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Applying value at risk and the Sharpe ratio to investment portfolio composition.

Application of Value at Risk and Sharpe Ratio for Investment Portfolio Composition

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SUMMARY

This study aims to evaluate how the Value at Risk (VaR) methodology can be used to quantify the maximum expected loss of an investment portfolio and, at the same time, serve as an easy-to-use tool, associated with the Sharpe Ratio, to optimize the risk-return ratio in the selection of financial assets for portfolio composition. The research was based on data collected from the Brazilian Stock Exchange, referring to the period from January 1, 2022 to December 31, 2024, totaling a time horizon of twenty-four months, in which the behavior of ten stocks traded daily was analyzed. With the application of the VaR and Sharpe Ratio methodologies, the stocks were evaluated regarding the risk assumed by the investor, their profitability, and whether there is compensation for the excess return in relation to the intrinsic risk, obtaining, in the end, a comparison between the initial and adjusted portfolios based on these criteria.

Keywords: Risk, Value at Risk, Sharpe Ratio, Profitability, Stock Market.

ABSTRACT

This study aims to evaluate how the Value at Risk (VaR) methodology can be used to quantify the maximum expected loss of an investment portfolio and, at the same time, serves as an easy-to-use tool, combined with the Sharpe Ratio, to optimize the risk-return relationship in the selection of financial assets for portfolio composition. The research was based on data collected from the Brazilian Stock Exchange, covering the period from January 1, 2022, to December 31, 2024, totaling a twenty-four-month time horizon, during which the behavior of ten stocks traded daily was analyzed. By applying the VaR and Sharpe Ratio methodologies, the stocks were assessed regarding the risk assumed by the investor, their profitability, and whether the excess return compensates for their intrinsic risk, resulting, in the end, in a comparison between the initial and adjusted portfolios based on these criteria.

Keywords: Risk, Value at Risk, Sharpe Ratio, Profitability, Stock Market.

1. INTRODUCTION

The expectations of investors in the Brazilian Stock Exchange have been showing a unequivocal resilience despite the most critical forecasts regarding interest rates and the situation. precarious state of public finances (BARBOSA et al., 2023). Since the impeachment suffered by the former-President Dilma Rousseff in 2016, the Ibovespa index reflects the average growth of the main Shares traded on the B3 grew by more than 260%, even after the sharp setback that occurred during the The first weeks of *lockdown* in the first year of the pandemic in 2020.

Despite the reasons that have led to this continuous growth, it is undeniable that the character of a virtually generalized increase in the value of the main stocks on the Brazilian stock market, is a fertile ground for the emergence of false and misguided "experts" in the financial market; something This is particularly easy to justify: in a favorable environment, where everyone wins and losses are minimal. The actions taken by the agents were quickly recovered over time. (almost always) generate marginal gains, leading to the feeling that the gain was due to a "Shrewd" decision-making, when in reality it is a general situation favorable to "all"

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market participants.

In this scenario, little or no calculation is made regarding the risk assumed in Investing in stocks, after all, is presumed to be where many apparently profit without much effort. Based on analyses grounded in empirical studies, what is the need to evaluate something unfavorable? When does the overall scenario appear favorable?

It was because of this presumption that financial giants like Barings, a respected bank, English with 233 years of history (HAMILTON et al., 1995), the Metallgesellschaft a conglomerate Considered the fourteenth largest German industrial group (NEUBAUER et al., 1996), the fund public of Orange County in the United States (BALDASSARE et al., 1998) and the Daiwa that to At the time it was the fourteenth largest bank in Japan (YAMADA, 1998), and they assumed losses in the billions. due to unmonitored exposure to the risk of their operations with financial assets.

In all these cases, these were highly credible financial institutions and solidity in the market, institutions that managed billions in investments, and, despite access to minds and resources that would allow for a careful assessment of the inherent risks of their operations, the lack This lack of control led to catastrophic losses, showing that even financial giants are not... safe from the fluctuations of the financial market. In fact, the outlook is even more worrying. when it comes to small domestic investors venturing into the stock market with little or no knowledge about the quantitative measurement of the risks of their investments.

According to B3 itself (2024), the number of CPF investors in the Brazilian stock exchange It had already surpassed 5 million. According to the study itself, another 3.8 million people had taken the test. Trading in the spot market for stocks; and, given the low level of financial literacy in Brazil. (SENA, 2023) it would not be reckless to assume that a minority of these investors do not feel capable of to quantitatively calculate the risks of their investments, whether due to a complete lack of knowledge of possibility, whether due to limitations in understanding and applying advanced mathematical methods.

For this reason, there is an urgent need for studies that bring this information to a wider audience. Beyond academic circles and financial institutions, simple and effective methods of quantitative measurement of the risks involved in actions, in effect, that go beyond the idea The merely abstract and intuitive notion of the stock market as something "risky" by its very nature. "unpredictable".

The persistence of this culture where risk monitoring is *considered unnecessary,* due to... continuous appreciation of Brazilian stocks or by the presumption regarding the impossibility of measurement, Given the low level of financial literacy among investors, this fosters the perception that the stock market... of values is a large casino (MOURA, 2023), as are losses packaged by investments. blind in an environment where “apparently” everyone wins. For this reason, methodologies of Effective and easy-to-apply risk measurement methods are of paramount importance, as JORION states.

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(1997), in particular, according to this author, given the increasing volatility of financial markets. engendered by the inseparable co-dependency of global economies and markets, the worsening of national debt and technological advancements.

