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Analysis of the performance of hedging with put options

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EDITORIAL DETAILS

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ABSTRACT

This study comparatively analyzed the performance of an investment portfolio *hedge*d with put options versus the same un*hedge*d portfolio from 2018 to 2022. The adopted methodology was quantitative, descriptive, and bibliographical, with systematic observation data collection using the BOVA11 index and at-the-money put options. The results indicated superior performance of the *hedge*d portfolio, particularly during periods of heightened economic volatility, such as the COVID-19 pandemic in 2020. Although hedging costs were significant, the accumulated balance was positive, demonstrating the effectiveness of hedging strategies in mitigating risk and preserving investor capital. This underscores the importance of investors understanding of *hedge* strategies given the increasing participation of individual investors in the Brazilian variable income market.

Keywords: derivatives market, *hedge*, options, variable income

1 INTRODUCTION

Investors with allocations in variable income assets, especially in the Brazilian Stock Exchange (B3), are exposed to the volatility and price fluctuations characteristic of this market. Such variations can represent significant risks, especially market risk, which can compromise the portfolio's profitability and, in more severe situations, result in patrimonial loss (Lira & Almeida, 2020). In Brazil, the average monthly volatility of stock prices, just in January 2023, was 22.15%, showing that a portfolio composed of stocks traded on the exchange presented, on average, a variation of almost a quarter of its value within the same month (B3, 2023).

A strategy used to mitigate the risks arising from these variations is hedge, which operates by offsetting the results of protected assets with the financial instruments used as defense (Assaf Neto, 2014). As pointed out by Canongia et al. (2015), hedge is a technique aimed at protection, whose purpose is to avoid the depreciation of an asset's value over time or to maintain the price of a future obligation. To qualify for hedge accounting, the operation must be related to a specific risk of the entity, not just general risks (Canongia et al., 2015).

Derivatives are used to carry out hedges. According to Assaf Neto (2014), derivatives are contracts whose value derives from a reference asset, which may be a commodity, stock, interest rate, or other. The derivatives most used as hedge instruments are futures, forward, swap, and option contracts (Assaf Neto, 2014). The options

market, in turn, is a derivative structure that offers the investor a kind of insurance, allowing protection against unfavorable price fluctuations (Hull, 2016). In this market, contracts grant the buyer the right, but not the obligation, to exercise the purchase or sale of the assets, while the seller assumes the contractual obligation (Rubash, 2001).

Given this scenario, it becomes relevant to deepen the study on hedge, considering its structure, applicability, and the financial instruments that comprise it (CPC, 2012). Although there are studies on the use of hedges, most focus on futures contracts, especially on exchange rate protection. Feyh et al. (2019) identified a lack of research on the use of options as hedge instruments and recommended further investigations on the subject. Martins and Filho (2013) analyzed the use of hedge by Brazilian companies listed on the stock exchange, highlighting its importance as a protection instrument, while Cardoso and Rosa (2017) observed an increase in the adoption of hedge by companies over time.

In this context, the following guiding question arises for this study: how does the performance of a portfolio with a hedge compare to the performance of a portfolio without a hedge? Thus, the central objective of the research is to analyze the performance of a portfolio that uses protection via put options, compared to the same portfolio without any protection structure.

The year 2023 was marked by instability in the Brazilian economic scenario, with high interest rates, inflationary pressure, and fiscal uncertainties, factors that increased the volatility of the variable income market (B3, 2023). According to B3 (2023), well over 246 thousand individual investors traded options contracts in the second quarter of the year, demonstrating the growth in the use of derivatives as protection instruments. This movement is especially relevant among younger and more digitalized investors, highlighting the timeliness of the topic addressed. Gama et al. (2023) point out that protection strategies with options remain effective even in periods of economic imbalance, reinforcing the usefulness of hedges.

According to B3 (2023), 5.3 million individual investors participated in the Brazilian stock market in the second quarter of 2023, marking a 21% increase compared to the same period the previous year. The amount under custody reached R$ 506 billion. Still, according to B3 (2023), 900 thousand new investors entered the variable income market in 2022, with emphasis on the young public between 25 and 39 years old, responsible for almost half of the options operations in the analyzed period.

