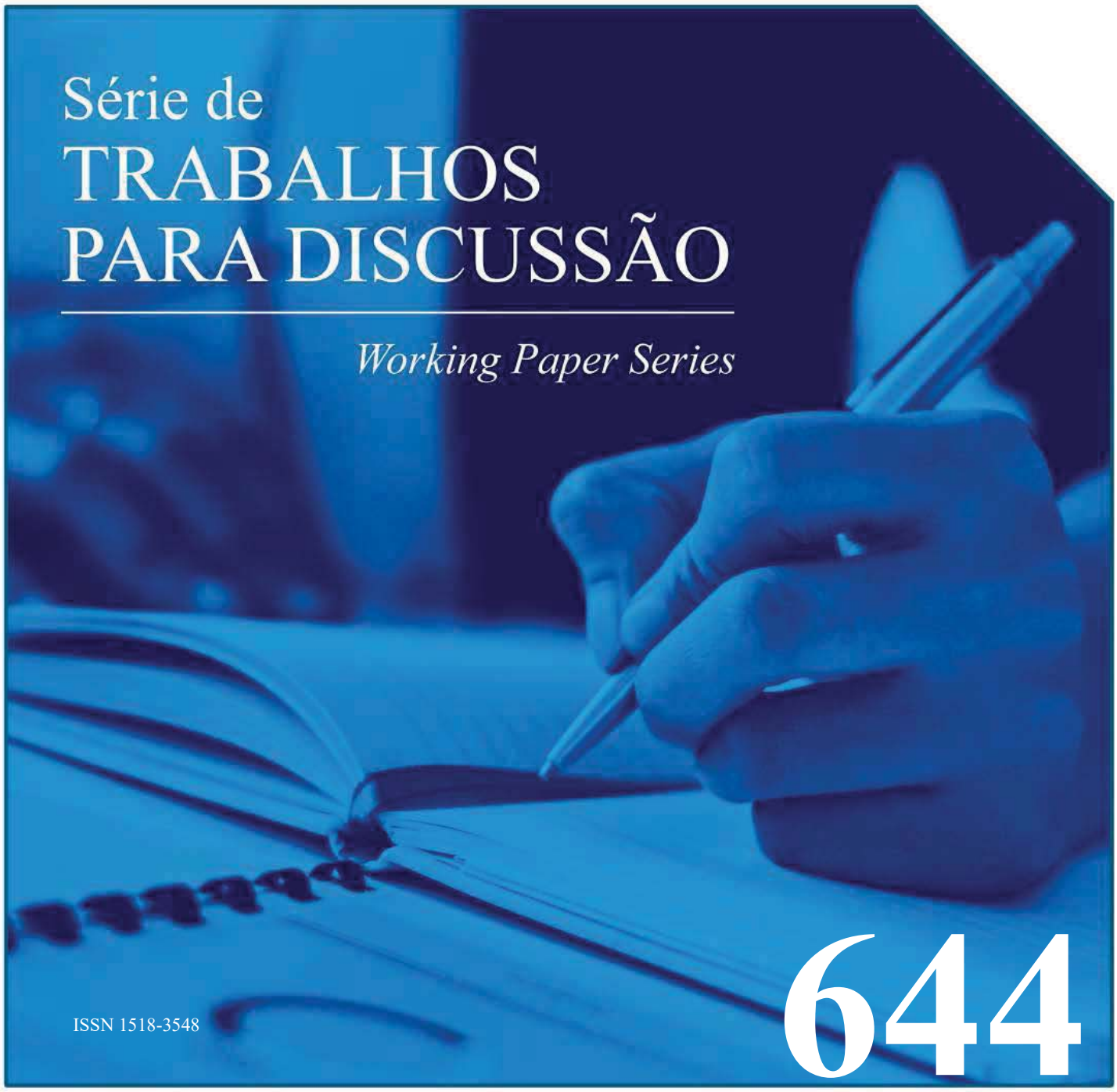

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Is The Risk of The Opening Price Gap Priced?

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Non-Technical Summary

Price movements that occur between the closing price of one trading day and the opening price of the next, known as opening price gaps, represent a source of risk for investors who hold positions overnight. These gaps may arise from news releases, macroeconomic events, or changes in market sentiment that occur outside regular trading hours. Despite their relevance, it remains unclear whether the Brazilian stock market properly compensates investors for bearing this type of risk.