According to JORION (1997), we can classify financial risks into five different categories. categories. 1) Market risk arises from the reduction in the value of financial assets as a result variations in interest rates, exchange rates, stock prices, and *commodity prices,* in other words, This refers to price and rate risk. (FEDERAL RESERVE, 1994). 2) Credit risk arises when The counterparties involved in the credit negotiation do not wish to, or are unable to, fulfilling contractual obligations. In general, credit risk also leads to losses. when debtors' ratings are downgraded by specialized agencies, resulting in reduction in the market value of its obligations. JORION (1997). In turn, 3) liquidity risk This refers to the cost of liquidating a relatively large position relative to the size of the market. In this case, there is a risk of having to pay a premium to find another agent willing to carry out the task. "reverse operation" (MOLLICA, 1999). 4) Operational risk is the type of potential risk that arises due to human error, inadequate operating systems, mismanagement – including fraud. –, and unexecuted operations that typically result in penalties. JORION (1997); and finally, the 5) Legal risk that arises when a counterparty does not have the legal or regulatory authority to to engage in a transaction (JORION, 1997).

In this context, the bank JP Morgan created the RiskMetrics document (MORGAN (GUARANTEE TRUST COMPANY, 1998), which contains at its core the Value at Risk method, which It measures the worst expected loss when investing in a particular financial asset. A priori, a method Simple, but it has been continuously improved, making measurement and monitoring easier. risk assessments are becoming increasingly precise and efficient.

Starting in the 1990s, the Value at Risk (VaR) methodology spread throughout the world, both in both financial and non-financial institutions, as a good risk measurement practice. (CARVALHO, 2006). The spread of this method began to change the attitude of investors, who, Previously passive regarding risk, they have become conscious investors, thanks to an efficient tool. an assessment of the greatest expected loss on your investments.

However, monitoring the risk of financial investments, especially in countries... With a low propensity to save, as in Brazil, it is still something not widely known, which is detrimental to... In a way, the main role of the stock exchange is to be a vector for raising capital for the companies, without having to compromise their profits due to the high interest rates of the market, by At the same time, people can earn passive income through the profits of these companies.

Due to the aforementioned problem arising from the failure to measure risks, which can expose both investors are subjected to losses exceeding their absorption capacity, as well as driving investors away from

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the stock market and foster the growth of companies and savings levels in Brazil, the

This paper aims to demonstrate the application of *Value at Risk* to a theoretical portfolio.

of assets in order to measure the greatest expected loss for an investor over a defined time horizon and confidence

level, and, once associated with the Sharpe Ratio, to consolidate simple and effective tools.

effective in choosing assets to build an investment portfolio, in order to reduce the

Risks and maximize returns.

2. THEORETICAL FRAMEWORK

2.1 The VaR *(Value at Risk)* Model

There are five different models for calculating VaR (JORION, 1997) with different

degrees of complexity. The first and simplest, used in this study as an instrument for

The Delta methodology is used to make decisions regarding the construction of an investment portfolio.

Normal, which assumes the normality of asset returns. There are also...

Methodologies: Delta Gamma, Historical Simulation, Monte Carlo Simulation, and Stress Testing.

Given that the objective of this study is to demonstrate a simple and effective method for measuring

Regarding the risk of investing in stocks, it is important to adhere to a simple model.

to be understood by the general public, in order to demonstrate its effectiveness, despite its simplicity.

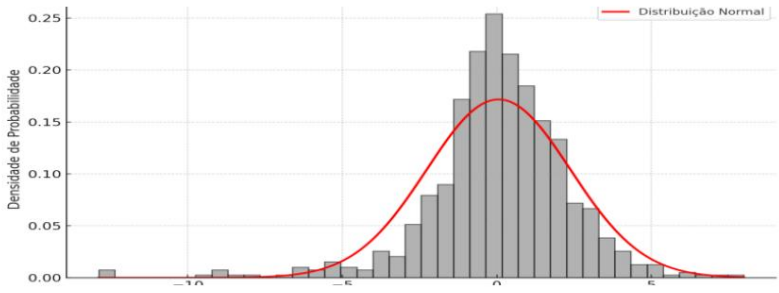
Given that the *Value at Risk* model is based on the assumption of normality of observations,

It is understood that the historical series of asset profitability has its observations normally...

distributed around the mean. This can be observed in Graph 1, obtained through the treatment.

from the theoretical portfolio data of this study.

Chart 1 - Distribution of Daily Returns of the Theoretical Portfolio



Source: Survey Data - 2024

Once it is assumed that the variation in stock prices follows the characteristics of a

Given a normal distribution, it is possible to use the convenient properties of this distribution to assume

certain patterns in the data that aid in their processing. Thus, VaR, while

measurement in financial units of the largest expected loss with a given time horizon and level of

Defined confidence levels can be understood mathematically as:

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= (ÿ)

Where,
Y = total value invested in the portfolio considered
z = quantile of the normal distribution for a given confidence level *c*
ÿ = standard deviation of the returns of the asset or portfolio presented in the period
ÿ = average of the returns presented in the period.

By adopting a one-tailed confidence margin of 95%, that is, a probability of 5% of

If the portfolio's return falls below expectations, the quantile is 1.645. Therefore, it follows that...

The Value Added (VAR) of the assets assumed in this study will be given by:

= (1,645 ÿ)

The standard deviation, in turn, is understood as the square root of the variance, that is, the

square root of the dispersion of observations around the mean:

$$\sigma = \sqrt{\sigma^2} \Rightarrow \sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(y_i - \mu)^2$$

Its nature therefore represents the volatility of the asset, and consequently the inherent *risk* of...

investment; in such a way that it is possible to say that the greater the standard deviation of the profitability of the

The more standard the asset in the historical series, the greater the flatness of the normal curve, the greater the volatility, and

Consequently, the greater the intrinsic risk – similarly, one could say that normal curves

Less flattened curves have smaller standard deviations, therefore the risk of these assets is lower.

2.2 Time Horizon

This study is an analysis of the value at risk of financial assets, using a model...

