

## ANALYSIS OF THE RISKS THAT COMPROMISED SOYBEAN PROFITABILITY IN THE CENTER-WEST REGION BETWEEN 2013 AND 2023

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**Abstract:** According to a survey by the Ministry of Agriculture, Livestock and Supply (MAPA), agribusiness accounted for 44% of the country's exports in 2017. In 2020, agribusiness GDP rose to a record 24.31%. In that same year of 2020, of Brazil's R\$7.45 trillion GDP, agribusiness accounted for almost R\$2 trillion. Between January and September 2023, agribusiness exports totaled R\$126.22 billion, an all-time record, with growth of 3.6% compared to the same period in 2022. In the economic scenario in which the world is currently inserted, there is a strong demand for *commodities*, a factor that is increasingly contributing to agribusiness and creating different possibilities throughout the production chain. Production takes place in all regions of the country, in production systems that alternate crops, with soybeans and corn standing out as the predominant crops. Regionally, the Midwest stands out as the largest grain producer, concentrating 45% of soybean production, 42% of sorghum and safrinha corn with 73% of national production, referring to the 2017/18 harvest. In view of this, the aim of this study is to verify which risks inherent to agricultural activity have the greatest impact on soybean cultivation and its profitability in the Midwest between 2013 and 2023. The results show that price and production risks are more prevalent in the Midwest region and that farmers need to be made aware of instruments for managing price risks, such as the futures and forward markets.

**Keywords:** Agribusiness. Soybeans. Risks. Profitability.

## INTRODUCTION

The concept of agribusiness is wide-ranging and includes rural properties, input production, logistics, distribution channels, technical assistance, among others. It is characterized as a system of production chains that includes suppliers of inputs and services, rural properties responsible for all agricultural production, storage, processing industries, distribution and marketing agents. Agribusiness has always played an important role in the national economy (MOREIRA, 2009).

The figures express the importance of agribusiness for Brazil. According to a survey by the Ministry of Agriculture, Livestock and Supply (MAPA), agribusiness was responsible for 44% of the country's exports in 2017, highlighting the importance of this segment of the economy for the trade balance. In 2018, agribusiness accounted for approximately 23% of the Gross Domestic Product (GDP) in the first quarter, as well as employing more than 18 million workers in the third quarter of the same year (ALCANTARA, 2020).

For 2023, exports have been reaching historic figures, with data showing that between January and September exports reached an all-time high of R\$126.22 billion, an increase of 3.6% compared to the same period in 2022. In the balance of 2023, Brazilian agribusiness exports hit a record of more than 140 billion dollars in 2023, an increase of 3% in value and 10% in volume compared to 2022 (AZEVEDO, 2023; CNN BRASIL, 2023; BONIN, 2023).

In view of the chain to which agribusiness is inserted, it is important to highlight the fact that there are market variables that are not under the total control of its managers. Thus, the risks associated with agribusiness-related activities arise and can arise in various ways, such as inflation, regulatory changes, wars, economic crises, natural phenomena, among others (ALCANTARA, 2020).

Rural activity presents greater risk and uncertainty than other activities, being subject to the seasonality of production and consumption, climatic variations, perishability, storage needs, processing and transformation of raw materials, as well as the influence of biological factors (COLETTI et al., 2022).

Various factors involving uncertainty make agriculture a risky activity. Climate instability, the emergence of pests in agricultural crops and diseases affecting livestock are unique to agribusiness. Other risks involving finances, institutional issues and seasonality of consumption are present in the business context, but in agribusiness they take on marked characteristics (MOREIRA, 2009).

Moribayashi et al. (2023) adds that some of the main risks associated with agribusiness involve issues such as climatic factors, operational errors, credit, the market, as well as price-related uncertainty. It is worth noting that all of these risks can directly affect the producer.

It is very common for prices of agricultural products to fluctuate by more than 30% in just one year. If the selling price falls to the level of costs, you could lose an entire cycle's work. It should be noted that for various agricultural *commodities* and for the exchange rate, it is possible to manage these risks with simple strategies using the concept of futures markets (WALTER, 2006).

With regard to climate risks, Lima (2018) adds that farmers must continually adapt their management practices in response to operational environmental changes. Seeking success in such adaptations, it is necessary to prepare professionals to manage climate risks.

Market risk is related to exposure to market uncertainties, where the economic factors involved are interest rates, exchange rates and *commodity* prices. Credit risk is associated with the possibility that the debtor will not honor its commitment. Operational risk is linked to losses resulting from human

error, processes and inadequate systems (ALCANTARA, 2020).

In addition, liquidity risk stems from the lack of availability to honor commitments, which may be related to the absence of resources and/or the difficulty of carrying out transactions in a given cash-generating asset on the market. Legal risk, on the other hand, involves operations that cannot be protected by law, which can lead to losses as a result of inspections, as well as lawsuits from players such as customers, suppliers and distributors. Environmental risk is directly linked to natural events, such as excess or lack of rain, earthquakes, frost, low or high temperatures, among others (ALCANTARA, 2020).

Moreira (2009) points out that in relation to production risks in agribusiness, production technology plays a fundamental role in trying to reduce risks. The development of new seed varieties and planting techniques for agriculture and new medicines and nutrition techniques for livestock generally increase production efficiency and resistance to natural events.

It's practically impossible to eliminate all risks and that's exactly why you have to manage them. It is essential to look for strategies to mitigate them. Risk management is therefore seen as an important tool in agribusiness, due to the aforementioned risk factors inherent in the activity of agro-industrial chains (ALCANTARA, 2020).

In terms of grain production, Brazil is the third largest producer, behind China and the United States. In the 2017/18 harvest, the country produced 227.6 million tons of grain, according to data from the National Supply Company (CONAB). Regionally, the Midwest stands out as the largest grain producer, concentrating 45% of soybean production, 42% of sorghum and safrinha corn with 73% of national production, referring to the 2017/18 harvest (GUIDUCCI; HIRAKURI, 2020).

