk analysis models of derivative markets. and (3) barriers to agricultural risk management.

This article presents the literature review following the conceptual or thematic structure. For Torracco (2016) the conceptual structure is organized around the main concepts of the review topic. Visual representations, such as concept maps, chronological schedules, maps or relationship diagrams, and other figures, make it easy to demonstrate how the review is organized.

2. A LITERATURE REVIEW ON RISK MANAGEMENT

Although rural producers are efficient in all production processes, that is, in the purchase of inputs and technologies, in the production and marketing of their products, they are still exposed to risks. In this context, understanding the ways to mitigate risks by rural producers can be found through current and relevant literature on the management of agricultural risks found in different databases.

The search for literature on risk management analysis models for agricultural derivatives started by listing as many keywords as possible using terms such as “agricultural derivatives”, “agricultural price risk”, “agricultural risk management”, “agricultural future market ”and“ agricultural options market ”,“ barter operations”, "risk analysis mode";"Value-at-Risk (VaR)";"risk analysis databases" in English, in the Web of Science - WOS and Scopus databases.

For each keyword, the following inclusion process was adopted to guarantee the quality of the manuscripts for analysis: 1) the articles should be published in journals that contained an impact factor and or a relevant H factor on the theme, as shown in Table 1; 2) selected



manuscripts should focus on agricultural derivatives and/or agricultural risk management; 3) older articles were also included in order to analyze the historical context of publications on the subject; 4) Publications that meet the previous criteria were selected for integrative review, regardless of the academic discipline for which they were written.

In the exclusion criterion, it was decided to exclude: 1) articles from journals that do not contain an impact factor and/or a recognized H factor; 2) an article whose theme is outside the focus of the subject under debate.

Below we present the findings according to the keywords, the main international journals that contribute with publications on agricultural risk management and agricultural derivatives.

Table 1: International journals that publish on the theme

"AGRICULTURAL DERIVATIVES"		
Author(s)	Periodicals	Impact Factor
Clapp, Helleiner, 2012	<u>Review of International Political Economy</u>	2.312
Guilleminot, Ohana, Ohana, 2014	Agricultural Economics & Policy	2.263
Porth, Assa, 2015	Agricultural Finance Review	1.19
Assa, 2016	Agricultural Finance Review	1.19
Calegari, Baigorri e Freire, 2012	Custos Agronegócios Online	0.464
Toledo Filho, Cardoso, Santos, 2009	Custos Agronegócios Online	0.464
Muehlen, Cezar, Costa, 2013	Ciência Rural	0.556
Kumar, 2020	<u>Asia-Pacific Financial Markets</u>	0.32
"AGRICULTURAL PRICE RISK"		
Jackson, Quaddus, Islan, Stanton, 2009	Rural Sociology	2.482
Paris, 2018	Bio-Based and Applied Economics	0.32
Walters, 2014	<u>Agricultural Economics-Zemledelska Ekonomika</u>	1.106
Miao, Yu & Tang 2011	African Journal of Agricultural Research	0.263
Barnes, Islan, Toma, 2013	Applied Geography	3.508
Gródek-Szostak et al., 2019	Sustainability	2.576
Chen, Härdle & Cabrera	Energy Economics Journal	3.199
Ghorbel & Trabelsi, 2009	Journal of Risk	0,375
"AGRICULTURAL RISK MANAGEMENT"		
Vedenov, Barnett, 2004	<u>Journal of Agricultural and Resource Economics</u>	1.184
Vogel, Obrien, 2006	Climate Resourch	2.023
Fraisse, Breuer, Zierden, Bellou, Paz et al. 2006	<u>Computers and Electronics in Agriculture</u>	3.858
Crane, Paz, Breuer, Broad, Ingram, Hoogenboom, 2010	Weather Climate and Society	1.958
Marston, 2011	Journal of Anthropological Archaeology	2.252
Kloper, Vogle e Landman, 2006	Climate Change	4,134
Hazell e Hess, 2010	Food Security	2.095
Anton et al., 2013	Global Environmental Change-Human and Policy Dimensions	10.466
Myers, Sexton, Tomek, 2010	American Journal of Agricultural Economics	3.028

Meinke, Sivakimar, Motha, & Nelson, 2007	Australian Journal of Agricultural Research	1.328
Severini, Biagini e Finger, 2019	Journal of Policy Modeling	1.486
Thilmany, Blanck, 1996	American Journal of Agricultural Economics	3.028
Duong, Brewer, Luck & Zander, 2019	Agriculture-Casel	2.072
Lorant, Farcas, 2015	Polish Journal of Management Studies	1.78
Ali, Man, Muharam, 2019	Journal of Animal and Plant Sciences	0.481
Finger, Waquill, 2013	Ciência Rural	0.556
Cresti, 2005	Applied Economics	0.968
“AGRICULTURAL FUTURE MARKET”		
He, Yang, Xie & Han, 2014	Emerging Markets Finance and Trade	1.214
Morgan, Cotter, Dowd, 2012	Journal of Agricultural Economics	2.529
Jia, Wang, Tu & Li, 2016	Physica a-Statistical Mechanics and its Applications	2.924
Jiang, Todorova, Roca & Su, 2017	Applied Economics	1.103
Xu, Pan, Wang & Li, 2019	Journal of Agricultural and Applied Economics	0.523
Hosseini-Yekani, Zibaei e Allen, 2010	Journal of Agricultural Science and Technology	0.897
“OPTIONS MARKET”		
Huh, Lin, Mello, 2015	Journal of Financial Markets	1.677
Ryu, ; Yang, 2019	European Journal of Finance	1.217
Zhang, Watada, 2019	International Review of Economics & Finance	1.818
Triantafyllou, Dotsis, Sarris, 2019	Journal of Agricultural Economics	1.545
Xi, Hayes, Lence, 2019	Agricultural Finance Review	1.19
Hart, Lence, Hayes & Jin, 2015	<u>American Journal of Agricultural Economics</u>	2.532

Forty five publications on the analysis models, strategies, and methods of agricultural risk management were identified using the pre-established keywords and criteria described above. Each piece of literature was examined using a phased review (ie, abstracts, then the main body of each source of literature). Next, the literature findings on agricultural risk management models are discussed, primarily in relation to price risks, through the use of derivatives.