It is based on a historical series, thus assuming an orthodox paradigm that "evidence

Events that occurred in the past serve as a basis for predicting events that will occur in the future" (DOWD, 1998).

In other words, it is possible to study the historical price behavior of assets, and based on this, make assumptions.

with a given margin of confidence, a prediction of the future behavior of these assets.

In this case, in addition to defining the confidence level, a time horizon must be assumed.

which should correspond to the time required for the complete liquidation of the portfolio, which depends

directly from its liquidity (LOMBARDO, 2000, *apud* JORION, 1997). Furthermore, the analysis regarding

The predictability of the maximum loss should also be weighed against the assumed time subdivision.

in the calculation of VaR. In other words, assuming daily, weekly, or monthly returns, the assumption

The greatest expected loss should be understood within the same periodicity as the returns.

In this study, the returns *R* of the assets that will make up the portfolio were considered .

[1] This is due to only considering the *left* side of the normal curve, that is, the negative values.

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investments with monthly periodicity, calculated considering the variation of the price *P* of

closing price of stock *i* on the first business day of month *t* in relation to the previous month *t-1,* in the interval between

From January 1, 2022 to December 31, 2024, as follows below.

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}$$

Indeed, the VaR calculation in this study considers the highest expected loss over a 30-day period.

2.3 Asset Portfolio

For the composition of the theoretical portfolio in this study, nine stocks that are among the most traded on the Stock Exchange and one ETF were chosen, as shown in the table below:

TABLE 1 - List of Selected Assets

Ticket	Name / Company
PETR4	Petróleo Brasileiro SA – Petrobras
BBSE3	BB Seguridade Participações SA
TAEE11	TAESA – Alliance Electric Power Transmission Company
USIM5	Steel Mills of Minas Gerais SA
BBDC4	Bradesco Bank SA
ITUB4	Itaú Unibanco Holding SA
BPAC11	BTG Pactual Bank SA
GGBR4	Gerdau SA
B3SA3	B3 SA – Brazil, Stock Exchange, Over-the-Counter Market
GOLD11	ETF / fund or bond linked to gold (GOLD11)

Source: Survey Data - 2024

To determine the portfolio size, once the assets have been chosen, two approaches would be possible.

methods that would simplify the analysis: a) composing the stock portfolio imagining that the agent

either buy x shares in equal quantities of each, or b) compose the portfolio having a quantity

monetary *L* equally distributed among the securities.

Both hypotheses are possible and correct; however, in attempting to simplify the understanding of

Based on VaR and IS values, the first option would not be ideal, as when composing the portfolio with

Equal amounts of each share, since the values of each vary from one another, the weight of each

Action on the aggregated portfolio data would be different, thus requiring a weighted average.

to determine the weight of each stock on the portfolio's profitability, and ultimately it will modify the standard deviation.

from the portfolio, which will be discussed later.

The second hypothesis appears to be more plausible, since when composing the portfolio with a volume

If all shares contribute equally, there would be a scenario where all shares contribute equally.

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regarding the aggregate profitability2 of the portfolio, so this hypothesis was assumed in the study for

To simplify the analyses, the portfolio composition is defined by:

$$L/P_a = v_a - k \qquad V = \sum_{i=1}^{n} v_{ai}$$

Where, *L* = hypothetical financial value used, *Pa* = share price , and *va* = quantity.

of shares purchased with the value L, *k* = financial value not used in the transaction and, therefore

discarded from analysis3 and *V* = total volume of shares in the portfolio, following which the portfolio value *Y* is

given by:

$$= \ddot{y}_{=1} (\ddot{y})$$

Once the portfolio is composed, its profitability will be defined as a linear combination.

the return on the assets that comprise it, and the weights calculated based on the prices of the assets.

Purchases made at the beginning of the period, in relation to the total portfolio amount. However, as the weight of

The return on assets relative to the portfolio is practically the same due to the methodology adopted and already

As explained previously, this weighting can be disregarded when treating the aggregated data from

A portfolio without any distinction regarding the number of shares.

The portfolio return is then defined by:

$$R_{p,t+1} = \sum_{i=1}^{n} w_{i,t} R_{i,t+1} \qquad w_{i,t} = Y/L - k$$

where wi,t = the weights of the assets, which in this study are all equal to 0.10 since there are ten.

assets purchased with the same value L, and Ri,t+1 = profitability of each asset.

It is also possible to write in matrix form, replacing the number series with

a single vector, thus defining:

$$= [\,1 \quad 2 \ldots] \qquad \begin{matrix} 1 \\ 2 \\ 3 \end{matrix} = \begin{matrix} \ddot{y} \\ \ddot{y} \end{matrix} \qquad [\quad]$$

such that w' is the transpose of the vector representing the weights, and R is the vertical vector.

which contains the individual returns.

Based on the calculation shown above, it is still possible to extend it further and obtain the expected return from...

The portfolio is weighted by summing the weights of the stocks based on their average returns, as follows:

[2] The sum of the returns of the assets that make up the portfolio.

[3] This unused financial volume would be the remainder of dividing *L* by the price Pa.

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$$( ) = = \ddot{y}$$
$$=1$$

Therefore, the variance and consequently the standard deviation can be described as:

$$= \ddot{y} ( ) \ddot{y} ( ) =$$

$$^2 = \ddot{y} \quad ^{2\,2} + \ddot{y} \quad \ddot{y} =$$
$$=1 \quad =1 \quad =1$$
$$\ddot{y}$$

$$= \ddot{y} \quad ^{2\,2} + \ddot{y} \quad \ddot{y}$$
$$=1 \quad =1 \quad <$$

As the number of assets in a given portfolio increases, the variance calculation...