This study investigates whether the risk associated with opening price gaps is priced in the Brazilian equity market. To answer this question, we construct Long & Short (L&S) investment strategies that take long positions in stocks with high overnight volatility (greater gap risk) and short positions in stocks with low overnight volatility. Portfolios are rebalanced annually based on the previous year's volatility of the opening gap returns.

Using daily data from 2001 to 2024, we test whether these portfolios generate abnormal returns after controlling for risk using three widely adopted asset pricing models: the Capital Asset Pricing Model (CAPM), the Fama-French Three-Factor Model, and an Extended Fama-French Model that incorporates momentum and liquidity factors.

The results show that the L&S strategy produces positive and statistically significant abnormal returns across all models, exceeding 13% per year. This suggests that the gap risk is not priced in the Brazilian stock market: stocks with higher exposure to this risk earn higher returns even after adjusting for traditional risk factors. Furthermore, we find that opening gaps do not occur only during periods associated with unexpected monetary or regulatory announcements; rather, they appear to be a structural feature of daily market dynamics.

The strategy's performance is largely uncorrelated with the Ibovespa, reinforcing its non-directional nature. It remains resilient even during major stress events such as the 2008 global financial crisis and the 2020 COVID-19 pandemic.

Overall, the evidence indicates that investors are not fully compensated for bearing the risk of overnight price gaps in Brazil. This finding points to a market inefficiency and highlights the importance of understanding overnight volatility when managing portfolios, designing trading strategies, or evaluating asset pricing models.

Sumário Não Técnico

As variações que ocorrem entre o preço de fechamento de um dia e o preço de abertura do dia seguinte (*gaps* de abertura) representam uma fonte relevante de risco para investidores que mantêm posições de um dia para o outro. Esses movimentos podem resultar da divulgação de notícias, eventos macroeconômicos ou mudanças de percepção que acontecem fora do horário regular de negociação. Apesar de sua importância, ainda não está claro se o mercado acionário brasileiro compensa adequadamente os investidores por esse tipo de risco.

Este estudo investiga se o risco associado aos *gaps* de abertura é precificado no mercado de ações do Brasil. Para isso, são construídas estratégias *Long* & *Short* (L&S) que assumem posições compradas em ações com maior volatilidade *overnight* (maior risco de *gap*) e posições vendidas em ações com menor volatilidade *overnight*. Os portfólios são rebalanceados anualmente com base na volatilidade dos retornos de *gap* do ano anterior.

Utilizando dados diários de 2001 a 2024, o estudo avalia se esses portfólios geram retornos anormais após o controle de risco por meio de três modelos tradicionais de precificação de ativos: o CAPM, o Modelo de Três Fatores de Fama–French e um Modelo Estendido de Fama–French que incorpora fatores de liquidez e momentum.

Os resultados mostram que a estratégia L&S produz retornos anormais positivos e estatisticamente significativos em todos os modelos, com retorno anualizado superior a 13%. Esse achado indica que o risco de *gap* não é precificado no mercado brasileiro: ações mais expostas a esse risco oferecem retornos superiores mesmo após o ajuste pelos fatores usuais de risco. Além disso, o estudo constata que os *gaps* de abertura não ocorrem apenas em dias associados a surpresas de política monetária ou mudanças regulatórias, mas parecem ser uma característica estrutural do mercado.

A estratégia apresenta desempenho pouco correlacionado com o Ibovespa, reforçando seu caráter não direcional, e mostra resiliência inclusive em períodos de forte estresse, como a crise do subprime em 2008 e a pandemia da COVID-19 em 2020.

Em síntese, as evidências sugerem que o mercado brasileiro não remunera adequadamente o investidor pelo risco dos *gaps* de abertura. Esse resultado aponta para uma ineficiência de mercado e reforça a importância de considerar a volatilidade *overnight* na gestão de portfólios, no desenvolvimento de estratégias de negociação e na avaliação de modelos de precificação.

Is The Risk of The Opening Price Gap Priced?