Therefore, this study is justified by the relevance of the topic, given the increase in the number of investors and the growing use of derivative instruments, especially options, by individual investors (B3, 2023). The academic contribution is also evident due to the scarcity of studies focused on strategies with options in the Brazilian market, which provides originality and practical applicability to this work (Feyh et al., 2019).

The structure of this study includes, in addition to this introduction, a literature review on derivatives and performance metrics, methodological procedures, data analysis and results, and the final considerations.

2 THEORETICAL FRAMEWORK

The theoretical framework underlying this research is divided into two main areas: the functioning of the capital market and derivative instruments, especially hedge structures. Additionally, the main metrics used for analyzing investment portfolio performance are presented. The construction of these sections supports the theoretical framework necessary for the development of analyses and discussion of results, ensuring adherence to the state of the art on the addressed topics (Kuaark et al., 2010).

For the development of this theoretical foundation, a comprehensive bibliographical review was carried out, using specialized databases such as SPELL, Scopus, Science Direct, JSTOR, Portal de Periódicos Capes, ProQuest, and specific finance journals, in addition to classical books and official regulations relevant to the object of the study.

2.1 The Capital Market

The Brazilian financial market is considered solid and stable, a result of globalization processes, economic openness, and structural modernization, such as the restructuring of the Brazilian Payment System (Brito, 2020). According to Brito (2020), the structure of the national financial system includes regulatory, monetary, and supervisory authorities, as well as public and private financial institutions. The central objective of the National Financial System is to promote the connection between surplus and deficit agents in the economy, which can occur in both the primary and secondary markets (Assaf Neto, 2014).

In the context of the capital market, defined by the Brazilian Securities Commission (CVM) as an inducer of savings and investment, essential for the growth of modern economies (CVM, 2020), investments are made in fixed and variable income. Fixed income investments are characterized by predetermined remuneration rules, such as fixed interest or rates linked to inflation indices, and can be represented by public or private securities (Banco do Brasil, 2020). On the other hand, variable income investments do not have known profitability at the time of application, as they depend on the future performance of the asset, with stocks being the most widespread example (Fortuna, 2015).

Investments made in the capital market are especially subject to market risk, which arises from uncertainty about the value changes of financial instruments and can affect portfolio results (Amaral, 2003). This risk is often associated with volatility, representing fluctuations in the prices of financial assets, whether positive or negative, resulting from multiple factors linked to the performance of institutions and the market as a whole (Jubert et al., 2008).

Volatility, in the context of the financial market, manifests itself through price fluctuations of assets such as stocks and bonds, and tends to intensify during periods of crisis (Lira & Almeida, 2020). Galvão et al. (2000) argue that the futures market plays economic roles in price predictability and risk sharing, with the volatility and oscillations of the market largely attributed to exogenous factors outside the market's internal dynamics.

2.2 Derivatives

Amaral (2003) highlights that the intensification of global volatility in interest rates and prices stimulated the creation of the derivatives market, aiming to provide protection and risk transfer instruments. According to the Securities and Exchange Commission, the derivatives market includes options, forward, swaps, futures, and structured operations contracts, regardless of the form of contracting (CVM, 2023).

The derivatives market is characterized as a secondary segment, as contracts derive their value from an asset previously traded in the primary market (Carvalho, 1996). These instruments can be used for speculation or for risk management and protection, also called hedge (Carvalho, 1996).

2.2.1 Types of Derivative Operations

There are four main operations in the derivatives market, according to the Securities and Exchange Commission regulations: swaps, futures contracts, forward contracts, and option contracts, with the latter being the focus of this study (CVM, 2023).

In the futures market, operations are predominantly traded on the exchange, with contracts standardized in date and price, in which one party commits to buying the asset and the other to selling it (Hull, 2016). These contracts are widely used in commodities, especially agriculture, as a form of protection against price fluctuations, a practice known as hedge (Tomáz & Monteiro, 2023).

Forward contracts, also present in the derivatives universe, establish the purchase or sale of a certain asset at a pre-agreed price and date. Its structure is relatively simple, with two sides: the buyer and the seller, each obligaded to buy or sell the asset at the agreed time (Hull, 2016). Companies often use forward contracts for currency hedges, reducing exchange exposure

risks and mitigating the impacts of suboptimal investments, which, in turn, can increase company value (Guimarães et al., 2020).