Using summation can become overly complex, so matrix notation is simpler:

$$^2 = [\,1 \quad \ddot{y}\,] \begin{bmatrix} ^{2\,1} & ^{12} & ^{13} \\ ^{21} & ^{2\,2} & ^{23} \\ ^{31} & ^{32} & ^{2\,3} \\ \ddot{y} & \ddot{y} & 3\,\ddot{y}\,\ddot{y}\,\ddot{y} \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} [\,1 \quad 2 \quad 3\,] \begin{bmatrix} 1 \\ 2 \\ 3 \\ \ddot{y} \end{bmatrix}$$

Defining the covariance matrix as ÿ, the portfolio variance can be written as

In short, as follows:

$$\sigma_p^2 = w'\Sigma w$$

2.4 Sharpe Ratio

The Sharpe Ratio was created by William Sharpe in 1966. Since then, it has been widely applied. scale across various investment funds. Its nature explicitly defines the return/risk relationship of a investment. In other words, the IS assesses whether the profitability of a given investment is compatible with the inherent risk involved. The higher the IS (Index of Risk) of an investment, provided it is positive, the better it is. its classification (SHARPE, 1994).

The operation of the Sharpe Ratio is simple since it only involves dividing the

The arithmetic mean of excess returns – given by the expected return of a portfolio or fund.

E(Rp) minus the expected return of a risk-free asset Rf, divided by the standard deviation ÿRp-

Rf of the excess returns of the portfolio or asset analyzed, that is, the Sharpe Ratio evaluates the excess returns for each unit of volatility of these returns.

$$IS = \frac{[\ddot{y}]}{-}$$

Using sample estimators, we have:

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= with = – 1 – ÿ (, ,), = ÿ 1 -1 ÿ ((, - ,) ÿ) – 2.
=1 =1

Although the Sharpe ratio is a parameter that is easy to use, it requires some care:

- Savings accounts should not be used as a *risk-free* asset because those who choose this type of investment are not seeking the percentage return of savings accounts. Furthermore, because the return on savings accounts is traditionally negligible, it overestimates the return on other funds, generating a distorted intrinsic risk. This study will use the SELIC Treasury bond as an index because it is the most liquid security with the lowest intrinsic risk in the financial market.

- Only funds with the same time horizon should be compared, meaning that both the risk-free fund and the investment being evaluated must have a) the same number of data points and b) the same period in question. Therefore, the data regarding the profitability of the SELIC Treasury bond are monthly – from January 2022 to December 2024 – the same period analyzed for the portfolio, and consequently the same for the stocks and ETFs used to calculate the Sharpe Ratio, whose profitability data were based on a monthly basis; hence twenty-four observations.

2.5 Considerations on Equivalent Return

Various methods, at different times, can be adopted in order to evaluate the return on investment. a specific asset or investment portfolio. As mentioned above in Item 2.2 of this study, the means The profitability or return in this study is determined by the difference between the asset price and the asset price. the price of the asset at the end of the analyzed period and the price at the beginning of the period, divided by the latter, as demonstrated in the formula below:

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}$$

In contrast, equivalent return refers not to the appreciation given by the variation of not just the price, but successive and equivalent profitability over a shorter period of time. considered in the analysis of absolute return; the latter being given by the equation above, that is, the percentage change in the asset price between the first day *tn* and the last day *t* of the analyzed period, It follows that the equivalent return Qi is defined by:

- , -1
= (ÿ , , -1 (+1 ÿ 1) × 100

This approach is useful and necessary for calculating IS, as it creates equivalence between the return.

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monthly return of the *risk-free asset,* in this study the Tesouro SELIC government bond, and the theoretical monthly return of asset analyzed.

3. RESULTS

The following describes the data processing and their respective analyses.

First, an assessment of the returns and standard deviation of the assets, followed by an evaluation of price correlation, then the VaR and Sharpe ratio of the stocks, so that...

In order to make it possible to construct the modified portfolio, the analysis of these takes into account.

indicators.

3.1 Profitability and Volatility

The initial analysis of the assets concerns only data relating to profitability and

Price volatility, as shown in Table 2 below:

Table 2 - Price Return and Volatility

Ticket	Average of Returns Diaries	Average of Returns Monthly	Return Absolute	Return Equiv. (am)	Return Equiv. (ad)	Detour Standard Daily	Detour Standard Monthly
PETR4	0.06%	1.18%	25.4%	0.95%	0.03%	2.33%	8.38%
BBSE3	0.08%	1.57%	76.1%	2.39%	0.08%	1.39%	5.81%
TAEE11	-0.01%	-0.06%	-10.2%	-0.45%	-0.01%	1.10%	4.61%
USIM5	-0.10%	-1.93%	-62.0%	-3.95%	-0.13%	2.61%	10.71%
BBDC4	-0.05%	0.06%	-0.79%	-42.0%	-2.25%	-0.07%	1.92%
ITUB4		1.44%	36.0%	1.29%	0.04%	1.46%	7.75%
BPAC11	-0.07%	1.57%	45.4%	1.57%	0.05%	2.19%	9.62%
GGBR4	0.00%	0.02%	0.21%	-18.1%	-0.83%	-0.03%	2.06%	8.57%
B3SA3	0.06%	0.29%	-10.8%	-0.47%	-0.02%	2.30%	11.95%
GOLD11		1.36%	57.1%	1.90%	0.06%	1.13%	5.11%

At first glance, it is possible to see the difference between the average monthly returns.

and the equivalent return (am), which, although dealing with monthly profitability over the period,

These are quite distinct concepts. While the average monthly return simply deals with the average...

Using the arithmetic of monthly returns over the period, the equivalent return (am) considers a “rate

"equivalent monthly return" over the same period. While the first says very little about the

The fluctuating behavior of the asset's price, given that the percentage return of an asset takes into account...