3. STRUCTURE FOR THEORETICAL REVIEW

3.1. Sources of agricultural risks

The literature on agricultural risk management can be divided between those dealing with risks inherent to the business environment, production risk, and market risk.

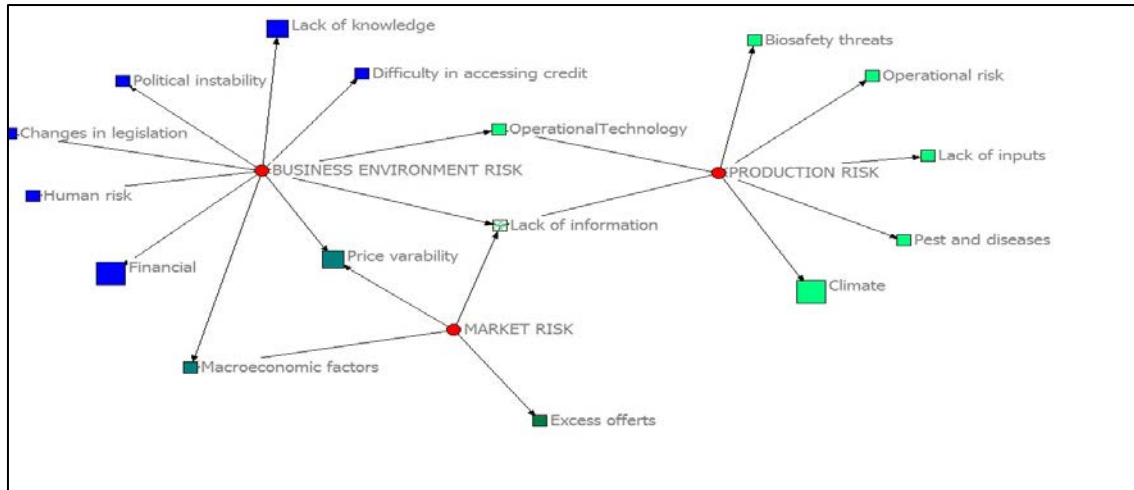


Figure 1: Agricultural Risk

Source: Research data, 2020. The output from UCINET software. The size of an item's square is determined by the item's weight, the larger the more quoted. The color of an item is determined by the cluster to which the item belongs.

The focus of this paper is on market risks, especially the risks inherent to price variability, so we will discuss the main risks involving the derivative transactions.

In derivative transactions, according to Toledo Filho et al. (2009), the risks can be market risk - related to the price and value of goods, services, indices, commodities, among others.

- Volatility - the volatility of the underlying asset is reflected in the value or premium of the options. The greater the volatility of the underlying asset, the greater the risk to the seller of an option and the greater the interest of the buyer in acquiring it to leverage its gains;
- Interest rate risk - the interest rate is used to calculate the value of an asset or a portfolio, as it represents the opportunity cost of the investor. When the interest rate varies the value of the assets also varies;
- Market liquidity risk - this risk is directly linked to the volume and inventory of outstanding contracts. For derivatives traded on the stock exchange, liquidity information is accurate and easy to obtain, which is not the case with derivatives traded on the over-the-counter market;
- Credit risk - This type of risk occurs due to the inability to settle the obligations. It consists of a numerical measure of the uncertainty related to the receipt of a contracted amount to be paid by a borrower, counterparty to a contract or issuer of a security, discounting expectations of recovery and realization of guarantees.

In the risk assessment, it is necessary to identify the degree of risk incidence, that is, what is the probability of occurrence and what will be the loss resulting from this risk.

After the relevant risks have been identified, there are several ways to mitigate the risks: 1) avoid risks, that is if the risk could have serious consequences, avoid them. 2) Transfer of risks to third parties, such as insurance. 3) risk mitigation - in this case, diversification is the best way to reduce risks, that is, not to invest everything in a single business or activity. 4) risk acceptance - in this case, the risk does not offer significant losses to the business.

Finally, the control or monitoring of risks includes the internal procedures adopted by the entrepreneurs, that is, they involve responsibilities, deadlines, among others; providing relevant information to decision-makers; and critical monitoring of the adopted strategy. In this case, if it is necessary to revise a strategy, the entire risk management process must be adopted again.

3.2. Price risk management methods and strategies

The following table, table 2, shows the relevance of using agricultural derivatives to manage price risks.