A swap is defined as an agreement for the exchange of cash flows between two parties and is used to mitigate risks in market operations (Teixeira, 2015). Swap contracts are traded over-the-counter and usually involve exchanges based on interest rates, exchange rates, or other variables (Hull, 2016).

Option operations, the central focus of this article, grant the holder the right, but not the obligation, to buy or sell an asset at a predetermined date and price, with the counterparty called the writer, who assumes the contractual obligation (Sanvicente, 2003; Carvalho, 1996). The option's underlying asset may be stock, index, currency, or commodity. The exercise of the options depends on the relationship between the strike price and the price of the underlying asset, which determines whether the option is in the money, at the money, or out of the money (Assaf Neto, 2014).

Table 1

Classification of the Relationship Between Strike Price and Underlying Asset Price

CLASSIFICATION	CALL (call option)	PUT (put option)
in the money	Asset prices are higher than strike prices	Asset prices are lower than strike prices
at the money	Asset prices are equal to strike prices	Asset prices are equal to strike prices
out of the money	Asset prices are lower than strike price	Asset prices are higher than strike prices

Note. Adapted from Hull (2014).

Regarding option expiration, it can be identified by letters ranging from A to X, which indicate the expiration month for each option, differentiating call and put options as shown in Table 2. The letters are also called exercise dates, and they occur once a month, always on the third Friday of each month (B3, 2023).

Table 2

Options Expiration

Expiration Month	*Call Option Series*	Put Option Series
January	A	M
February	B	N
March	C	O
April	D	P
May	E	Q
June	F	R
July	G	S
August	H	T
September	I	U
October	J	V
November	K	W
December	L	X

Note. Adapted from Hull (2014).

In the options market, as in other derivative structures, agents are classified according to their position in relation to risk. An agent seeking risk protection and adopting a conservative stance is called a hedger, while an agent seeking financial gain and having a more aggressive profile is called a speculator (Carmona, 2009). This derivative is traded both over-the-counter and on the stock exchange.

2.3 *Hedge*

Option structures allow investors to limit losses and protect their positions, being widely used both for protection and speculative purposes (Géczy et al., 2007). The concept of hedge, whose origin dates back to Keynes' studies (1930), is characterized as a defensive position aimed at risk minimization (Sanvicente, 2003).

Central Bank of Brazil Circular 3,082 (2002) defines hedge as a financial instrument intended to fully or partially offset the risks of fluctuations in the market value of assets, liabilities, commitments, or future transactions. Hull (2016) illustrates the practical application of hedge by exemplifying the use of put options to limit losses in stock portfolios. Despite the cost of the protection structure, it provides the investor with additional security against adverse price movements.

The relevance of hedge was especially evident in 2023, with a significant increase in derivative operations among individual investors, especially in the 25–39 age group, reflecting the environment of high volatility and economic uncertainty (B3, 2023). Laurent (2023) and Gama et al. (2023) reiterate that the use of hedges is fundamental to preserving capital and reducing losses during periods of instability.

2.4 Related studies

Caffagni (2023), in his study on hedging operations with put options, highlights that such instruments "are a good way for agents to protect themselves against price fluctuations, as they set a barrier in the undesired direction of prices," practically demonstrating how one can understand the pricing of the analyzed commodity as well as the behavior of the futures market applied to the options market, presenting hypothetical scenarios of falls and rises on the options' expiration date.

Florindo (2021) aimed to evaluate the performance of an investment strategy with the main objective of capital preservation during crisis periods, composing two portfolios formed by shares of state-owned companies, one of which used the hedge strategy implemented through out-of-the-money put options. The portfolios were analyzed and compared based on total return during the period and from a risk-return perspective, using the Sharpe and Treynor indices, with the results indicating that the continuously hedged portfolio showed higher returns and a better risk-return ratio than the unhedged portfolio.

Albuquerque (2020) investigated the optimal hedge of a stock portfolio using futures contracts, analyzing the optimization of a stock portfolio in two distinct scenarios: high and low performance of the Brazilian stock exchange, and concluded that the hedge was effective by reducing the return risk and decreasing the Ibovespa's variance by more than 90%.