The first always reflects the same price in the previous period; the second more clearly reflects the average return.

of the period due to the similarity of asset returns in the long term resembling a "rate

"compound," where the percentage change in return over period *n* is given with reference to period n.

n-1, which in turn has period n-2 as its reference, and so on.

In other words, using the average return is not very useful because...

It completely disregards the nature of asset volatility. Table 3 below shows two assets.

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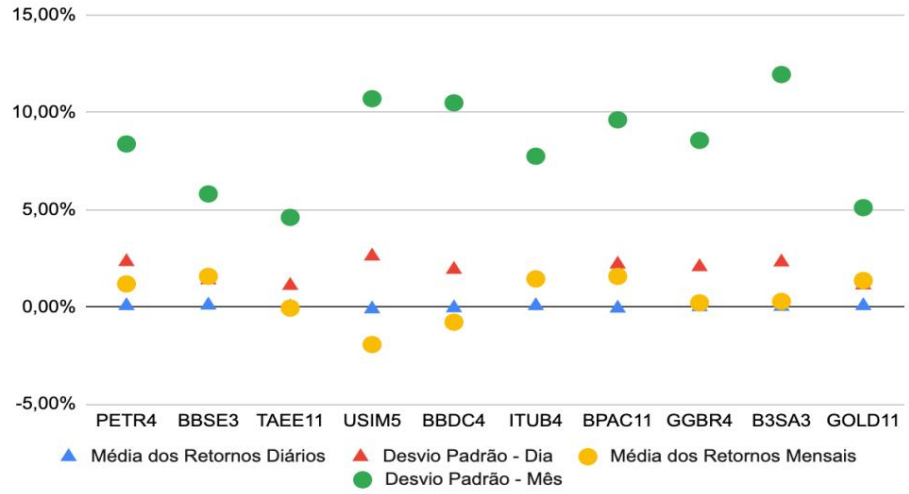
hypothetical scenarios A and B, which despite having the same average profitability, exhibit profitability...
completely different equivalents.

Chart 2 - Profitability and Risk: Daily vs. Monthly



Source: Survey Data - 2024

Table 3 - Price Return and Volatility

Active	Return in month *n*	Return in the month n+1	Return in the month n+2	Average of Returns	Return Equivalent
THE	-10%	30%	10%	10%	8.8%
B	10%	10%	10%	10%	10%

The importance of this weighting can be seen in Table 2, given that the GGBR4 and actions
B3SA3 had average monthly returns of 0.21% and 0.29%, respectively, but at the same time
However, over the same 24-month period, they showed negative absolute returns of -18.1% and -10.8%, respectively.
At first glance, this would seem contradictory, since if the average monthly returns are...
If this is positive, how could these assets show a negative return when the entire period is considered?
This demonstrates that the arithmetic mean of monthly returns does not reflect the behavior of the variation.
the asset's price; therefore, the equivalent return is more effective for evaluating it.

Another important inference can be made when observing the relationship between the standard deviation.
and the price fluctuations with daily and monthly periodicity. When observing monthly profitability
Compared to the average return over the period, the difference fluctuates around twenty times the first.
Regarding the second point. Indeed, assuming the standard deviation as the metric for measuring risk,
This, in turn, is multiplied by four when comparing daily to monthly periodicity.
proving that the risk/return ratio becomes increasingly advantageous for the investor as...
that the investment period is extended.

Although the risk of long-term investment in stocks has proven to be lower in

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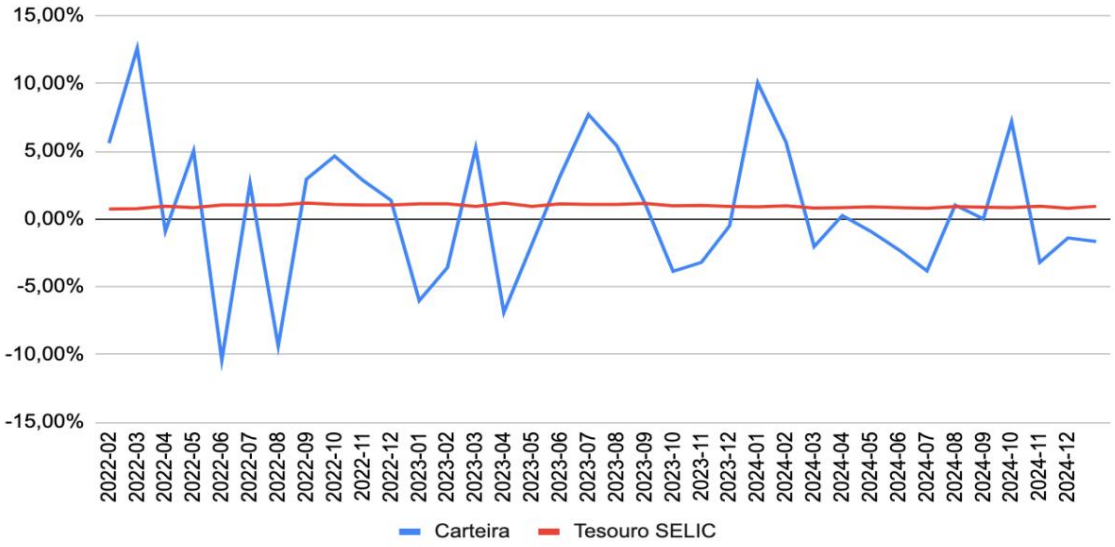
Regarding short-term investments, the inherent risk of this type of investment is very high.
superior when compared to post-fixed income investments such as the SELIC Treasury. While
The standard deviation of the portfolio's monthly return was 8.30%, for the government bond in question it was...
of only 0.12%.