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Abstract

The objective of this work is to analyze whether the risk of differences between the closing price and the opening price of the subsequent day, the opening price gap rate, is priced in the Brazilian stock market. This inquiry stems from the recognition that an investor is impacted by the volatility of these gaps. Long and Short strategies are simulated, entailing long positions in stocks with higher overnight volatility and short positions on those with lower overnight volatility. The one-year volatility of daily gap returns is utilized to define the portfolio for the subsequent year, and to categorize the strategy into long and short positions. The results reveal that the strategy generates positive abnormal returns across all models (CAPM, Fama-French Three Factor Model and Fama-French Extended Model), indicating that the gap risk is not priced in the Brazilian market. The strategy yields an annualized abnormal return exceeding 13%.

Keywords: opening price gap, overnight volatility, CAPM, FAMA-FRENCH, asset pricing, stock risk.

JEL Code: G11, G12, G14.

The views expressed in this working paper are those of the authors and do not necessarily reflect those of the Central Bank of Brazil.

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1 INTRODUCTION

Asset pricing stands as one of the foremost topics of discussion among researchers, investors, firm executives, and other market participants due to its relevance and influence on investment decisions and project evaluations. This study aims to analyze whether the risk associated with variations between the closing price and the opening price of the subsequent day is priced in the Brazilian stock market. This risk is incurred by investors who maintain their positions invested in assets on the stock exchange, as well as speculators in the futures market, who are passively subject to differences between the closing price and the opening price of the following day (hereinafter referred to as opening price gap rate).

To verify whether this opening price gap rate is priced in the Brazilian stock market, we employed three models: CAPM, Fama-French Three Factor Model and the Fama-French Model plus the Momentum and Liquidity factors (Fama-French Extended Model). To our knowledge, this study marks the first attempt to assess whether the variations between the closing and opening prices of stocks on the subsequent day are priced.

The study tests the hypothesis that the risk associated with the opening price gap rate is indeed priced by simulating a mutual fund that employs the standard deviation of the price gap of each stock as a metric for decision-making in a long and short strategy (L&S). The objective is to quantitatively analyze the generation of abnormal returns from the L&S strategy in the period from 2001 to 2024, thereby examining whether the market players price this risk.

A Long and Short (L&S) investment strategy is characterized by assuming two opposite positions of equal value without requiring capital. In this study, a long position is taken in stocks with higher gap volatilities while a short position is taken in stocks with lower gap volatilities. It operates as a paired trading approach uncorrelated with the market (a non-directional strategy).

The sample of our experiment consists of stocks that comprised the bovespa index (IBOVESPA - the main benchmark stock index of the Brazilian stock exchange) to mitigate the impact of illiquidity on stock prices. Each year, we construct a portfolio consisting of long and short positions in stocks with higher and lower gap volatilities, respectively. Portfolios are defined based on the previous year's gap volatility.

The opening gap puzzle constitutes an important area of academic inquiry in financial economics. It refers to the difficulty in explaining and predicting price movements associated with opening gaps, given that they appear to create anomalous profit opportunities, something

that should not occur in perfectly efficient markets. Avishay, Cohen, and Griskin (2024) analyze strategies related to opening gaps using artificial intelligence and big data, and discusses how prices adjust to new information, a central point for understanding the opening gap puzzle.

Futhermore, the opening price gap provide critical insights into the dynamics of information transmission and the behavioral responses of market participants. They serve as indicators of how efficiently markets incorporate newly available information and how traders interpret and react to such information events. The importance of the opening price gap rate effect in the literature can also be observed through works such as Bacidore and Lipson (2001), which describes the relationship between the stock prices of closing and opening auctions of the most important US exchanges (NYSE and NASDAQ). Even though the paper does not use the price gap as a risk factor, it shows the importance of considering the gap between closing and opening prices for investors' strategies.