According to data from the United States Department of Agriculture (USDA), between the 2014/2015 and 2016/2017 harvests Brazil was responsible for 31.2% of the world's soybean production, 8% of corn production and 6% of the world's cotton lint production. Brazil also stands out when it comes to exporting soybeans, as it has been the leader in this regard since the 2012/2013 harvest, with Brazil accounting for 42.4% of all soybeans exported worldwide in the 2015/2016 harvest (LIMA, 2018).

Among the world's major soybean producers (USA, Brazil and Argentina), Brazil is the country with the greatest potential to expand its cultivated area and, depending on the consumption needs of the market for meal (feed production) and oil (domestic consumption, biodiesel and H-Bio), it could more than double its current production and as a result become the world's largest producer and exporter of soybeans and their derivatives (DALL'AGNOL et al., 2021).

Faced with a context in which soybeans are essential to Brazil's trade balance, as well as being relevant on the international stage, with high production and export rates (Brazil's main export product) and taking into account the risks inherent in agricultural activity and the producers' attempt to achieve long-term sustainability for their business, in addition to the fact that the Midwest region is the country's largest soybean producer, the guiding questions of this study arise: What are the types of risks that affect agricultural activity and especially soybean cultivation? What are the risks that most jeopardize the profitability of soybean cultivation between 2013 and 2023 ?

## THEORETICAL FRAMEWORK

### SOYBEAN CULTIVATION IN BRAZIL

Soybeans were first cultivated in Brazil in 1901 at the Campinas Agricultural Station and seeds were distributed to producers in São Paulo. The grain became easier to identify in the country with the increase in Japanese migration in 1908. Soybeans were officially introduced in Rio Grande do Sul in 1914, a state with climatic conditions similar to those of the producing region in the United States (APROSOJA, 2020).

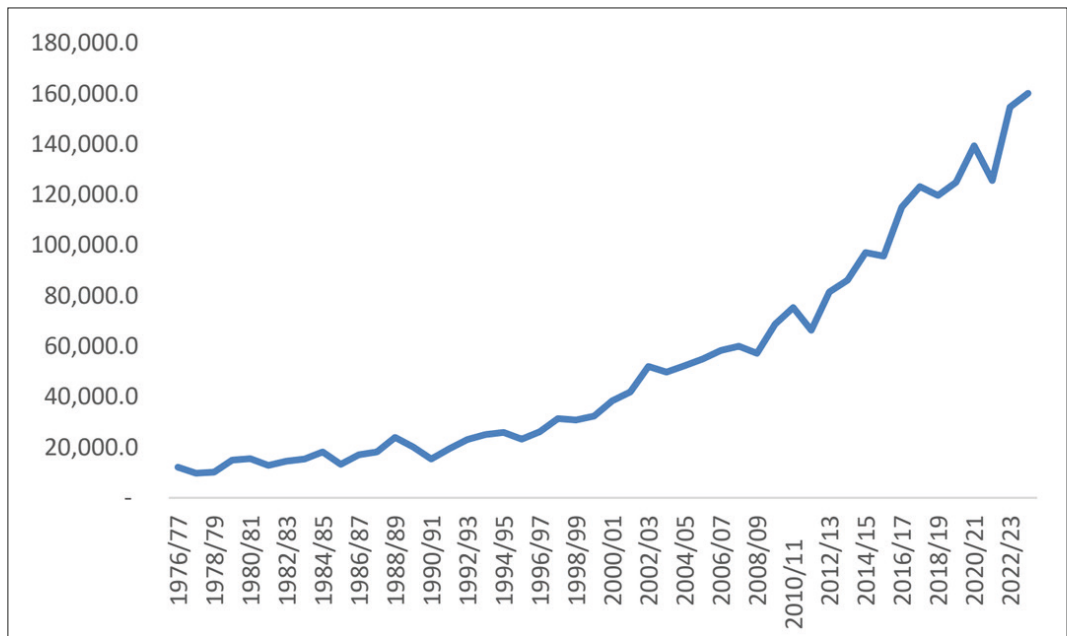
In the 1960s, two internal factors contributed to Brazil's perception of soybeans as a commercial product. At the time, wheat was the main product produced in the south of Brazil, with soya being the summer alternative. In addition, the country began a strategic effort to produce pigs and poultry, which consequently generated demand for soybean meal (EMBRAPA, 2020).

In the 1970s, soy was already the main crop in national agribusiness. National production rose from 1.5 million tons in 1970 to over 15 million tons in 1979 (APROSOJA, 2020).

All of the above-mentioned factors in the development of soybean cultivation have led Brazil to become a global crop powerhouse. Production has jumped 557% in the last 30 years, according to CONAB data. The figures show that in the 1992/1993 harvest, the country produced 23.04 million tons of soybeans. By 2022/2023, projections indicate a production of 151.4 million tons of the grain (FAVERIN, 2023).