Bertoncello (2018) carried out a comparative analysis of the use of hedges with options aimed at the commodities sector, especially soybeans, with the objective of demonstrating to producers' ways to protect against price fluctuations. The author concluded that the use of hedge in the options market, especially for soybeans, provides significant protection against price changes of the underlying asset, reducing the risk faced by producers.

Gama et al. (2023) analyzed evidence of hedge behavior during crises, such as in 2008, and concluded that the stability and effectiveness of hedges remain during periods of economic imbalance, indicating that this instrument is effective for controlling risks during times of instability and uncertainty.

Laurent (2023) discussed gold as a traditional hedge instrument, especially in scenarios of geopolitical and global economic uncertainty, highlighting that, in the face of intensified international conflicts and inflationary pressures, investors and central banks increased their positions in gold as protection against systemic risks, reinforcing the role of the metal as a defensive strategy in portfolios.

Liu (2023) investigated the relationship between risk tolerance and the use of digital financial platforms, with an emphasis on investment transactions, demonstrating that individuals with a greater appetite for risk tend to adopt digital financial instruments, including derivatives. This finding is relevant to the context of this work, as it shows that investors' risk profiles directly influence the adoption of hedge strategies and the use of derivatives for portfolio protection, especially in emerging and digitalized markets.

Moreover, Feyh et al. (2019) analyzed the impact of not using a currency hedge in a pulp exporting company, discussing different types of hedges and pointing out the limited number of studies published on this topic, and recommending future research. Martins and Filho (2013) published on the use of hedges by Brazilian companies listed on the stock exchange, exploring the derivatives market and the types of hedges present, justifying the importance of these financial instruments. Later, Cardoso and Rosa (2017) continued the research line, analyzing the factors determining the adoption of hedges by listed companies, and noted growth in the number of companies using protection from one year to the next.

3 METHODOLOGY

This study aims to perform a comparative analysis of two simulated investment portfolios: one that includes a hedge structure using at-the-money put options and another that does not include this structure, in order to verify their performance. Thus, the present study is classified as applied research in terms of its purpose, as "it aims to generate knowledge for practical application and is directed toward the solution of specific problems" (Silva, 2005, p. 20). This research will analyze the results obtained using indexes, percentages, volatility numbers, and performance metrics, thereby classifying it as quantitative research in terms of its approach. According to Silva (2005, p. 20), this type of research "considers that everything can be quantified, which means translating opinions and information into numbers to classify and analyze them".

Regarding its objectives, it is characterized as descriptive research, as it seeks to describe the results, in line with Kauark et al. (2010, p. 28), who state that descriptive research "aims to describe the characteristics of a given population or phenomenon, or the establishment of relationships between variables." It is expected that the results obtained may serve as reference and guidance for new investigations on the subject. Regarding procedures, it is characterized as bibliographic research, as it uses already published material, especially journal articles, in its elaboration (Silva, 2005).

The population of this research, described by Silva (2005, p. 32) as "the totality of individuals who have the same characteristics defined for a given study," comprises the stocks listed on the Brazilian Stock Exchange (B3). The sample, defined by Silva (2005, p. 32) as "the subset of the universe or population by which the characteristics of this universe or population are established or estimated," consists of the BOVA11 index fund, an ETF (Exchange Traded Fund), that is, a portfolio of assets based on a benchmark index, in this case, the Ibovespa, aiming to cover all the stocks of the Brazilian Stock Exchange in a general way. Therefore, the final sample is characterized as non-probabilistic and intentional, as it is composed of the index chosen by the researcher (Silva, 2005) and is due to its comprehensiveness, making it possible to have a macro view of the Brazilian stock scenario.

The instrument defined for data collection is systematic observation, defined as the "obtaining of data on certain aspects of reality" in a planned manner (Silva, 2005, p. 33). The analysis period is 5 years, covering 2018-2022, totaling 60 observations, 12 annual observations divided by months. The portfolios will be simulated with historical data taken directly from the Brazilian Stock Exchange (B3) website. Additionally, for extracting historical data, the websites Investing (2023) and Comdinheiro (2023) are used, providing the necessary information for simulating the put options structures traded on the Brazilian Stock Exchange (B3) during the observed years.