Similarly, Sumiyana (2009) employs a quantitative approach to analyze the opening and closing prices of financial assets across various markets around the world. The study demonstrates that opening and closing prices exhibit distinct behaviors in different markets and periods. It identifies price discontinuity between consecutive days' prices as a relevant event that investors passively endure when trading assets in the stock exchange. Furthermore, the study identifies the presence of seasonality effects, indicating that certain days of the week or months of the year may present distinct behavioral patterns of opening and closing prices. The author also identifies the importance of considering the liquidity of financial assets when analyzing opening and closing prices, noting that liquidity shortage can significantly influence the behavior of these prices. The study concludes that there are always noises and overreaction that influence closing and opening prices, and that investors typically correct for this within the first 30 minutes of the trading section. Opening prices tend to be more volatile due to economic events and news releases, while closing prices converge towards the general market trend.

Lou et al. (2014) analyze the heterogeneity of investors and their preferences for trading in different time intervals, which causes price distortions. The study categorizes the period into "overnight" (the period between market closing on the previous day and market opening on the following day) and "intraday" (market open throughout the day) revealing abnormal returns in momentum and short-term reversal strategies during the "overnight" period, while other strategies exhibit abnormal returns in the "intraday" period. These temporal patterns strategies create a challenge for neoclassical risk and return models.

The results of our study highlight the existence of positive abnormal returns of the L&S strategy in all three pricing models, indicating that gap risk is not priced in the Brazilian stock market. Among all models, the lowest abnormal return was 13.11% per year, and the highest was 13.60%. The return of the L&S strategy without controlling for risk factors was 13.16% per year.

From the perspective of the Efficient Market Hypothesis (EMH), particularly its Weak Form, persistent or significant price gaps may be interpreted as market anomalies that deviate from theoretical expectations. These deviations can be largely attributed to information lags, as corporate announcements, earnings reports, and major news events are frequently disclosed outside of trading hours. Consequently, when trading resumes, the delayed assimilation of new information manifests as abrupt opening price adjustments, challenging the notion that all available information is instantaneously reflected in asset prices.

Moreover, behavioral factors play a significant role in explaining such anomalies. Contrary to the EMH assumption of rational investor behavior, panic selling or exuberant buying at market open may amplify price discrepancies. Additionally, the liquidity constraints that typically characterize the early trading period can exacerbate price volatility. During this interval, relatively low market depth means that even modest buy or sell orders can induce pronounced price movements. These factors suggest that market efficiency may be temporarily impaired during the opening session, with prices not fully or immediately reflecting all relevant information. The study of opening price gaps thus offers valuable insights into the complex interplay between information dissemination, macroeconomic information, behavioral biases, and market microstructure dynamics.

Si, Nadarajah and Zhang (2025) find that domestic market indices, international market variables, liquidity indicators and measures of market activity are specific factors contributing to price gap anomalies. Johannees (2004) conducted a study on the impact of anomalous price movements and identifies that they are caused by unanticipated macroeconomic news. Abbody et al. (2018) show that investor panic or excessive optimism is a crucial factor affecting stock prices. Li et al. (2021) demonstrate that variations in market microstructure characteristics, such as trading volume and transaction frequency, affect stock price dynamics, thereby contributing to the opening price gap rate.

This work is structured as follows: section 2 presents the sample and the methodology, including the pricing models; section 3 shows the results of the L&S strategy; finally, in section 4, the final considerations are presented.

2 METHODOLOGY AND SAMPLE

This section is divided into two subsections: the first presents the asset pricing models used in this work, while the second addresses the sample used for the empirical exercise with the L&S strategy.

2.1 ASSET PRICE MODELS AND RISK FACTORS

To provide robustness to the results, three asset pricing models were used: the single-index model (derived from the Capital Asset Pricing Model - CAPM), the Fama-French (1993) three-factor model, and an extended Fama-French model that incorporates momentum and liquidity risk factors.[1]

The Capital Asset Pricing Model (CAPM) was developed by Sharpe (1964), Lintner (1965), and Mossin (1966), based on Markowitz's (1952) portfolio theory. The CAPM can be defined as the linear relationship wherein the expected return of an asset or portfolio is a function of its systematic risk (market risk):

$$\boldsymbol{E(R) = Rf + \beta\,[(E(Rm) - Rf)]}$$

where

- E(R) represents the expected return of an asset or a portfolio;
- Rf is the risk-free interest rate;
- β is the systematic risk of an asset or portfolio; and
- E(Rm) is the expected return of the market portfolio.