Table 2: Price risk and use of derivatives

#	Author (s)	Main contributions
	Calegari et al., 2012	They stressed that in order to protect against price fluctuations (price risk), they can use the derivatives market to determine the sale price of their products and guarantee the sale of their production at a price sufficient to cover their costs and still pay the capital.
	Hart et al., 2015	They commented on the importance of agricultural commodity options and reported that those maturing after one year are rarely traded. They emphasized that the reason for not using it is due to the fact that they do not have a precise option pricing model and in their research, they proposed an option pricing model.
	Muhlen et al., 2013	They analyzed the behavior of the soy producer in Maracaju-MS regarding price risk and the use of agricultural derivatives, seeking to identify the price protection mechanisms used and the reasons for their use or rejection. Producers who have already used the Futures Market (hedge) and the options market operate in medium and large properties, have a high level of education, and are more capitalized. The low use of derivatives (futures and options) is mainly due to the lack of knowledge and the lack of confidence in professionals capable of guiding producers.
	Toledo Filho et al., 2010	Derivative operations are booming worldwide, including in developing countries, such as Brazil. The derivative object of the article is the Butterfly operation, which consists of the purchase and sale of options, the cost of which is net premiums, in order to increase results in coffee contracts. Thus, we demonstrate how a derivative can contribute, with low cost, to increase the result of the sale of a commodity.



Kumar, 2020	Future price forecasts are essential tools for operations in the derivatives market.
Triantafyllou et al., 2019	Our findings have implications for optimal hedge decisions in agricultural markets, as we show that commodity market participants should avoid hedges (particularly long hedges) when our probit models indicate increasing probabilities of price spikes.

Source: Research data, 2020.

The level of exposure and strategies to protect market risks in agricultural activities are presented by Finger and Waquil (2013), Toledo Filho et al (2010), Triantafyllou et al. (2019), the use of derivatives for price risk management is emphasized by Calegari et al. (2012), Clapp and Helleiner (2012), Muhlen, Cezar and Costa (2013), Hart et al (2015), Kumar (2020), among others.

Jia, et al (2017) highlighted that agricultural futures markets play an important role in risk aversion.

It is worth mentioning that several authors, including Cotter et al. (2012), Xu et al. (2019), Jiang et al. (2016), Jia et al. (2017), Assa (2015 and 2016), Paris (2018) presented models for understanding and monitoring price variations, which will be discussed in the topic of risk analysis models of derivative markets.

Based on the findings on risk management, it was possible to develop a conceptual framework, addressing the tools and strategies for agricultural price risk management. Also providing an expansion of the discussion with a focus on the derivatives market, in which we can understand risk management through agricultural derivatives, present the main models of analysis of agricultural risk management, and providing support to propose a theoretical model on risk management through derivatives.

We also realized that the market, at times, needs government intervention, as leaving it to the mercy of the balance between the strength of supply and demand can cause an increase in revenue too much for those who have more information and market power. On the other hand, negotiation at low prices, in the case of rural producers, cannot even afford production.

In addition, in this case, rural producers are at the mercy of the market both in the purchase of inputs and in the marketing of their products. We will understand this finding through the example of the coffee market. When purchasing inputs, the supplier dictates the price, that is, producers pay the prices that large companies, often oligopolists, place on their products. In the sales of its coffee, the producer is dependent on the prices adopted by the roasters, which are no more than ten worldwide, with enormous market power.



It can be seen here that the price risk management strategies adopted by rural producers are sometimes not efficient. Because in a barter operation (exchange) the supplier can raise prices in these operations. On the other hand, in the sale of products, there is a preference for negotiations in the forward market, with the physical delivery of the product. This fact can be explained by the fact that roasters need to guarantee the raw material for production and exporting companies and cooperatives are not concerned with the risk management for the producer, but with the negotiation of production itself.

We highlight the importance of companies not linked to product marketing processes, such as investment brokers, to assist rural producers in managing price risks, acting in an impartial and transparent manner.

One of the most adopted and essential mechanisms to mitigate price risks, the focus of this study, is the use of agricultural derivatives that will be dealt with below.

3.3. Risk Management through Agricultural Derivatives

Risk management comprises all measures that help to identify and manage the risks that put an enterprise at risk. Evidently, the existence of risks in agricultural activity has always been perceived and understood by farmers around the world. However, save for exceptions, the use of formal methods of analysis and protection against risks has been little used and observed (Finger & Waquil, 2013).

Derivatives are financial instruments whose price is derived according to the price of another asset, the underlying asset. These instruments are formalized based on contracts in which one party makes a purchase and the other party makes a sale of a certain asset at a pre-established price and quantity for settlement at a future date (Calegari et al., 2012).

In Brazil, according to Toledo Filho et al. (2010), derivatives appeared more recently with the creation of the Bolsa de Mercadorias e Futuros (BM&F), on 06/30/1991, which incorporated the Brazilian Futures Exchange (BBF) in Rio de Janeiro in 1997 and Bovespa in 2007, becoming BM&FBOVESPA. BM&F in recent years has increased its efforts to attract rural producers to agricultural derivatives, demonstrating its good cost/benefit ratio, especially small ones, who are unaware of these operations. Currently B3 - Brasil, Bolsa, Balcão, also incorporating the services of the Central Custody and Financial Settlement of Securities (CETIP), through a merger.

For Calegari et al. (2012), derivative instruments can be divided into the first-generation and second generation. The first concerns traditional instruments: forward contracts, futures,



options, and swaps, and the second is the result of the combination of two or more traditional instruments.

Toledo Filho et al. (2010) commented that derivative transactions arose due to the practical need of producers, traders, and other market agents to protect themselves from risk, and are expanding rapidly in the world, including in developing countries, such as Brazil.

However, Muhlen et al. (2013), analyzing the behavior of soy producers, highlighted that the use of price protection tools is still not very significant, that is, a small percentage of producers use the Futures Market (hedge) and the Options Market, being the main mechanism used. Producers who have already used the Futures Market (hedge) and the options market operate in medium and large properties, have a high level of education, and are more capitalized. The low use of derivatives (futures and options) is mainly due to the lack of knowledge and the absence of reliable professionals capable of guiding producers.