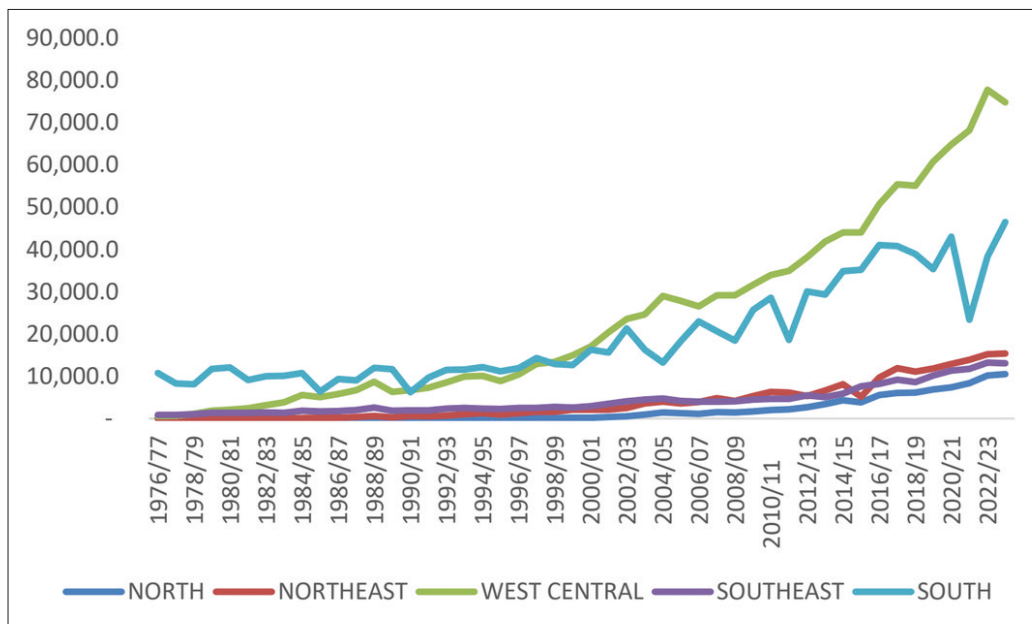
The evolution of production between 1976 and 2023 can be seen in detail in Figure 1.

Specifically in relation to the Central-West region, it can be said that it is the largest soybean producer in Brazil, followed by the South. The other three regions of the country are significantly less important for soybean production. Figure 2 details soybean production in Brazil by region between 1976/77 and 2022/23.



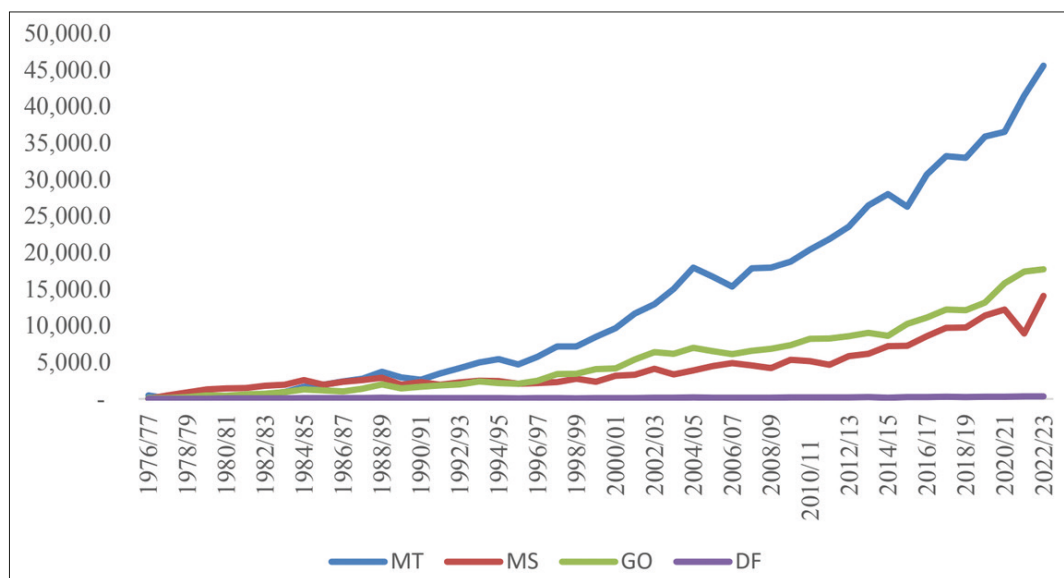
**Figure 1** - Soybean production between 1976 and 2023

Source: IBGE (2021)



**Figure 2** - Soybean production in Brazil by region between 76/77 and 22/23

Source: Conab (2023)



**Figure 3** - Soybean production in the states of the Central-West region

Source: Conab (2023)

Figure 3 highlights soybean production in the Midwest region and its respective Federative Units (FU), with Mato Grosso dominating in relation to Goiás, Mato Grosso do Sul and the Federal District.

Soybeans are increasingly consolidating their place in summer crops, due to international prices and the tendency for producers to sow corn as a second crop after the soybean harvest. The area occupied by soybeans in Brazil jumped from 36.9 million hectares in the 2019/2020 crop year to 43.4 million hectares in the crop year being harvested in early 2023 (SANTIN, 2023).

### RISKS INHERENT IN AGRICULTURAL ACTIVITY

Risk is inherent in any activity, whether in personal life or in the workplace. Risk management is fundamental to the health of a business, be it industrial, commercial or agricultural. Risk management involves applying strategies to avoid or reduce the costs generated by risks. In agribusiness, there are four types of imminent risk: production risk (associated with biological production factors, such

as pests, diseases, climate, soil, etc.), operational risk (production process failures, such as problems with fertilization, irrigation, harvest time, etc.), financial risk (management of third-party capital) and market risk (CALEGARI; BAIGORRI; FREIRE, 2012).

Schouchana, Sheng and Decotelli (2014) add that agribusiness producers are susceptible to various risks, including the risks of the business itself, such as climatic effects (frosts, droughts, excessive rainfall, etc.), unbalanced supply and demand, directly impacting prices, and risks that affect the economy as a whole, such as interest rates and the exchange rate.

Specifically with regard to agribusiness, production risks cover climatic, biological and environmental issues. Climate risks include floods, excessive rainfall, lack of rainfall, frost, hail, fires, drought and temperature variations. Biological risks include production diseases, pests, incompatible genetic material, animal health and genetic contamination. Finally, the environmental risks that stand out in agribusiness involve water and soil degradation, landslides and changes in vegetation (CORRÊA and NETO, 2017).