Hull (2014), who discusses portfolio insurance through hedge options and calculates the portfolio's beta, provides the basis for the percentage of at-the-money put options purchased. As in this research, the portfolio consists only of the BOVA11 index, which follows the Ibovespa and has beta 1, our portfolio follows the same definition, making it possible to determine the percentage of the portfolio to be protected (Hull, 2014). This percentage is defined according to market expectations, the investor, and the guidelines of the investment specialist who may be assisting the investor in this protection; a commonly used percentage is to protect the entire portfolio (Campos, 2021). In this research, a protection percentage of 100% of the portfolio or as close as possible was considered, according to the individual cost of each option. To arrive at these values, percentages between 0.7% and 0.8% of the total portfolio value were used to approximate 100% protection.

Only at-the-money (ATM) options were used, as they offer a balance between cost and protection. These options have a strike price close to the asset's market value, providing an effective hedge without requiring excessive premiums. In-the-money (ITM) options are more expensive, and out-of-the-money (OTM) options offer limited protection. Hull (2014) points out that ATM options are the most suitable when seeking hedge efficiency with cost control. Likewise, according to Silva et al. (2023), the use of ATM options is more efficient in simulations seeking to analyze total protection with viable costs, aligning with this study's proposal.

After collection, the data were analyzed according to the objective outlined in the study and presented in tables and figures for clearer visualization. Although the related studies listed are not of the same methodology, they were used as a basis for interpreting and comparing the collected data, given the scarcity of articles addressing exactly the same topic (Feyh et al., 2019).

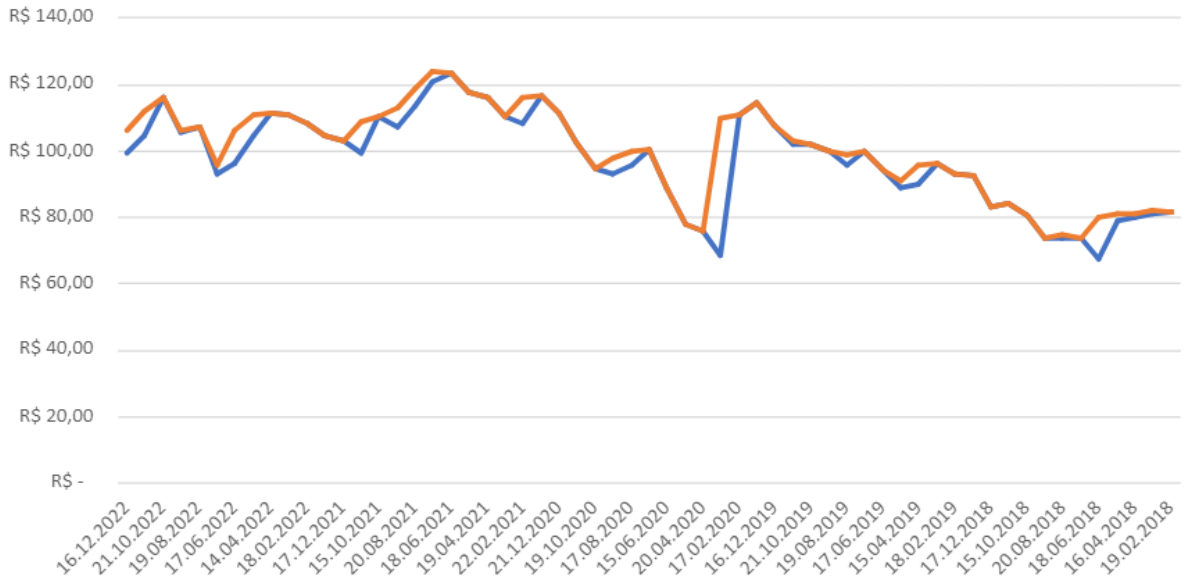
4 DATA ANALYSIS AND DISCUSSION

This section presents the analysis of the data obtained to answer the objective proposed in this study. The data were collected and analyzed as set out and determined in the methodology of this research and in accordance with the objective outlined. We developed the results and discussions from the data collection, drawing inspiration from related studies listed in the theoretical framework of this research. For the analysis of the data, the information obtained was presented in tables and figures for better visualization and understanding.