We fully agree with the aforementioned authors, and we can still report that the prevalence of use of the forward market occurs in all commodities. For example, in coffee, the reality is the same, rural coffee producers also negotiate their production in the vast majority through the forward market.

The forward market has its advantages, however, the mandatory future delivery of production is one of the obstacles, due to the standardization of contracts, for the producer to fulfill the contract, mainly to guarantee the quality of production in relation to the specifications in the contracts. This fact, in turn, makes the producer averse to agricultural derivatives.

Toledo Filho et al. (2010) explained that people and/or institutions participate in the derivatives market, and are classified according to their interests: 1) Hedgers: They use the market to protect against undesirable price variations, avoiding losses, however, the profit is limited. 2) Speculators: These participants provide liquidity to the market, assuming the risks of hedgers, with the intention of obtaining financial gains with information and forecasts about the various markets. They generally use two sequential operations, and do not wait for the contracts to expire, leaving the position they hold, days before, their purpose is only financial. 3) Arbitrators: these ensure that future prices on the market are compatible with prices on the physical market. Whenever there is a discrepancy between these prices, the arbitrator takes the opportunity to realize his profits, without risk, using two simultaneous transactions and close the transactions.



3.3.1. Forward market

In the forward market, forward contracts are negotiated, which are contracts negotiated directly between the interested parties, in which there is a commitment to deliver or receive goods with a fixed term and price. However, they are not standardized or guaranteed by the grants (Toledo Filho et al., 2010).

Muhlen et al. (2013) report that the main mechanism used to minimize price risks is the Forward Market, with operations in the Options and Futures Market appearing last.

3.3.2. Future Market

In the futures market, they negotiate futures contracts, specifically through commodities and futures exchanges, which establish conditions such as terms, contract size, place of delivery, the margin of guarantee, etc., are established by the exchange and standardized in terms of maturity and quantity (Toledo Filho et al., 2010)

Commodity futures have attracted a lot of attention in recent years because they facilitate price discovery and allow protection against changes in spot commodity prices (Kumar, 2020).

According to Toledo Filho et al. (2010) futures and options, markets should be understood as a powerful tool in the management of costs and prices of goods, integrating with the physical market.

Kumar (2020) highlights that the commodity futures market is efficient and can be used to protect against changes in spot commodity prices. Risk management through hedging is an important function of the futures market. In addition, the fundamental view holders who make their decisions based on the demand and supply of the underlying commodity will trade in the futures market to obtain profits from the market.

The Brazilian futures market has already been highlighted before, through the Commodities and Futures Exchange - B3. Jiang et al. (2016) reported that the US futures market, ie Chicago Board of Trade (CBOT) and Intercontinental Exchange (ICE), is a well-established agricultural futures market globally and can be accessed by different types of participants, that is, professionals, owners, national, foreign, institutional and individual. In the Chinese futures market, there are some access restrictions. Thus, due to the restriction and potential interference that foreign investors may cause in the local market, the Chinese futures market, ie Dalian Commodities Exchange (DCE) and Zhengzhou Commodities Exchange



(ZCE), is more restricted to foreign participation and more than 95% of investors in the Chinese futures market are domestic.

Agricultural futures market participants are comprised of producers, sellers, processors, and import-exporters, as well as speculators, most of whom are familiar with commodity markets and able to expect future price trends from different perspectives (Xu et al., 2019).

Jiang et al. (2016) made a comparison between the American future market and the Chinese one. They pointed out that the majority of participants in the foreign market are institutional investors and fund managers who enter the Chinese futures market through partnerships with local companies. Unlike the US futures market, where more than 70% of participants are institutional investors, less than 10% of local participants in the Chinese futures market are institutional investors, while the remaining 90% are predominantly individual investors, which can stimulate speculative trading.

3.3.3. Options Market

In the last decades, with the globalization of the markets and the advance of the means of communication, the derivatives had recognized expansion, serving to protect assets (hedge), for speculation, and also to stop gains or losses in several markets. With the emergence of options markets, the derivatives of these assets appeared, giving investors new possibilities for structured transactions, including for agribusiness (Toledo Filho et al., 2010).

The aforementioned author further explains that the options market is an operational modality in which object shares are not traded, but rights over them. The lack of caution or excessive ambition in derivative transactions has already brought losses to companies and banks.

Options are a financial asset that can be bought or sold, as well as a stock, bond, or commodity. They are classified as derivatives because the value of an option is derived from another asset, called a base asset. For Toledo Filho et al. (2010) there are two types of options: call options and put options. A call option gives its holder (holder) the right to buy an asset at a certain price on a given date. In the put option, the holder acquires the right to sell the asset for a certain price on a certain date.

Table 2: Type of Options

Type Options	Holder (buyer)	Launcher(seller)
Call Option	Right to buy at the fixed price	Obligation to sell at the fixed price
Put Option	Right to buy at the fixed price	Obligation to sell at the fixed price

Source: Adapted from Toledo Filho, Cardoso e Santos (2010)



It is noticed that in this market there is the holder who is the holder of the right to buy, that is, whoever buys the option. The launcher is the one who sells the option, has the obligation to sell at a pre-established price. In transactions involving options contracts, there is a fixed price, known as the exercise price, and a premium paid by the buyer to the seller for the acquisition of the right.

A buyer of a call option expects the base asset (share or commodity) to rise in price. In the case of commodity options, the buyer of the call option has the right to control a futures contract for a specified period of time at a given price level. The buyer is under no obligation to exercise the option contract and convert it into a long position in the underlying asset if this is not financially interesting to him. But, if you do not exercise, you will lose the premium paid, however, you have unlimited earning potential at the high.