The CAPM indicates that the expected return of an asset or portfolio is a function of a single factor, its market risk (systematic risk). The single-index model used in this study is derived directly from CAPM:

$$R_{i,t} - Rf_t = \alpha_i + \beta_i\,(Rm_t - Rf_t) + \varepsilon_{i,t} \qquad (1)$$

where index t refers to the dates of the time series sample, i refers to the asset or portfolio and ε is the residual. When comparing the model with CAPM, the expected value for α_i is zero, and if α_i is different from zero, there is some return that is not explained by the market factor,

[1] Fama and French published an extended model in Fama and French (2015).

called abnormal return.

Black et al. (1972) tested the CAPM and concluded that there is sufficiently strong evidence to reject the model, as the expected return would not be exactly proportional to beta. They stated that there are economic hypotheses consistent with the existence of other risk factors to explain asset returns.

Fama and French (1992) also found no evidence supporting the CAPM model and warned that investors should get closer to market reality. They highlighted the model's limitation of having only one independent variable. Fama and French (1993) suggested additional variables based on other studies to improve the model and help it to explain abnormal returns. Among all the studies, some listed below stand out.

Stattman (1980) and Rosenberg et al. (1985) found that US stocks returns are positively related to the market-to-book ratio. Chan et al. (1991) noted that this ratio had strong explanatory power for the average return of Japanese stocks. Bhandari (1988) argues that leverage helps explain the average stocks returns in tests that include market capitalization and market risk.

Banz (1981) inferred that market equity (market capitalization), calculated as the product of stock price and the number of shares held by the market, is relevant in explaining stock returns. According to the author, on average, the returns of firms with low market value are higher than those estimated by market risk. Conversely, for firms with high market capitalization, on average, returns are lower than those indicated by market risk.

Given all these criticisms about the CAPM, Fama and French (1993) assessed the potential impact of omitted variables cited in the literature. The authors concluded that firm size and the relationship between firm market value and book value could represent risk factors in a rational asset pricing environment. Thus, they developed a model capable of explaining stock returns incorporating three factors: (a) a factor linked to overall market performance (already present in the CAPM); (b) a factor associated with firm size; and (c) a factor related to the market-to-book ratio (P/B). Therefore, the factors added to the CAPM are:

- The SMB factor (Small Minus Big), which denotes the historical excess return of small-cap stocks compared to big-cap stocks; and
- The HML factor (High Minus Low), which refers to stocks with high market value relative to their book value (P/B). It represents the historical excess return of high P/B stocks compared to low P/B stocks.

The formula for the Fama-French 3 Factors model (1993) is as follows:

$$E(R) = Rf + \beta\,[(E(Rm) - Rf)] + \beta_s(SMB) + \beta_v(HML)$$

The P/B ratio and firm size are linked to economic fundamentals. Firms with a high P/B ratio, indicating a high market value relative to book value, are associated with high and persistent returns. Additionally, firm size is correlated with profitability: According to the authors, returns on investments in small firms tend to surpass those in large firms, even when controlling for the P/B ratio.

In this study, we employ the model within a time series framework (equation 2):

$$R_{i,t} - Rf_t = \alpha_i + \beta_i\,(Rm_t - Rf_t) + \beta_s\,SMB_t + \beta_v HML_t + \varepsilon_{i,t} \qquad (2)$$

Asset pricing models are continuously refined to enhance their ability to explain stock returns. In this study, two factors are added to the Fama-French model: momentum and liquidity.

Carhart (1997) introduced the momentum factor into the original Fama-French model. This factor is based on the idea that assets that have performed well in the past will continue to perform well in the future, and assets that have performed poorly will continue to perform poorly.

Some studies have incorporated the liquidity factor into asset pricing models. Liu (2006) proposed a two-factor model by integrating it into the CAPM framework. Similarly, Keene and Peterson (2007) added the liquidity risk premium to the Carhart model (1997). In both cases, there is an improvement in the explanatory power of the models. Less liquid assets demand higher returns compared to more liquid assets, as investors require a risk premium in terms of expected return to forgo liquidity. Therefore, the price of illiquid assets must drop sufficiently to attract investors. Thus, in equilibrium, expected returns are an increasing function of illiquidity.