From January 2022 to December 2024, the volatility of some stocks such as TAEE11 and
BBSE3's returns were 4.61% and 5.81% respectively, lower than the portfolio's volatility. Notwithstanding other...
Stocks like B3SA3 showed values close to 12%, almost 100 times higher than the standard deviation.
from the SELIC Treasury. Furthermore, it is worth noting that variable income assets such as stocks, ETFs,
Derivatives, etc., can exhibit negative returns, whereas post-fixed income assets,
Due to the structure of their operation, they do not show negative returns at any time.
period.

This leads to the conclusion that the risk/return ratio of investing in stocks is...
directly correlated to the opportunity cost compared to other types of income-generating investments
Fixed. Given its volatile nature, for stock market investment to be attractive to investors,
The expectation of the expected return, exceeding that obtained through fixed income, needs to be so...
higher the standard deviation from the average returns observed in the past; if
On the contrary, the return on this type of investment would not compensate for its inherent risks and therefore, the
The stock market would contract. However, following the same reasoning, but from a different perspective,
The higher the interest rates, the less attractive investing in stocks becomes, since the relationship
The risk/return ratio of the latter is negatively affected by an exogenous variable; this will be discussed in more
detail later in the section on the Sharpe Ratio.

Chart 3 - Variation in Monthly Portfolio Profitability Compared to the SELIC Treasury Bond



Source: Survey Data - 2024

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

3.2 Covariance and Correlation

Consider the profitability of an investment portfolio, the volatility of assets, and even the...
VaR, which will be discussed in detail in the next section, without, however, evaluating the correlation between them.
This can give a false impression regarding the risk of this portfolio. This is because a portfolio with
a high degree of correlation between assets, once exposed to some type of macroeconomic shock, or
Even short-term fluctuations resulting from market speculation can cause everyone to...
These assets experience price fluctuations in the same direction, which can lead to even greater losses.

Since this portfolio is primarily composed of stocks, it is perfectly plausible to infer that they have a positive
correlation with variations in the Ibovespa Index, that is, any eventual...
Shocks that impact the stock market as a whole tend to have the same impact on other markets.
The stocks that make up the proposed theoretical portfolio must be checked for internal correlation.
among the portfolio assets, since VaR calculates the largest expected loss in normal situations.
market conditions, that is, without acute shocks like the pandemic experienced in 2020 and 2021, if
There is a high correlation between the assets in the portfolio, even if these shocks do not occur, it is possible
that losses are increased by simultaneous price fluctuations of the portfolio's assets. For this reason
For a brief evaluation of the covariance matrix and consequently, derived from it, the matrix of
Correlation of assets is necessary.

Table 4 - Asset Covariance Matrix

	PETR4	BBSE3	TAEE11	USIM5	BBDC4	TUB4	BPAC11	GGBR4	B3SA3			GOLD11
PETR4	0.00054	0.00003	0.00001	0.00003	0.00005	0.00007	0.00010	0.00009	0.00007	-0.00003		
BBSE3	0.00003	0.00019	0.00004	0.00001	0.00002	0.00004	0.00008	0.00005	0.00008	-0.00003		
TAEE11	0.00001	0.00004	0.00012	0.00001	0.00002	0.00004	0.00006	0.00004	0.00007	-0.00001		
USIM5	0.00003	0.00001	0.00001	0.00068	0.00004	0.00003	0.00001	0.00004	0.00000	-0.00001		
BBDC4	0.00005	0.00002	0.00002	0.00004	0.00037	0.00013	0.00014	0.00004	0.00012	-0.00004		
ITUB4	0.00007	0.00004	0.00004	0.00003	0.00013	0.00021	0.00017	0.00007	0.00017	-0.00003		
BPAC11	0.00010	0.00008	0.00006	0.00001	0.00014	0.00017	0.00048	0.00011	0.00033	-0.00006		
GGBR4	0.00009	0.00005	0.00004	0.00004	0.00004	0.00007	0.00011	0.00043	0.00011	-0.00001		
B3SA3	0.00007	0.00008	0.00007	0.00000	0.00012	0.00017	0.00033	0.00011	0.00053	-0.00006		
GOLD11	-0.00003	-0.00003	-0.00001	-0.00001	-0.00004	-0.00003	-0.00006	-0.00001	-0.00006	0.00013		

Source: Survey Data - 2024

Given that the price correlation of assets ranges from -1 to 1, the closer the correlation, the greater the correlation.
The higher the value of 1, the greater the chances that the assets will experience variations in the same "direction," as shown in Table 5 below.
Highlighted in red, there are four assets with a considerable correlation between them:

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

BPAC11, ITUB4, BBDC4 and B3SA3. Thus, when placed together in a portfolio, **Table 5 - Asset Correlation Matrix**

They do not increase security through asset diversification.

	PETR4	BBSE3	TAEE11	USIM5	BBDC4	ITUB4	BPAC11	GGBR4	B3SA3	GOLD11
PETR4	1.00	-0.11	0.06	0.05		0.22	0.20		0.13	
BBSE3	-0.09	1.00	-0.08	-0.17	-0.25	-0.04		-0.22	-0.27	-0.17	0.25	
TAEE11	0.06		1.00		0.03		0.28		-0.25	0.16	0.28	
USIM5	0.05			1.00			0.07		0.01	0.07	-0.01	
BBDC4	0.12	0.08	0.08	1.00	0.10			0.48	0.33	0.10	0.26	-0.20
ITUB4	0.22	0.22	0.28	0.07	0.48	1.00	0.54	0.24	0.49	-0.19
BPAC11	0.20	0.27	0.25	0.01	0.33	0.54	1.00	0.25	0.65	-0.24
GGBR4	0.18	0.17	0.16	0.07	0.10	0.24	0.25	1.00	0.22	-0.02
B3SA3	0.13	0.25	0.28	-0.01	0.26	0.49	0.65	0.22	1.00	-0.22
GOLD11	-0.11	-0.17	-0.08	-0.03	-0.20	-0.19	-0.24	-0.02	-0.22	1.00

Source: Survey Data - 2024

The considerable correlation between these actions is due to the fact that they are companies in the sector financial, with BPAC11 and B3SA3 being shares of companies directly linked to the financial market. Investments, which justifies the higher correlation between these assets. In turn, although also Whether it's a stock linked to the financial market, BB Seguridade (BBSE3) shares have a Low correlation with the others, suggesting its validity in a risk mitigation strategy through diversification, taking these assets into account.