The writer does not make any decision, that is, the decision is made only by the option buyer, the holder. The holder only exercises the contract if the market price is not attractive.

Briefly, in a call option, if the market price is less than or equal to the exercise price, the holder will not exercise his right and will lose the premium paid to the writer. However, if the market price is greater than or equal to the exercise price, the holder will exercise his right and purchase the asset in question.

On the other hand, the put option buyer expects the underlying asset to fall in price. Also, as in the case of the call option, the put option buyer has no obligation to exercise the option contract and convert it into a sale of the underlying asset if it is not profitable for him. Thus, the put option buyer has a limited risk of loss equal to the price paid for the option and unlimited gain potential.

In a put option, if the market price is greater than or equal to the exercise price, the holder will not exercise his right and will lose the premium paid to the writer. However, if the market price is less than or equal to the exercise price, the holder will exercise his right.

3.3.4. Swaps

Credit derivatives are financial instruments used to mitigate or take risks by hedgers or speculators. Contracts to guarantee maximum interest rates, cap, or minimum rates, the floor can be classified under this heading. Securities backed by credits (receivables) also fall under this item, as does the exchange of cash flows (swaps) (Toledo Filho et al., 2009).



3.4. Derivative market risk analysis models

Regarding the risk analysis models of derivative markets, they can be subdivided into operating models and auxiliary models. The operational models are related to the methods and the main tools adopted to mitigate price risks. Auxiliary models are those that assist in making decisions about the use of derivatives. It mainly involves qualitative and quantitative analyzes of commodity price variability, price transmission, risk measurement, etc.

3.4.1. Operating Models

For Calegari et al. (2012) the future market is a great tool for managing agricultural risks. Despite the need for capital as a guaranteed margin, as a result of these daily adjustments, this market has high liquidity of the future contract, the position assumed can be zeroed through the opposite position, whereas in the forward market, the assumed position is usually loaded until the contract expires. Thus, for producers to exercise the risk management of their production, it is enough to make a contract for the sale of the base asset (a product with a similar characteristic to that of their production) and before the contract expires, especially at the best times to maximize gains, make the transaction goes against, buying a futures contract with the same specifications as the previous contract and closing the position.

Toledo Filho et al. (2010) through the Options Market, used the Butterfly Put operation, which consists of buying and selling options, as a lock for an increase in the result of coffee operations. With a small cost related to the net premiums paid, the producer will have an additional profit on the sale of the commodity, if at maturity prices are within a certain range. Although the transaction is not set up and registered with BM&F, options traded on the stock exchange are used. Your loss on the transaction will not exceed the disbursed premiums.

Cresti (2005) carried out research on exchange operations in the USA, demonstrating that this operation brings benefits to companies and institutions. He points out that neither companies nor corporations resort to exchange to obtain better use of their productive capacity. On the contrary, such a positive relationship reinforces the idea that exchange is adopted to increase profits and, to a greater extent, to gain a competitive advantage.

Here in Brazil, barter operations for agricultural inputs for production are frequently adopted practices. The companies of agricultural inputs in order to increase their sales launch this type of negotiation and the rural producers, sometimes without capital or not, seek an alternative of credit without having to resort to banks, avoiding the payment of interest.



In order to have a guarantee of the negotiations, the input companies use the fixed-term contract, in which the producer assumes the responsibility of delivering his production at a future date, in quantities and pre-stipulated values according to the contract.

Rural producers can still make a future sale of their production, on a fixed-term contract. In this case, according to Calegari et al. (2012), does not require a margin of guarantee or standardization, has less liquidity than futures contracts traded on exchanges, however, there is a need for future delivery of the transacted product.

3.4.2. Auxiliary Models

Risk is an inherent characteristic of agricultural production and marketing and its measurement needs to help inform more efficient use of resources. In this context, the effective and accurate measurement of risk in agricultural markets is essential to inform the best way to design strategies and instruments aimed at helping farmers to manage the risks they face. To that end, Cotter et al. (2012), applied the Peaks-OverThreshold version of the Extreme Value Theory to estimate the measures of extreme financial risk for a selection of agricultural contracts.

Xu et al. (2019) highlight that the full functioning of the futures market is closely related to the vibrant spot trade; therefore, efficient price transmission creates a barrier between the future market and the spot market and has a critical effect on the functioning of the futures market, such as price discovery. To this end, the authors used the normal vector error correction (VECM), model.

The VECM measures the price transmission effect using three types of parameters. The first type includes error correction coefficients, the relative speed with which the spot price and the future price could reconstruct the long-term cointegration status, after markets are shocked by external factors, such as changes in policy and technology (Xu et al., 2019) The second type of parameters are the cointegration coefficients that reflect the direct long-term relationship between prices. They are used to measure the degree to which the spot (futures) price is affected by changes in future (spot) prices. The last type of parameter is the interaction coefficients, reflecting the short-term mutual effects between prices. If β_j (γ_i) is significant, it means that the future price (spot) will affect the spot price (futures) in the short term. Together, the three types of coefficients are complementary, providing useful toolkits for analyzing the effects of the transmission between futures prices and spot prices (Xu et al., 2019).



Jiang et al. (2016) applied the self-regressive heterogeneous multivariate model (HAR), to study the volatility interrelationships of different markets (the USA and China). This model allows us to analyze the process of transmitting volatility between agricultural futures markets over several time horizons. It has more desirable properties compared to other techniques, such as the long memory volatility feature that is often modeled by fractionally integrated GARCH return models (FIGARCH) or fractionally integrated autoregressive moving average (ARFIMA) models of realized volatility. therefore, integrated fractional models are not trivial to estimate and are not easily extensible for multivariate processes.