In this study, we employ a model similar to Keene and Peterson (2007) and referred to as the Fama-French Extended Model (equation 3):

$$R_{i,t} - Rf_t = \alpha_i + \beta_i\,(Rm_t - Rf_t) + \beta_s\,SMB_t + \beta_v HML_t + \beta_w WML_t + \beta_i IML_t + \varepsilon_{i,t} \qquad (3)$$

where

- WML_t is the factor related to the return premium on a portfolio long in stocks with high past returns (Winners) and short in stocks with low past returns (Losers); and
- IML_t is the liquidity factor related to the return premium on a portfolio long in less liquid stocks and short in more liquid stocks.

2.2 SAMPLE

We utilized daily opening and closing prices of each stock included in the Bovespa Index (Ibovespa) from the year 2000 to 2024. The Ibovespa is the main index of the Brazilian stock exchange. Price series are adjusted for dividends and other similar events. We only utilized stocks comprising Ibovespa to form the L&S strategy portfolios. The stock codes forming the Ibovespa were collected from the Brazilian stock exchange website. In cases where both preferred and common stocks of the same firm were presented in the index, we use only the most liquid one.[2]

We extracted the risk factors, namely *SMB*, *HML*, *IML*, and *WML*, from the Nefin/FEA-USP website.[3] This website provides the historical daily returns of each of these factors. The risk-free rate (*Rf*) is the 30-day DI Swap, and the market return (*Rm*) was calculated using the daily returns of the Ibovespa closing prices.

As mentioned earlier, the key measure for portfolio selection is the sample standard deviation of returns between the closing and next day opening prices (opening price gap rate) of each stock comprising the Ibovespa. Next, we present the methodology for defining the last portfolio (used in the year 2024 based on the year 2023 stock standard deviations) as an example. The portfolios of previous years are formed in the same manner.

We calculate the daily returns between the closing and opening prices of each asset included in the Ibovespa at the end of the year 2023 (the base year, in this case), for all trading days throughout the year. Using the standard deviations of these returns, we create a ranking to construct the year 2024 L&S portfolio.[4]

[2] Preferred stocks in the Brazilian stock market are those that carry voting rights.

[3] https://nefin.com.br. The methodology building the risk factors can be found at Appendix A.

[4] For standardization purposes, we did not use the exact set of returns from the base year. Instead, we considered the returns from the 248 trading days preceding the first trading day of the year following the base year to calculate the standard deviations.

Stock Ticker	SD (per day)		Stock Ticker	SD (per day)		Stock Ticker	SD (per day)
BHIA3	2.64%		B3SA3	0.94%		FLRY3	0.71%
HAPV3	2.40%		CMIN3	0.92%		HYPE3	0.70%
BRKM5	2.29%		BPAC11	0.92%		ABEV3	0.70%
PCAR3	2.19%		RENT3	0.92%		SBSP3	0.69%
BRAV3	1.78%		EZTC3	0.92%		MOTV3	0.69%
MGLU3	1.75%		BBDC4	0.91%		ITUB4	0.69%
AZUL4	1.56%		VBBR3	0.90%		CIEL3	0.69%
NATU3	1.48%		CYRE3	0.89%		GOAU4	0.68%
ALPA4	1.46%		ISAE4	0.88%		MULT3	0.67%
GOLL54	1.36%		DXCO3	0.88%		RAIZ4	0.67%
BEEF3	1.29%		PETR4	0.88%		EMBR3	0.65%
BRFS3	1.29%		CRFB3	0.87%		CSAN3	0.64%
YDUQ3	1.29%		ENEV3	0.87%		WEGE3	0.60%
CVCB3	1.27%		USIM5	0.86%		SUZB3	0.60%
CSNA3	1.17%		AZZA3	0.86%		SANB11	0.59%
LWSA3	1.16%		ELET3	0.85%		CPLE6	0.57%
COGN3	1.16%		UGPA3	0.85%		RADL3	0.56%
SOMA3	1.15%		BRAP4	0.84%		SLCE3	0.56%
JBSS3	1.13%		RECV3	0.84%		BBAS3	0.55%
RDOR3	1.13%		RAIL3	0.83%		CMIG4	0.54%
IRBR3	1.12%		VAMO3	0.83%		EQTL3	0.53%
LREN3	1.11%		SMTO3	0.82%		VIVT3	0.52%
MBRF3	1.09%		GGBR4	0.81%		CPFE3	0.52%
VALE3	1.05%		ALOS3	0.78%		TIMS3	0.48%
PRIO3	1.04%		IGTI11	0.73%		KLBN11	0.48%
PETZ3	1.03%		TOTS3	0.73%		BBSE3	0.45%
ASAI3	1.01%		ENGI11	0.71%		EGIE3	0.34%
MRVE3	0.95%					TAEE11	0.31%