Another notable point is the negative, albeit small, correlation of the GOLD11 ETF in with regard to the chosen actions. This demonstrates the decision-making bias of investing in assets directly The price of gold is linked to expectations of a decline in the stock market; in other words, the Investors sought to buy this ETF during periods of low stock prices, which justifies the... Negative correlation.

3.3 Value at Risk and Sharpe Ratio

VaR results are expressed as percentages which, once applied to the total amount... The financial investment in the asset reveals the largest estimated financial loss. Thus, the greatest loss The expected (monthly) return of the assets analyzed ranged from 7.04% (GOLD11) to 19.54% (USIM5), which This demonstrates the heterogeneity of risk in this asset class, something that needs to be considered in light of... The portfolio composition, given the concentration of various assets with high VaR, especially If they have a high degree of price correlation, they can render the risk mitigation strategy ineffective. through diversification.

Another important point seen when observing Table 6 below is that the greatest expected loss It increases more than three times in the monthly analysis compared to the daily analysis; some assets such as stocks BBDC4 and B3SA3 exceed five times. Although at first glance it seems reasonably obvious. To infer that the magnitude of the oscillations is greater the longer the period, the comparison between the The assets reveal something that needs to be considered when deciding on the composition of the portfolio. Investments: the higher the ratio between monthly VaR and daily VaR, the greater the risk of...

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

The long-term liquidity of these assets. In other words, maintaining these assets in the portfolio,

When associated with swing trading strategies , it increases the maximum loss to which the investor is exposed. One

A clear example of this point are the PETR4 and B3SA3 stocks, while both have a daily VaR of

The monthly VaR of the second stock was 3.77% higher than that of the first stock.

In this regard, BBSE3 and TAEE11 stocks stood out, with their monthly VaR approaching...

The GOLD11 ETF has shown price stability similar to that seen in other investments.

They are notably known for their low volatility, especially when it comes to variable income assets.

Table 6 - Value at Risk and Sharpe Ratio

ACTIVE	Daily VAR	Monthly Var	Var (m) / VaR (d)	Sharpe Ratio
PETR4	3.77%	12.61%	3.35	0.00
BBSE3	2.20%	7.99%	3.63	0.25
TAEE11	1.95%	7.64%	3.91	-0.30
USIM5	4.40%	19.54%	4.45	-0.46
BBDC4	3.22%	18.05%	5.61	-0.31
ITUB4	2.49%	11.31%	4.55	0.04
BPAC11	3.54%	14.26%	4.03	0.07
GGBR4	3.39%	13.88%	4.09	-0.21
B3SA3	3.77%	19.38%	5.14	-0.12
GOLD11	1.79%	7.04%	3.93	0.18

Source: Survey Data - 2024

In turn, the Sharpe ratio of the assets proved to be extremely low. Since

This indicator measures the excess return of an asset, using another investment as a benchmark.

In the risk book, for each unit of risk assumed by the investor, it became clear that these assets in

The period in question offered practically no return to offset their inherent risk.

Shares ITUB4 and BPAC11, for example, delivered returns of 0.04% and 0.07% to investors, respectively.

return for every 1% of volatility, while another 5 stocks did not even exceed the return obtained.

by the SELIC Treasury. Although this result may at first glance lead to the conclusion that the

The real return on assets was low; a more in-depth analysis is needed before proceeding.

inference.

During the period analyzed, the profitability of the SELIC Treasury bond, indexed to the SELIC rate, was

Give 40.85% (BACEN, 2024), an equivalent rate of 1.44% per month, on the other hand inflation

The equivalent rate for the period was 16% (0.62% per month), resulting in an actual rate of 21.42%, considered

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

the second largest in the world, behind only Turkey (CNN, 2024). Indeed, even though actions

Given that ITUB4 and PETR4 have outperformed inflation and delivered real returns, due to the interest rate...

Given that risk-free rates are so high, it follows that the expected return on stocks needs to be high enough.

a point that far exceeds the net cash generation capacity of most companies.

Brazilian companies, which, ultimately, would be the collateral for the investor acquiring the asset in question.

in the ability of companies to pay dividends. Therefore, investing in stocks

It acquires a largely speculative character, so susceptible to short-term fluctuations, in

to the detriment of a long-term view where the stock price is determined by fundamentals.

of the company.

Furthermore, given the nature of the Sharpe Ratio calculation, countries with a risk-free rate

Such high levels tend to exhibit a negative IS, since any investment that incorporates some

To be even minimally attractive to investors, the risk must deliver a higher monthly return.

at a rate that is, in itself, very high.

3.4 Defining the Portfolio Composition

The indicators for making decisions regarding the assets that will make up the portfolio have been presented.

As modified, the following assumptions will guide the decisions: a) to place assets that

a) guarantee the highest possible return, b) assume the greatest possible diversification in order to reduce the

risks of the portfolio ec) maintain the criterion of financially equal distribution among the assets.

It is also worth noting that the presented composition only takes past data into account.

Regarding stock prices and their fluctuations, it does not consider other equally relevant factors.