According to Jia et al. (2017), with the integration of the global economy, the link between domestic and international futures markets is closer than ever. The authors used the thermal ideal path method (TOP) to study the lead-lag relationship in return and future market volatility between China and the USA. As a non-linear and non-parametric method, it was originally proposed by Sornette and Zhou (2005) to test the dynamic evolution of the lead-lag structure between two-time series. Since then, the approach has been successfully improved and allows analyzing the relationship between two economic or financial variables.

Paris (2018) combines a more comprehensive specification of Positive Mathematical Programming - PMP (calibration of production quantities and limiting input prices) with generalized risk preferences, where the risk-avoiding farmer behavior can vary over all theoretically possible preferences.

The author reports that a Positive Mathematical Programming approach has been adopted frequently to analyze agricultural policy scenarios since Howitt proposed the methodology. He comments that the PMP methodology has been extended to deal with generalized risk preference and risky market product prices. In addition, they extended to deal with calibration restrictions involving observed prices of limiting inputs, for example, land. This extension modifies the traditional specification of calibration restrictions and the notion of calibration solution, as explained later. It concludes that a version of the presented calibration equilibrium model allows the analysis of decoupled agricultural subsidies that are most often the target of policymakers

The storage model, initially proposed by Gustafson (1958), was developed to investigate an ideal supply control policy for governments to transport grain stocks to the next year. More recently, many authors have improved the storage model to better capture statistical characteristics; Assa (2015) concentrated on studies on the speculative storage model of Deaton



and Laroque (1992,1995, 1996). The main idea in this model is that, due to the storage capacity of many commodities, market participants can increase market prices by adding to the demand for inventory. More precisely, through storage, market participants can account for the differences between current and future prices at a discount.

In order to present a speculative model in continuous time and use it for the pricing of derivatives. Assa (2015) showed how, using financial engineering techniques, it is possible to find the prices of derivatives, either by solving a PDE or by Monte-Carlo simulation. This configuration can be considered as an alternative to the structure of the Black model, which has been used to price derivatives on agricultural prices. I also simulated price series using a set of parameters and compared the statistics generated from the geometric Brownian motion model and the speculative model.

Assa (2016) explored the links between commodity demand, price dynamics, and volatility by establishing the Cox, Ingersoll, and Ross model in 1985 (CIR) to understand the market demand process and the volatility model constant elastic pressure (CEV) for market prices. The CEV model is an extension of the Black-Scholes-Merton (BSM) model that was developed primarily in 1973 to estimate derivative prices.

The aforementioned author argued that the CEV model was adopted to model options on commodity prices, it was possible to observe that all non-livestock commodities, except orange juice, have an inverse leverage effect on prices, while livestock commodities and orange has leverage.

3.5. Barriers to agricultural risk management.

The lack of information to help farmers to control agricultural risks is one of the main barriers, especially in developing countries. The inefficiency of access to formal, low-risk, and regulated financing undermines farmers' ability to manage their agricultural enterprises. It is also worth mentioning the limited institutional support and the lack of market mechanisms (access and supply of inputs) were additional barriers encountered by farmers (Duong et al., 2019).

Toledo Filho et al. (2010) points out that losses with derivatives were caused by their lack of knowledge, which needs caution, as it can lead to high losses.

Muhlen et al. (2013), inferred that the lack of knowledge and the lack of trust in professionals to guide them in operations in the futures and options markets is a limiting and inhibiting fact of the use of derivatives by rural producers. Another difficulty reported by the



authors is in relation to not having brokers in inland cities that operate with derivatives, so if the producer wants to do transactions with derivatives, he will have to look for brokers in larger cities.

They also commented that there is a cultural issue, of resistance to changes, in addition to the argument that monitoring the market and exchanges demands time, reinforcing the need for a specific professional. These operations require effective security, which in turn would require several insurance policies.

To understand the problems and barriers highlighted so far, we will turn to agribusiness production systems. We know that relationships with agents increase or decrease risks and uncertainties, also that there are many opportunistic actions in the market for any commodities.

In this context, the predominance of trading through the forward market by negotiating agents along the production chain can be explained by the opportunities and guarantees (gains with zero risk through matched operations) that intermediaries have in trading in the forward market.

Thus, the availability of trades in the forward market is gigantic, and the interest in setting up investment brokers in small towns that work with agricultural derivatives is not the focus of these agents and it seems that it is not interesting and viable for brokers as well.

Low utilization also occurs due to the decapitalization of the producer and the lack of public policies to encourage operations in the agricultural derivatives market, which suggests greater attention from government agencies to this issue (Muhlen et al., 2013).

4. OPOSED MODEL FOR RISK ANALYSIS OF THE AGRICULTURAL DERIVATIVES MARKET

Our theoretical model for the management of agricultural risks through agricultural derivatives aims to demonstrate the step by step to implement efficient and effective risk management.

In this context, it is necessary to identify the main sources of risks inherent in agricultural production in question; adopt the best methods or strategies to mitigate risks. Specifically, with respect to market risks, analyze the models to be adopted and the main factors that interfere in price variability using the proposed models, in order to identify the barriers to risk management and seek to remedy them.