Figure 1 shows the monthly fluctuation of BOVA11 index prices, comparing the performance of the portfolio with a hedge (protection with put options) and the portfolio without protection. Options were purchased monthly, being exercised or not on the expiration date, with repurchase on the following day. The selection criterion prioritized liquidity and "at the money" options, or as close as possible, with exclusive focus on protection, not speculation. This approach aimed to limit losses, mitigate risks, and manage fluctuations, as argued by Gécz et al. (2007).

Figure 1

Monthly price fluctuation of the portfolios - in orange portfolio with hedge and in blue portfolio without hedge



Note. Research data (2025).

The dates used in Figure 1 correspond to the monthly expiration of options over the five observed years. The objective is to provide a clear view of the difference between the two strategies. For protection close to 100% of the portfolio, the total accumulated cost was R$ 108,096.08, while the return generated by the executed put options totaled R$ 109,508.36.

This result shows that, despite the costs involved, the hedge structure was effective. As presented in Table 3, only in 2018 and 2019 did the cost of protection exceed the return obtained. Over the period, the balance was positive, with the return exceeding the cost, demonstrating the feasibility of the strategy.

Table 3

Cost and return

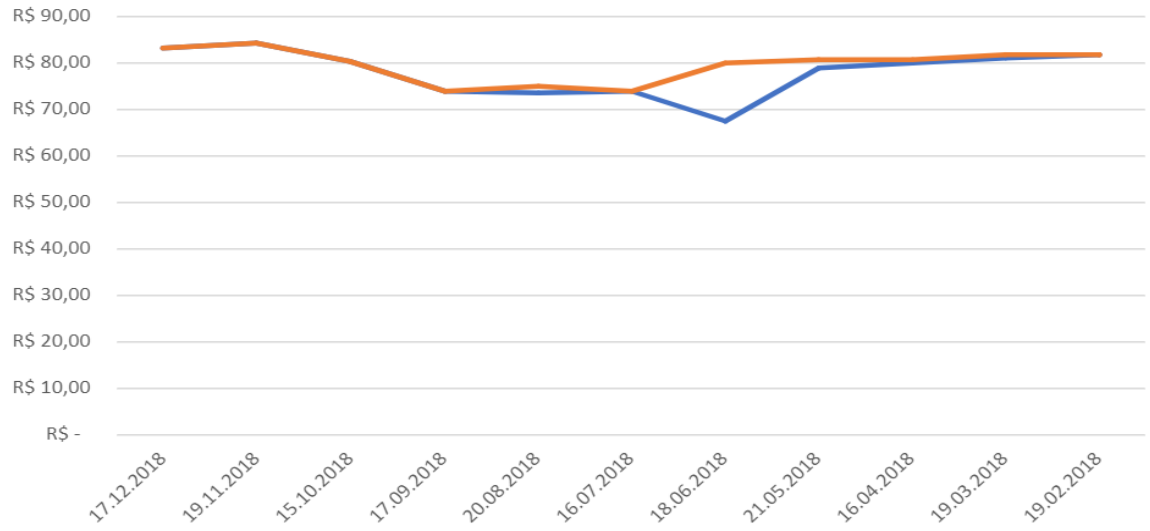
	2018	**2019**	**2020**	**2021**	**2022**
Cost	R$11.423,84	R$17.380,54	R$26.335,53	R$28.179,76	R$24.776,42
Return	R$9.835,03	R$9.390,38	R$32.296,65	R$29.333,23	R$28.653,07
Result	-R$1.588,81	-R$7.990,16	R$ 5.961,13	R$ 1.153,47	R$ 3.876,65

Note. Research data (2025).

In 2018 and 2019, the protected portfolio performed worse than the unhedged portfolio, since the structure costs exceeded the returns obtained, especially in 2019. Despite the negative result in 2018, it is important to highlight that, at the expiration of the option in June, the protection structure fulfilled its role of smoothing fluctuations, as can be seen in the section presented in Figure 2.