It is noteworthy that agriculture plays two roles in the climate change scenario. It is an activity that involves the emission of GHG, contributing to global warming, and it is an activity that is sensitive to climate change, highlighting the need for low-carbon agriculture (EMBRAPA, 2020).

Climate change in agriculture is of great concern to all actors in the production chains, since cultivation and climate change are directly connected. Strategies for adapting to climate change in agriculture and mitigating its negative effects are currently important tasks (EOS, 2022).

With regard to soybean cultivation, the climatic factors that most affect the crop are related to solar radiation, air temperature, photoperiod and rainfall. Knowledge of the crop's response to climatic conditions enables the use of different crop management strategies, such as choosing the best sowing date, cultivar, growing location, pest and disease management, etc (OLIVEIRA, 2020).

Still on the subject of soya, it's worth noting that it is a crop that is widely adaptable to the Brazilian climate and soils, on both sides of the equator. With regard to water requirements for soybean cultivation, the ideal is around 450 to 800 mm of available water throughout the crop's growing season, which varies depending on the cultivar's cycle. Rain is the main source of water for most of Brazil's soybean production (MAPA, 2023).

For climate issues, the so-called Agricultural Climate Risk Zoning (ZARC) is used, a risk analysis tool that aids decision-making in the field, considering the likelihood of adverse weather events, based on a historical series of climate data, as well as crop and soil characteristics. Specifically in relation to soybeans, areas and sowing periods are defined, simulating probabilities of yield loss of 20%, 30% and 40%, due to the occurrence of adverse weather events (MAPA, 2023).

As far as pests are concerned, soybean plants can be attacked by pests from plant germination and emergence to the physiological maturation stage, and the organisms that cause these attacks vary from insects to molluscs, diplopods and mites (ÁVILA; GRIGOLLI, 2014).

Still on the subject of risks related to soybean production, weeds stand out. Finding weeds in the soybean crop can mean a great deal of damage, with immense grain loss. Soybeans infected with weeds are subject to different forms of interference. Damage can manifest itself through competition for elements such as light, water and nutrients, directly impacting the yield and quality of the product (BRIGHENTI et al., 2021).

As far as price risks are concerned, these can be managed by the futures and options markets, promoting the early fixing of the price of the commodity, thus protecting economic agents from price fluctuations, known as volatility (SHOUCHANA; SHENG; DECOTELLI, 2014).

Aoun (2015) adds that, specifically, price risk occurs due to the volatility of agricultural *commodity* prices (production is generally short-cycle and has a low elasticity of demand). Elasticities of demand in the short term are generally low due to the low added value of agricultural *commodities* and the high degree of substitution of raw materials.

In this sense, risk management in agribusiness has come to play an important role in the lives of companies operating in this sector of the economy and for this reason knowledge of tools involving the derivatives market has become increasingly important (SHOUCHANA; SHENG; DECOTELLI, 2014).

Futures markets as a whole are used to reduce risks and stabilize trades exposed to price fluctuations. They serve as a hedge by amortizing the effect of price fluctuations on business. Such *hedging* operations are known

worldwide as *hedges*. The individual or legal entity that carries out *hedging* operations is called a *hedger* (WALTER, 2006).

Aoun (2015) adds that in order to reduce or avoid the aforementioned risks, there is *hedging*, which is characterized as an operation in which the agent takes a certain position to combat price variations and consequently their income. Generally speaking, the agent who takes a future position to avoid variations seeks to minimize price variations. These agents, by taking a position in futures, even if it is not a one-to-one spot ratio, are *hedging*, with the possibility of unpredictable gains.

*Hedging* is a strategy for reducing risk through the futures market, which consists of an operation that neutralizes the speculation implicit in any given deal. Normally, this operation boils down to buying or selling a futures contract with a value similar to the value of that particular business, i.e. any loss due to fluctuations is offset by a gain on the futures market (AZEVEDO, 2012).

On the stock exchange, risk is transferred from those who want to minimize the effects of price fluctuations to those who want to take them. This is done on the basis of expectations about the future supply and demand of a commodity. The risk taker plays the role of insurer (SHOUCIANA; SHENG; DECOTELLI, 2014).

Therefore, carrying out a *hedge* operation is similar to acquiring insurance. Through this mechanism, the seller and buyer protect themselves against the effects of fluctuations in commodity prices (SHOUCIANA; SHENG; DECOTELLI, 2014).

Financial risks encompass threats to the financial health of agribusiness, with four basic components: the cost and availability of capital; the ability to meet cash flows in a timely manner; the ability to maintain and increase equity and the ability to absorb short-term financial shocks (ALCANTARA, 2020).

They can be understood as the likelihood of a company not being able to cover all its financial obligations and are generally linked to issues involving liquidity, profitability and credit. As far as credit risk is concerned, it involves possible losses when a contractor fails to honor its commitments, ceasing to receive funds, with promised cash flows not being met (LIMA, 2012).

They derive from the possibility of a company quickly entering and exiting markets in which it does not affect prices. Mitigating instruments involve the use of contracts traded on the stock exchange, which has clear and strict rules to prevent the concentration of positions in its markets (SHOUCIANA; SILVA FILHO, 2009).

With regard to operational risks, Silva, Rodrigues and Ferreira (2019) point out that operational risks involve the production process and the company's management. It can be exemplified by losses in the production process, resulting from failures in planting and harvesting, accidents at work, mechanical problems with agricultural machinery, etc.

Operational risks are inherent in the production, storage and distribution process. They include various situations, such as the availability of suppliers, delivery times for inputs, inefficient production systems, low productivity, price variations for goods and finished products, occupational safety, etc. It is directly linked to inadequate systems, management failures and human error. One of the factors that differentiates agriculture from other sectors is the high operational risk to which the sector is subjected, which has two distinct aspects (LIMA, 2012).

Schouchana and Silva Filho (2009) add that operational risks originate from human error and control failures. They range from accounting practices to stock monitoring systems, among others.