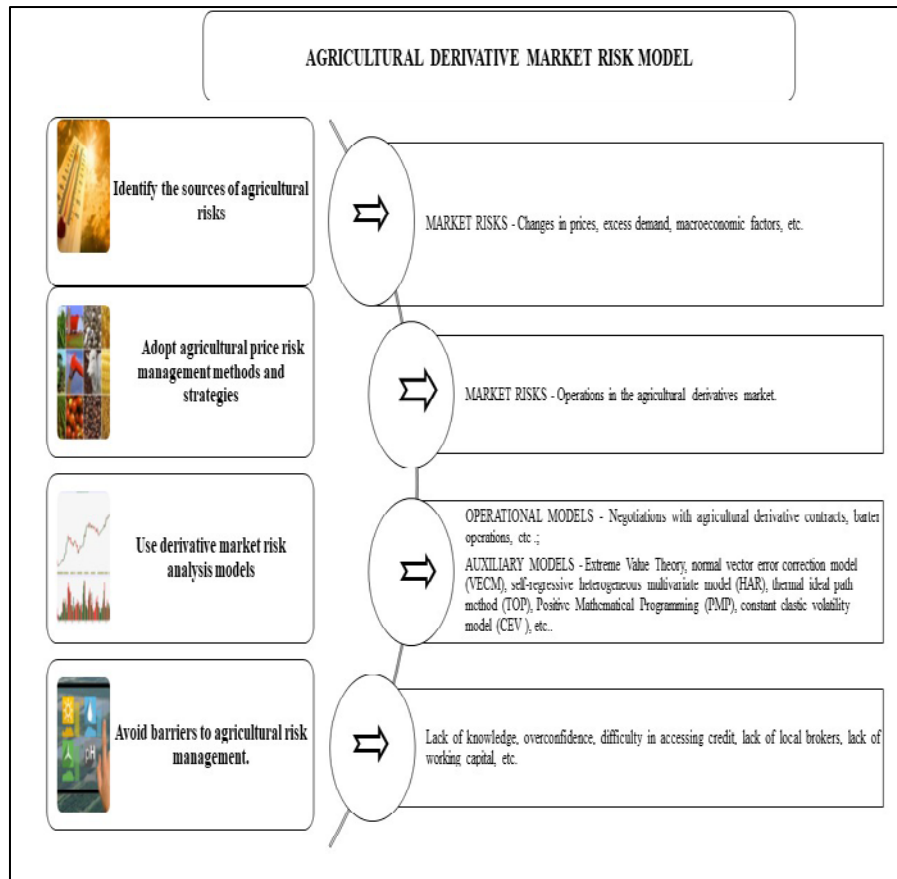


Figure 2: Proposed Model of Analysis of Agricultural Derivatives Market Risks

Knowledge of the sources of risk in the agricultural business is extremely important for producers to adopt risk mitigation strategies. The variability of commodity prices throughout the year means that the members of the productive system, among them, rural producers, have a constant concern with the commercialization of their products in order to obtain profitability with their production.

The use of the agricultural derivatives market as a tool for risk management does not guarantee the best price, it only “hangs prices”. Thus, rural producers need to know the information regarding production costs in order to know the minimum price necessary for them to have acceptable profitability in future negotiations.

An essential fundament in finance for risk management is diversification. Thus, producers do not need to negotiate all of their production through agricultural derivatives, they can leave a percentage for cash sales during the harvest period, or even negotiate several contracts throughout the year, working with average prices, as it is impossible to hit the top of prices and/or the bottom in negotiations with agricultural derivatives.

Deepening the studies on price risks and their modeling, among the risk metrics, to assess liquidity, the most used is Value at Risk (VaR).

The JP Morgan team developed a system to measure risks in different commercial positions, throughout the institution and also aggregate these risks in a single risk measure, the measure used was Value at Risk (VaR).

VaR is defined as the maximum potential loss in a value of a portfolio over a defined period for a given confidence interval in normal market condition (Amin et al., 2018).

Thus, Value at Risk (VaR) is a metric that measures losses due to normal market movements. Losses greater than the value at risk occur only with a specified small probability. Given the simplifying assumptions used in its calculation, VaR aggregates all the risks in a portfolio in a single number, thus being useful for use in company management, reporting to regulators, or disclosure to the market (Linsmeier & Pearson, 2000).

Value at risk VAR has become a standard for measuring and evaluating risks, defined as a quantile of the distribution of returns (or losses) of the asset or asset portfolio, it can also be considered the worst-case loss predicted at a given level of confidence during a certain period of time (Ghorbel & Trabelsi, 2009).

It became evident that VAR is a risk assessment method that uses basic statistical techniques, when evaluating the results, the greatest possible loss is observed, taking into account the analysis time and a confidence interval.

Therefore, its relevance is due to the fact of summarizing in a single express number, the total exposure of a company, business unit, and/or portfolio of assets, to market risk. In addition, it brings together in its essence aspects related to the exposure incurred and market conditions.

Souza (2017) highlights the bid/ask spread analysis. The bid-ask spread is an important measure for assessing the price dynamics of financial instruments traded on the market. It directly measures the cost of executing exchanges at very short intervals, calculated as the difference between the price offered to buy and the price offered to sell a security.

Another analysis that deserves to be highlighted is the analysis of scenarios. Scenario analysis is another type of approach in which different scenarios are established and, based on them, the potential for gain or loss in the portfolio is assessed.



When dealing with derivative positions, we can also estimate their risks from Greek letters. Each Greek letter measures a different dimension of the risk in a derivative instrument, and the trader's objective is to manage the Greek ones so that all risks are acceptable (Souza, 2017).

The high integration of world trade and the financial market in several countries makes their economies interdependent. Thus, to understand the level of interdependence between markets in different countries, we have a correlation analysis that is one of the main variables, specifically the linear correlation coefficient.