Figure 2

2018 price fluctuation with date highlights - in orange portfolio with hedge and in blue portfolio without hedge

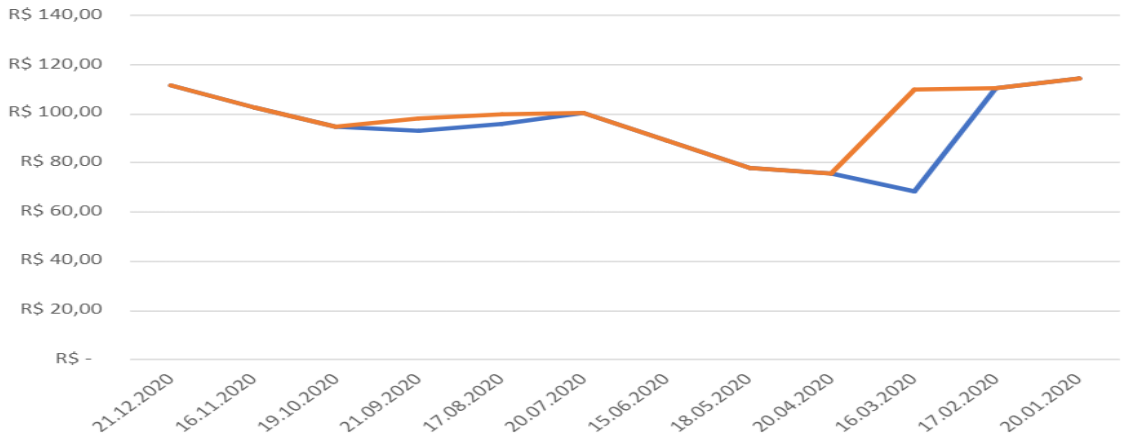


Note. Research data (2025).

From 2020 onwards, the protection structure started to show better performance compared to the unhedged portfolio. This was the year when the strategy achieved its best result, even with few options actually executed—only three—while the others expired worthless. Even so, especially in March, during the onset of the pandemic, the protection performed very effectively, as illustrated in Figure 3.

Figure 3

2020 price fluctuation with date highlights - in orange portfolio with hedge and in blue portfolio without hedge



Note. Research data (2025).

For a more specific analysis of the protection structure's performance, Figure 3 highlights only the expiration dates of the put options in 2020, both those that were executed and those that expired worthless.

Table 4 shows more clearly the portfolio performance in 2020, demonstrating the closing price of the underlying asset on the option's expiration date, shown in the first column and symbolized by the letter at the end of the index name, as well as the values of the portfolio with and without hedge.

Table 4

Portfolio values with and without hedge

Option	Date	Closing	Portfolio without hedge	Portfolio with hedge
BOVAM8	17/12/2019	R$ 108,41	R$ 114.410,00	R$ 114.410,00
BOVAN12	21/01/2020	R$ 112,65	R$ 110,800,00	R$ 110,800,00
BOVAO110	18/02/2020	R$ 111,14	R$ 68.400,00	R$ 93.862,29
BOVAP71	17/03/2020	R$ 71,00	R$ 75.660,00	R$ 75.660,00
BOVAQ77	22/04/2020	R$ 77,70	R$ 78.030,00	R$ 78.030,00
BOVAR77	19/05/2020	R$ 77,65	R$ 89.070,00	R$ 89.070,00
BOVAS90	16/06/2020	R$ 90,00	R$ 100.500,00	R$ 100.500,00
BOVAT100	21/07/2020	R$ 100,29	R$ 95.830,00	R$ 98.829,26
BOVAU980	18/08/2020	R$ 98,25	R$ 93.400,00	R$ 97.235,10
BOVAV930	22/09/2020	R$ 93,67	R$ 95.000,00	R$ 95.000,00
BOVAW960	20/10/2020	R$ 96,67	R$ 102.510,00	R$ 102.510,00
BOVAX102	17/11/2020	R$ 103,10	R$ 111.430,00	R$ 111.430,00

Note. Research data (2025).

Highlighted in yellow are the put options executed in 2020, evidencing the smoothing effect, especially in February, of the index's drop and the aggregate portfolio value. Following the observation, in 2021 and 2022 the protection structure's performance remained positive despite costs, as in 2020.

4.1 Discussion of results

In 2018 and 2019, it was observed that the performance of the portfolio with hedge was inferior to the unhedged portfolio. This difference arises from the fact that, in these years, the costs of purchasing the options exceeded the returns obtained from their execution. This limitation was also noted by Florindo (2021), who identified periods when the protection cost exceeded the return gains.