Institutional risks in agribusiness can involve issues linked to high inflation rates, industry codes of conduct, lack of a crop purchase contract, international political instability, government legislation and regulation, changes in labor legislation, changes in government policy, changes in interest rates, agricultural and trade policy, environmental regulations, animal welfare policies, among others (CORRÊA and NETO, 2017).

Moreira (2009) points out that institutional risks are mainly defined by changes in legislation, tax policies, tariffs and interest rates, health standards, environmental restrictions and the availability of subsidized rural credit, promoted or encouraged by the government. The establishment of tax barriers or limitations on import quotas by foreign countries can also significantly affect demand and the selling price of products, in other words, making it difficult for consumers to sell or accept a given product. With regard to institutional risks, rural producers do not have the tools or management practices to reduce their incidence, so protection against this type of risk is the most subjective of all.

## METHODOLOGY

The research is exploratory and descriptive, with bibliographical research. The vast majority of exploratory research involves a bibliographical survey and analysis of examples that help to understand the subject in question, dealing with issues that are configured in time and in the context of the study, and cannot be resolved using quantitative data alone (GERHARDT; SILVEIRA, 2009).

In short, bibliographical research is mainly used in academic circles and its purpose is to improve and update knowledge by means of a scientific investigation of works that have already been published. It is essential in the construction of scientific research, as it allows us to better understand the phenomenon

under study. The instruments used to carry out bibliographical research are: books, scientific articles, theses, dissertations, yearbooks, magazines, laws and other types of written sources that have already been published (SOUSA; OLIVEIRA, ALVES, 2021).

In order to answer the guiding questions of this study and meet the proposed objectives, a search was carried out on the Google Scholar portal for publications in Portuguese between 2013 and 2023, using the keywords “soybean”, “risks”, “Midwest” and “profitability”. The selected materials (articles, theses and dissertations) were analyzed by reading their title, abstract, introduction, results and final considerations. Publications that did not focus on issues involving the risks to soybean cultivation that affect its profitability in the Midwest region were eliminated. In addition, any publications other than articles published in scientific journals, full articles published in conference proceedings, theses and dissertations were eliminated from the analysis.

A total of 16 publications were found which dealt in different ways with soybean cultivation in the Midwest region and the risks to its profitability. The analysis was carried out according to the objectives of each paper, as well as the results and final considerations, in order to identify the greatest risks to soybean profitability in the Midwest region, highlighting the fact that papers published between 2013 and 2023 were chosen.

It is worth noting that 2013 was chosen as the reference year for this research, as 2023 will mark exactly one decade of a historic soybean harvest for Brazil. According to IBGE (2014), in 2013 Brazil had a record harvest of 81.7 million tons, 15.9 million tons more than the previous year, an increase of 24.1%. The area planted was 27.9 million hectares, 2.9 million hectares more than in 2012.

## RESULTS AND DISCUSSIONS

Table 1 details the authors, year of publication and objectives of each of the selected papers.

Figure 4 details the type of risk to soybean crop profitability addressed in the selected publications.

Figure 5 highlights the year of publication of the material selected in this study. It is noteworthy that there was a balance between the number of publications per year, with a peak of five occurrences in 2020. The topic of risks that can affect profitability in soybean cultivation has remained relevant and of interest to academics and agents in the chain over the years.

With regard to the considerations that the publications obtained about the problem involving risks in soybean cultivation, Costa et al. (2014) highlight the evaluations of *hedging* strategies for soybeans in the Midwest, stating that the use of agricultural futures markets is validated in order to mitigate price risks in soybean cultivation.

Still on the subject of price risk, Costa (2015) studied price risk management in the Midwest region. To this end, the author sought to analyze the soybean chain in the Midwest with regard to *hedging* strategies for price risk. The results showed reduced effectiveness of soybean futures contracts for the municipalities of Maracaju (MS), Sorriso (MT) and Rio Verde (GO), identifying inefficiency in the strategies outlined. Among the possible causes for this performance, we highlight the exchange rate risk, highlighting the need to apply simultaneous hedging, low price synchronization and competition with the forward market.

Sediyama et al. (2013) highlight a number of factors for the soybean processing industry to achieve cost leadership, including increasing its scale of production, reducing its idle capacity to reduce average costs, increasing efficiency in logistics, improving financial

management to reduce risks in the face of price volatility and dealing efficiently with resources, interest and credit. It was found that 31.5% of the 200 soybean growers in Goiás and Mato Grosso adopted hybrid contractual forms, involving advance sales to processors, the input industry and soybean producers.

Nardino and Figueiredo (2022) state that in an environment of uncertainty, the futures and forward contract markets have emerged as an alternative for managing and reducing market risks, enabling better planning, reducing transaction costs and increasing the competitiveness of production chains, with hedging being the most common alternative for this situation. The results showed that there is a pattern of loss (reduction in revenue) for agents who use *hedging* as a tool to protect against price risk in the municipalities of the Midwest region.

Johann, Cunha and Wander (2017) detail that barter transactions can present various risks, including price, credit, operational and legal risks, so that agricultural producers and companies behave with an aversion to risk and end up giving up on barter transactions, often because they are unaware of risk protection methodologies or sometimes because they are financially conservative. The research was carried out at agricultural retailers in the states of Mato Grosso and Goiás, with the aim of describing the reality of swap operations. The survey reported that the majority of responses from survey participants involved price risk as the main risk in soybean swap operations.

Alves et al. (2019) carried out a study involving the economic viability of growing soybeans and sorghum off-season, in Catalão - GO. They found that growing soybeans and sorghum in the off-season were economically viable activities for the study region. However, the authors point out that there is a risk to economic returns in the face of unexpected changes.