Already for the consideration of non-linear aspects, we have the copulation technique that emerged thanks to advances in studies on risk management analysis.

Extending studies on risk assessment metrics, Gródek-Szostak et al. (2019), in order to identify and estimate the model of dependence between the extreme prices of selected agricultural products in the derivatives market using the link function, adopted the t-EV copula.

The empirical results of this research demonstrated that the copulas of extreme values, which best describes the dependence between the extreme values of all pairs of agricultural products researched, regardless of whether the limit distribution adopted is the extreme t-Student, also known as t-EV copula.

Copulas of extreme values not only appear naturally in the domain of extreme events but can also be a convenient choice for modeling data with positive dependence (Gudendorf & Segers, 2010).

The term copulas was introduced by Sklar in 1959; it is based on the notion of “coupling”. Copulas are functions that unite, or couple, multivariate distribution functions to their one-dimensional marginal distribution functions. the strength of the copulas comes from the characteristic that there are no assumptions about the joint distributions between the financial assets of a portfolio, the use of copulas to estimate the VaR has been researched for several years.

Other widely disseminated studies are the network modeling of the derivatives market. Chen, Härdle, and Cabrera (2019) performed a network analysis of the German energy derivatives market, highlighted that this analysis helps us to complement a full picture of system risk, and have a better understanding of the German power market functioning and environment.



A dynamic network analysis has the purpose of observing the interconnections of the derivatives market of an asset and clearly identifying the significant channels of potential increases in risks.

It is worth noting here that the authors mentioned above used the regularization technique adopted for simultaneous estimation and selection of variables, important for the regression analysis was the Lasso de Tibshirani estimator, 1996.

Throughout this research, we have evidence that there are mathematical models in order to predict the oscillations of the financial market with the greatest possible reality. The use of these methods and models as a way to anticipate possible movements in the financial market is not a new practice.

The systems for forecasting the stock market range from the simplest statistical techniques, present in technical analysis, in fuzzy logic, in genetic algorithms, in Markov models, in econometric models, even in more complex heuristic methods, such as Neural Networks.

In the areas of Administration and Economics, neural networks are generally used to forecast prices in the stock market due to the non-linear mapping between network inputs and outputs.

Dase, Pawar, (2010) reported that a neural network has the ability to extract useful information from a large set of data. They also commented that the Artificial Neural Network is very useful for forecasting global stock markets.

It became evident that the artificial neural network has the ability to predict a more accurate stock index, as well as predict whether it is better to buy, hold or sell stocks and / or assets.

In this context, we can use the artificial neural networks to understand market risks, through an analysis of time series.

It is known that efficient market theory is only theory, and the use of the artificial neural networks help in the recognition of non-linear patterns and regularities present in time series, among other purposes. It is also worth mentioning that there are software that can be used as a fundamental tool in this process, such as the NeuralWorks Explorer software.



We have seen throughout this research that the analysis and assessment of market risks is not a trivial task. It requires an in-depth knowledge of mathematics, statistics, econometrics, making it quite complex, very far from the reality of rural producers.

5. NEW PERSPECTIVES FOR FUTURE STUDIES AND RESEARCH

In order to deepen the understanding of agricultural risk management, it is necessary to research the price risk management practices adopted by rural producers, in the purchase of inputs and in the marketing of their products, and to demonstrate ways to practice risk management through operations. futures and options markets.

In this context, public policies and programs inherent to agricultural risk management are essential, specifically focusing on the future market, hedge operations, and the options market. Both in the coordination and implementation of these policies, as well as in incentives, as an example: premium payments made by the government for operations with options.

It is also worth mentioning the importance of cooperatives operating with a predominance of their social function to the detriment of economic aspects. The performance of a cooperative with the purpose of assisting rural producers in risk management, with hedge operations, both in the futures and options markets. The implementation of negotiation points for investment brokers in small towns, closer to the rural producer, with autonomous investment agents trained to operate and negotiate in a simpler language to facilitate understanding by farmers.

Future research that seeks to map the main agricultural risk management policies and programs worldwide will be important as they can assist the Brazilian government in implementing specific policies on risk management for the sector.

6. CONCLUSION

This work aimed to build conceptual guidelines regarding the management of agricultural price risks through the use of derivatives. Based on the literature review, it was possible to list the main information on the subject and still propose a theoretical model of analysis of agricultural derivatives market risks, presenting a logical sequence to be practiced to implement risk management using agricultural derivatives, being necessary to identify the main sources of agricultural risks; adopt the best methods or strategies in order to mitigate price risks, analyze the models to be adopted and the main factors that interfere in price variability using the proposed models, and identify the barriers to risk management and seek to remedy them.



According to the literature review, it was possible to notice that among the methodologies for measuring market risk, Value at Risk (VaR) stands out.

We exemplify and demonstrate the existence of several statistical analyzes and mathematical models, as well as software available for the management of price risks.

It is concluded that strategies with the futures and options market, even though they are the most efficient for risk management, lack incentives to become practical.

It is well known that the majority of rural producers do not have the knowledge and skills necessary for effective price risk management, given its complexity.

Thus, the need arises to support the rural producer in relation to the management of agricultural risks, by the institutions with social character (associations, cooperatives).

Besides, the public policies focused on training producers in relation to the use of agricultural derivatives, and other policies aimed at putting hedge operations into practice through the future market and options, that is, the adoption of mechanisms that these operations may become routine for producers.

It is not difficult, because barter operations, that is, the exchange of inputs for future production is practical today. But, for sure the input companies have great benefits with these operations, being that they implanted with mastery.

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