When choosing assets to invest in, factors such as the company's fundamentals and expectations should be considered.

future discussions regarding macroeconomic issues.

Table 7 below classifies assets according to the main criteria for decision-making.

The decision of this study is such that: a) the “higher” the asset's risk value, the lower its risk will be.

classification; b) the lower the ratio of monthly VaR to daily VaR, the better the classification; c)

The higher the IS (Index of Equity), the better ranked the asset will be; and finally d) the higher the equivalent return,

The better your ranking, the better.

Table 7 - Asset Ranking

ACTIVE	Monthly Var	Var (m) / VaR (d) Sharpe	Ratio Return Equi.	
1st	GOLD11	PETR4	BBSE3	BBSE3
2nd	TAEE11	BBSE3	GOLD11	GOLD11
3rd	BBSE3	TAEE11	BPAC11	BPAC11
4th	ITUB4	GOLD11	ITUB4	ITUB4

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

5th	PETR4	BPAC11	PETR4	PETR4
6th	GGBR4	GGBR4	B3SA3	TAEE11
7th	BPAC11	USIM5	GGBR4	B3SA3
8th	BBDC4	ITUB4	TAEE11	GGBR4
9th	B3SA3	B3SA3	BBDC4	BBDC4
10th	USIM5	BBDC4	USIM5	USIM5

Source: Survey Data - 2024

As can be observed, the assets USIM5, B3SA3 and BBDC4, recurrently,
They appeared with the worst indicators in all the indicators analyzed, and therefore, not
These assets would make up the portfolio. The monthly Variable Reduction (VAR) of these assets exceeds a maximum loss of 18%, given the level...
with a 95% confidence level, while the equivalent return over the period was negative, leaving
These assets are outside the composition of the theoretical portfolio.

Furthermore, the reasonable degree of positive correlation between the shares of BBDC4 and ITUB4 suggests that, in the event of a portfolio composition including Banco Itaú shares, the maintenance of the shares Bradesco's decision would increase the portfolio's risk.

The positive highlights are the GOLD11 ETF and the BBSE3 stock. Among the stocks...
When analyzed, both are associated with a lower Monthly VaR, respectively, 7.04% and 7.99%, and returns.
equivalents of 2.39% per month and 1.90% per month, presented as papers that delivered to the same
Low risk and high return, when compared to others. Regarding the matrix of
correlation, both roles stand out. The BBSE3 stock had a low correlation index between the
The assets studied did not add risk to the portfolio. In turn, the GOLD11 stock presented...
Negative correlation with other assets, suggesting that maintaining it in the portfolio would increase...
Profitability would reduce VaR and the risk of concentrating positively correlated assets.

ITUB4 and PETR4 shares had mixed results, with the exception of the standout performance of...
Secondly, regarding the relationship between the Monthly VaR and the Daily VaR, it obtained the lowest index among the...
Based on the analyzed stocks, it is suggested that PETR4 stock would reduce the intrinsic risk of this portfolio by adopting...
a swing trading strategy .

TAEE11 stock stands out for its low VaR, a common characteristic in companies that...
They operate in the generation and transmission of electrical energy, achieving the lowest expected maximum loss.
among the stocks, it is second only to the GOLD11 ETF, while preserving a
low correlation with other assets.

Finally, the BPAC11 stock presented a high VaR, resulting from one of the highest volatilities.
of the portfolio, however, during the period analyzed, it was the third stock that appreciated the most, being

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

Thus, one of the assets that stood out most in the Sharpe Ratio. Therefore, the decision regarding...

The continued presence of this asset in the portfolio is due to the exclusion of assets that have a high correlation.

price fluctuations with the BPAC11 stock, respectively, B3SA and BBDC4.

3.5 Results of the Theoretical Portfolio

Below is Table 8 comparing the initial theoretical portfolio with the ten listed assets.

Initially, the portfolio was modified by excluding the 3 assets that performed negatively:

USIM5, B3SA3 and BBDC4.

Table 8 - Comparison between Portfolios

	Initial Portfolio	Modified Wallet
Average Monthly Return	0.49%	1.04%
Standard Deviation	5.14%	3.81%
Monthly Var	7.96%	5.23%
Daily VAR	1.74%	0.95%
VaR (m) / VaR (d)	4.57	5.51
Absolute Return	13.31%	40.21%
Equivalent Return	0.54% am	1.48% am
Sharpe Ratio	-0.08%	0.14%

Source: Survey Data - 2024

In the initial portfolio, although the return was positive, the IS (Index of Sustainability) was negative, meaning the profitability during the period was lower than the SELIC Treasury bond – a risk-free investment – whereas

In the modified portfolio, not only was a positive IS obtained, but also a return of more than double.

superior to the initial portfolio. In effect, the risk was mitigated.

When observing the Monthly VaR of the modified portfolio, the maximum expected loss has decreased by 25.9%, that is, given a hypothetical investment of R$ 100,000, the greatest expected loss in thirty days

In the modified portfolio, the value drops from R$ 5,140 to -R$ 3,810.

Another positive point, however, not explicitly stated in Table 8, is the exclusion of assets that

They showed a high price correlation with assets that remained, which caused the risk of

Asset concentration is reduced, enabling a portfolio composition where risk is minimized.

The intrinsic value of the assets is lower, as is the risk of combining these assets into the same asset.

Investment is reduced.

These results demonstrate that the use of simple tools such as VaR and the Index

Sharpe ratios combined can result in a more rational and effective choice of the assets that will make up the portfolio.

an investment portfolio, comprising valuable tools in order to maximize returns with

Year V, v.2 2025 | Submission: 07/11/2025 | Accepted: 09/11/2025 | Publication: 11/11/2025

subsequent risk reduction, something extremely valuable, especially for small investors who

They lack the resources, capital, and human resources for more complex analyses.

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