Title	Authors	Year of publication	Type of publication	Objective
Evaluation of <i>hedging</i> strategies for soybeans in the Midwest using CME <i>Group</i> futures contracts: analysis of the period from 2004 to 2013.	COSTA, A.R.R. et al.	2014	Paper presented at a congress.	Evaluate the effectiveness of hedging the price risk of soybeans in the Midwest using futures contracts from the CME Group in Chicago, USA
Statistical analysis of occupational accidents in soybean cultivation in Brazil and the Midwest region from 2008 to 2018.	MOZENA, A.L.K.; MENDES, N.A.C.; SANTOS, P.S.B.	2020	Article published in a scientific journal.	To verify the initiatives of the soybean cultivation sector with regard to the incidence of occupational accidents in Brazil and in the Central-West region.
Temperature effects on soybeans and corn in the state of Mato Grosso do Sul	NASCIMENTO, W.F. et al.	2018	Article published in a scientific journal	To verify the effects, without taking into account the grain production of each crop, but rather the minimum temperature on soybean and corn crops in municipalities in Mato Grosso do Sul between 2008 and 2014.
Price risk management and the economic and financial performance of the main companies in the Brazilian soybean production chain	COSTA, A.R.R.	2015	Master's dissertation	To analyze the Central-West soybean production chain in terms of price risk hedging strategies and the economic and financial performance of the main companies in the production chain.
Analysis of the structure, conduct and performance of the soybean processing industry from 2003 to 2020	SEDIYAMA, A.F. et al.	2013	Article published in a scientific journal	To analyze the structure of the soy processing industry, as well as its conduct and performance in Brazil.
Basis risk and its volatility in the soybean trade in Mato Grosso (2009 to 2019)	NARDINO, F.P.; FIGUEIREDO, A.M.R.	2022	Article published in a scientific journal	Analyze the volatility of the basis in soybean hedges in municipalities in Mato Grosso between 2009 and 2019.
Barter operations to finance soybean and corn production in Goiás and Mato Grosso, Brazil	JOHANN, A.R.G.; CUNHA, C.A.; WANDER, A.E.	2017	Article published in a scientific journal	To analyze the determining factors for the use of corn and soybean barter operations from the perspective of agricultural input dealers at Goiás and Mato Grosso in 2015.
Resistance and tolerance of soybean defoliator caterpillars to insecticides	CONTINI, R.E.	2020	Master's dissertation	To evaluate the tolerance of insects of different instars of <i>C. includens</i> and <i>A. gemmatalis</i> to insecticides.
Economic study of safrinha soybean and sorghum cultivation	ALVES, G.N. et al.	2019	Article published in a scientific journal	To assess the economic viability of planting soybean crops and sorghum for the off-season.
Comparative analysis of input payments for soybean production in the state of Mato Grosso	KUNITAKE, A.; MOTA, E.P.	2016	Article published in a scientific journal	Comparing four forms of payment for agricultural inputs in the soybean crop in the state of Mato Grosso in the 2014/15 harvest.
Economic viability for soybean and corn crops in the southeastern region of Goiás	ROCHA, L.G. et al.	2021	Article published in a scientific journal	Analyze the economic viability of soybean and corn crops in the 2018/19 harvest.
Impact of sowing time on the economic viability of two second crop soybean-maize systems in Mato Grosso do Sul	KAMOI, M.Y.T. et al.	2022	Article presented at congress	To evaluate the impact of the sowing time for soybeans and second crop corn, following the ZARC parameters, on the economic viability of two systems in Mato Grosso.
Grain production systems and economic risk in consolidated and expanding agricultural areas in Brazil	GUIDUCCI, R.C.N.; HIRAHURI, M.H.	2020	Article published in a scientific journal	To analyze the economic risk of six grain production systems representative of consolidated areas and more recent expansion areas in Brazil (2000 to 2015), seeking to identify the risk factors that affect income and production costs.
Study on the feasibility of using weather derivatives as a risk management tool for soybean cultivation in the state of Mato Grosso	ALVES NETO, A.	2021	Master's dissertation	Proposal of a climate contract for soybean production in the state of Mato Grosso.
Price risk in soybean trading: use of derivatives by rural producers in Maracaju - MS	MÜHLEN, A.S.R.W.; CEZAR, I.M.; COSTA, F.P.	2013	Article published in a scientific journal	To analyze the behavior of soybean producers at Maracaju - MS with regard to price risk and the use of agricultural derivatives and to identify the price protection mechanisms used.

Climate risk zoning for soybean cultivation in the Cerrado	MELO, A.C.A. et al.	2020	Article published in a scientific journal	Comparing two methodologies for agricultural zoning of soybean climate risk in the Cerrado Biome.
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Table 1 - Title, authors, year and type of publication and their respective objectives

Source: Prepared by the author (2023)