Despite this, the performance of the hedged portfolio improved substantially from 2020 onwards, the year when the COVID-19 pandemic caused high volatility in the financial market. In this scenario, the protection was effective, as shown in the figures and tables, especially in February, when the sharp drop in the BOVA11 index was partially offset by the appreciation of the put options. This result corroborates the effectiveness of hedge structures discussed by authors such as Gama et al. (2023) and Bertoncello (2018).

Over the five-year period, the final balance of the hedge strategy was positive. This reinforces the argument that, although hedge represents an additional cost to the investor, it also acts as an effective tool to smooth losses in times of instability, protecting the portfolio's capital. This point is particularly relevant for investors who, due to necessity, may need to

redeem their investments during downturns, when the market performs poorly (Caffagni, 2023).

Moreover, the results obtained align with the concept of hedge as a risk mitigation instrument, as defined by the Central Bank of Brazil (2002) and the specialized literature (Hull, 2016; Sanvicente, 2003).

4.2 Risk-Return of the Portfolios

The Sharpe and Treynor indices were used to assess the risk-adjusted performance of the analyzed portfolios. The Sharpe Ratio, developed by Sharpe (1966), measures the excess return relative to total risk (volatility), while the Treynor Index (1965) considers the portfolio's systematic risk, here assumed to be 1 since it is an ETF that replicates the Ibovespa.

Table 5

Risk-Return Indicators (2018–2022)

Portfolio	Sharpe ratio	Treynor ratio
BOVA11 (no hedge)	-3,11%	-0,08%
BOVA11 (0,8% hedge)	-1,50%	-0,04%

Note. Research data (2025).

Although both portfolios present negative ratios, indicating performance below the risk-free return (~10% per year), the portfolio with 0.8% hedge showed lower losses, with ratios close to zero. This suggests effective protection in terms of risk-adjusted return.

4.3 Statistical test of returns

To verify if the differences between the mean returns of the portfolios with and without the hedge are statistically significant, a t-test for independent samples was applied, as described by Bussab and Morettin (2017), using a significance level of 5%. The t-test results were a t-statistic of -0.83 and a p-value of 0.435.

Since the p-value exceeds 0.05, there is no statistical evidence to reject the null hypothesis. Therefore, no statistically significant difference is found between the mean returns of the portfolios over the analyzed period.

Still, it is noteworthy that the hedged portfolio showed lower volatility, contributing to a more stable distribution of returns over time. This is compatible with the objectives of defensive strategies in finance, which prioritize capital protection over high returns, as pointed out by Laurent (2023) and Liu (2023).

FINAL CONSIDERATIONS

The present study aimed to analyze the performance of an investment portfolio with a hedge structure, using put options, in comparison to an unhedged portfolio, over the period from 2018 to 2022. The simulation was carried out based on historical data from the BOVA11 index and at-the-money options, adopting a monthly protection strategy focused on risk mitigation.

The results showed that, despite the costs associated with protection, the hedged portfolio performed better over the accumulated period, with special emphasis on the year 2020, in which market volatility was accentuated by the COVID-19 pandemic. Under these adverse conditions, the hedge structure acted effectively in reducing losses, demonstrating its relevance as a mechanism for financial stability.

The statistical analysis of returns indicated that there was no significant difference between the average performances of the portfolios, but the protected portfolio showed lower

volatility and better risk-return indicators, which reinforces the role of hedge as a loss containment instrument in scenarios of uncertainty, especially for investors who need to maintain liquidity and predictability in their investments.

Among the limitations of the study, it is worth noting the absence of an in-depth analysis of the formation of option prices, which could directly influence the efficiency of the hedge structure. Moreover, the five-year period, although sufficient to identify relevant patterns, may be considered restrictive given the cyclical nature of financial markets.

As suggestions for future research, it is proposed to adopt longer analysis periods, investigate the impact of choosing different types of options, such as in and out of the money, study strategies with different expiration periods, and evaluate alternative hedge models, including exotic derivatives or structures combined with swaps and futures.

In summary, the findings of this research reinforce the importance of knowledge and application of protection structures in the financial market, especially in a scenario of increasing participation of individual investors in Brazil, with the dissemination of this knowledge being fundamental to increasing the maturity and resilience of agents in the variable income market.

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