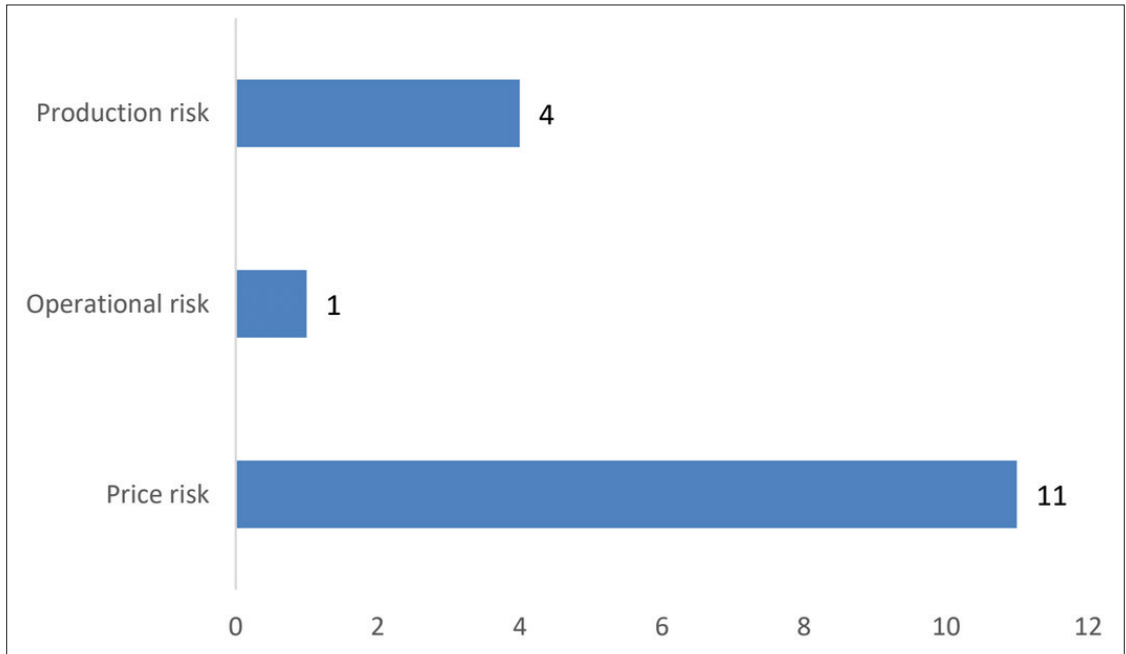


Figure 4 - Type of risk addressed in the selected publications

Source: Prepared by the author (2023)

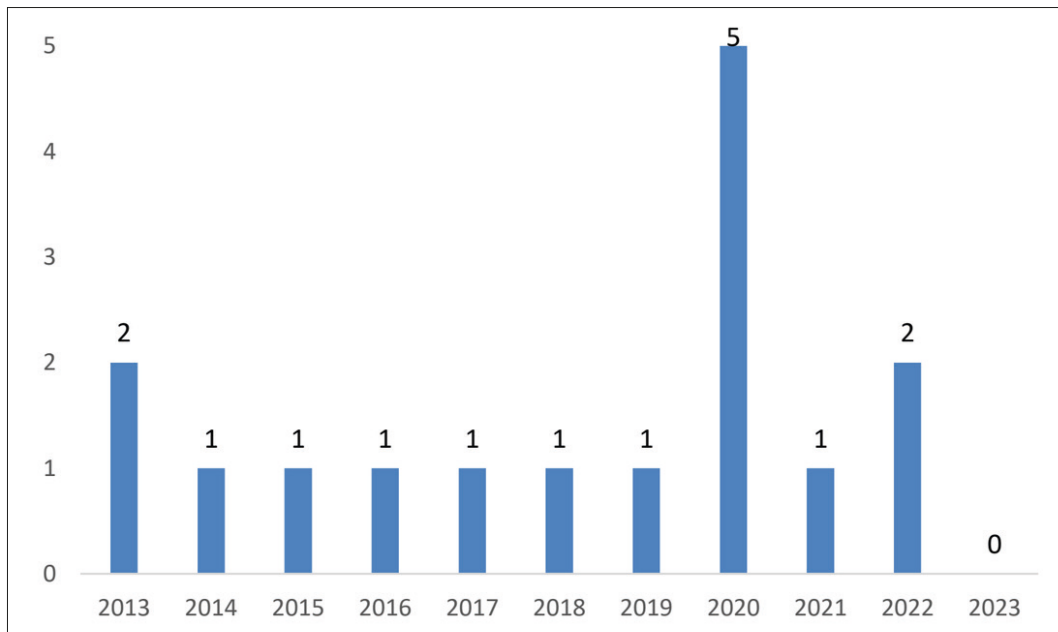


Figure 5 - Number of publications per year

Source: Prepared by the author (2023)

Kunitake and Mota (2016) discuss the payment of inputs for soybean production in the state of Mato Grosso, highlighting that the purchase of inputs has a large weight in the cost of soybean production, making the producer check for the best possible payment terms. The survey showed that rural producers have a positive perception of barter operations (the producer eliminates two concerns: financing and storing production) in order to control risk, as they are aware of the price fluctuations arising from the price of the *commodity*.

Rocha et al. (2021) discuss the economic viability of growing soybeans and corn in southeastern Goiás. The study was carried out during the 2018/19 summer harvest, using data from a rural property located in the municipality of Ipameri, Goiás. In the case study in question, the authors conclude that there is economic viability in the southeastern region of Goiás, noting that soybeans performed better than corn.

Kamoi et al. (2022) highlight the impact of sowing time on the economic viability of two second crop soybean-maize systems in the state of Mato Grosso. The authors state that by identifying the risk factors associated with a given activity, producers can look for mechanisms to mitigate them. The study concluded that a producer who does not consider any price or production risk management strategy has the economic viability of his system directly affected by choices such as the sowing time of his crops.

Guiducci and Hirahuri (2020a) analyzed the economic risk in grain production systems in Brazil, comparing areas at different stages of production consolidation, using data from municipalities in Mato Grosso, Paraná, Maranhão, Minas Gerais, Tocantins and Pará. The results indicated that soya was the most economically stable grain, with a moderate level of risk.

Mühlen, Cezar and Costa (2013) addressed the issue of price risk in soybean trading

in the municipality of Maracaju, in Mato Grosso do Sul, by analyzing the behavior of rural producers with regard to price risk and the use of agricultural derivatives. It was concluded that producers in Maracaju are concerned about price risk. Even so, the use of price protection tools, such as the Futures Market (*hedge*) and Options Market, is still insignificant, as 11.1% of those interviewed use such tools and 38% have already used them, so that the most used mechanism is the Forward Market. It was found that the low use of derivatives (futures and options) is mainly due to a lack of knowledge and the absence of reliable professionals to advise producers.

With regard to production risks, Nascimento et al. (2018) focus their research on the effects of temperature on soybeans and corn in the state of Mato Grosso do Sul. The authors point out that the dynamic climate in Mato Grosso do Sul leads to an understanding of the succession rhythm of the types of minimum grass temperatures linked to soybean and corn crops. The optimum conditions for soybean crop development are between 20 and 30°C, so that 30°C is the ideal temperature. In view of this, the various drastic variations in temperature throughout the year can be detrimental to the soybean crop when planting, developing and harvesting.

Melo et al. (2020) also highlight climate risk zoning for soybean cultivation in the Cerrado. They point out that climate variables are agronomic risk factors, so that crop performance depends directly on soil and climate conditions. The authors emphasize that Agricultural Climate Risk Zoning (ZARC) indicates what, where and when to plant in order to avoid unexpected climatic events. Finally, the authors point out that the low climate risk agricultural zones for soybeans are located in the central area of the Cerrado biome and also in the transition area between the Cerrado biome and the Amazon biome.

Alves Neto (2021) presents a study on the feasibility of using weather derivatives as a risk management tool for soybean cultivation in the state of Mato Grosso. The author states that climate derivatives were created for the energy sector with the aim of mitigating the risk linked to problems arising from the climate that could harm the sector's performance. The results offer Brazil a discussion on the introduction of new tools linked to agricultural policy in Brazil, especially with regard to soybean cultivation in Mato Grosso.

Contini (2020) studied the resistance and tolerance of soybean defoliator caterpillars to insecticides, with the aim of assessing the tolerance of insects of different instars of *C.includens* and *A.gemmatalis* to insecticides. It is noteworthy that in 2003 and 2004 population outbreaks of *C.includens* were observed soybeans in the Midwest, showing a strong risk to production. The author explains that failure to use insecticides can lead to a risk of environmental contamination, human poisoning, food insecurity and an increase in production costs for the producer, i.e. application must be targeted and efficient in order to avoid major problems in cultivation. It was concluded that *C.includens* can cause serious damage to commercial crops of different types, constituting a production risk that needs to be managed efficiently in order to avoid damaging crops.

Mozena, Mendes and Santos (2020) carried out a statistical analysis of the number of occupational accidents in soybean cultivation in the Midwest region between 2008 and 2018. It was found that typical accidents were the most prevalent during the period analyzed (80.67%), with a tendency to increase, in addition to the fact that the occurrences of accidents in the Midwest contribute directly to the increase in the national average of accidents.

## FINAL CONSIDERATIONS

The literature search returned 16 publications, 11 of which were articles published in scientific journals, three dissertations and two articles published in congresses. It is clear from the selected publications that there is concern about two types of risk that can impact the profitability of soybean cultivation in the Midwest: production risk and price risk.

In fact, the importance of soya is clear, since the revenue from exports from the soya agro-industrial complex represents around 8% of Brazil's total exports, so that its contributions go beyond its production chain, helping Brazil's trade balance to perform year after year.

With regard to price risks, there is a tendency for producers and other agents in the chain to lack knowledge about how the futures market works (especially *hedging*), which contributes to their low adherence. There is a need for access to information for producers, as well as professionals trained to advise them on *hedging* strategies.

The articles also highlight the importance of the barter strategy, in this case detailing this operation in the states of Goiás and Mato Grosso. The research also showed that producers have a positive view of bartering.

It is clear from the publications selected that it is important to define risk management strategies in order to guarantee profitability in the soybean crop, both in the Midwest and in any other region of the country. Strategies that ensure the price of soya help to guarantee the viability of an agricultural enterprise in a more consistent way.

With regard to production risks, the publications on the subject show great concern about climate issues, demonstrating that various drastic changes in temperature throughout the year could harm the soybean crop during planting, development and harvesting, characterizing the production risk due to climate change.

Another production issue is linked to the application of insecticides on soybean crops, due to the presence of *C.includens* and *A.gemmatalis*, highlighting the importance of correct applications of insecticides on the crop, since failures in the use of insecticides can lead to a risk of environmental contamination.

In short, according to the publications selected for this research, price and production risks are the ones that most demand care from agents in the soybean production chain, especially rural producers in the Midwest, who are the biggest contributors to production and planted area figures in Brazil, and who should seek to guarantee their profitability through efficient risk management. However, a significant proportion of producers do not have access to issues involving the instruments used to manage price risks, such as the futures and forward markets. With regard to pests or any other factor that could harm production, government instruments such as EMBRAPA, MAPA and others present various ways of mitigating production risks.

It can be seen that risk management is a determining factor in improving the profitability of soybean production, and as already mentioned in this paper, in contributing to the management of the risks highlighted. In recent years, the participation of technology has been notable, with various platforms and applications providing faster and easier access to information, promoting various ways of mitigating or minimizing risks. One prominent example is monitoring climate risk, whe-

re it is possible to estimate an assertive forecast of expected rainfall or lack thereof, thus being able to choose the most suitable crop for the planting window or reducing the amount of planted area in order to avoid greater losses. Hiring agricultural insurance is a way of ensuring minimum production coverage to at least cover operational and product costs.

It should also be noted that structured barter operations have been a growing strategy over the last 10 years, mainly because they provide security and guarantee the stability of purchases without the risk of succumbing to market fluctuations or speculation. The production risk is the most relevant and at the same time the most controllable because it depends on the decision factors themselves. These are risks related to production but directly linked to the way in which the operational management and management of the crop is carried out, employees, handling of products, use and maintenance of machinery are key to obtaining greater profitability. The importance of professional agronomic support with the appropriate recommendations for crop management is also highlighted in the contribution to better results.

Future research would suggest studying the factors that most impact the profitability of other crops such as corn and sugar cane, which are also of great importance to the agribusiness trade balance. It is also suggested that a broader study be carried out on the soybean crop, at a national level, regarding the risks that most impact its profitability.

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