Table 1 – Stocks that compose the Ibovespa at the end of year 2023 with its respectively standard deviations and the 2024 portfolio: stocks highlighted in blue represent the tercile with the highest volatility (long position), while stocks highlighted in pink represent the tercile with the lowest volatility (short position).

The portfolio invested in 2024 (and similarly in other years) allocates the same amount of investment to each long position in a stock (those with higher volatility in the previous year) and the same amount to each short position in a stock (those with lower volatility in the previous year), resulting in a net zero value for the L&S portfolio. Only the extreme terciles of the ranking were used to compose the L&S portfolio, ensuring that stocks with similar standard deviations are not in opposite positions. In Table 1, we present the sample and the 2024 portfolio: the blue section represents the tercile of the sample with higher volatility (SD), indicating the long stocks. Conversely, the red section in Table 1 represents the lower tercile, indicating the short stocks. This process is repeated with portfolios from 2001 onwards until

2024, always based on the composition of the Ibovespa at the end of the previous year, resulting in 24 different portfolios (one for each year) and 5,946 sample days. The Appendix B contains the portfolios for each year, from 2001 to 2024.

The daily return of the portfolio is simply the average of the returns of the assets, considering whether the asset is in a long or short position.

Figure 1 displays the terciles of stock volatility (measured by standard deviation) used to construct the L&S portfolios for each year. For instance, the volatility terciles from 2023 are used to build the L&S portfolio for 2024: stocks with volatility above 0.95% comprise the long portfolio, while those with volatility below 0.71% form the short portfolio for that year. Figure 1 reveals a downward trend in stock volatility over the years, with notable spikes during the subprime crisis and the COVID-19 pandemic. The average difference between the first and second terciles of volatility is 0.25%.

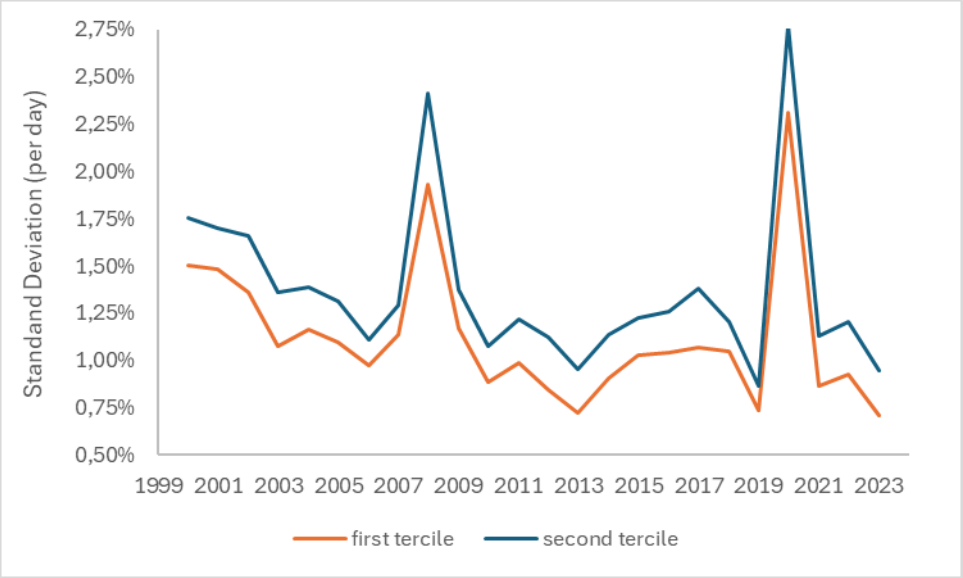

Figure 1- Terciles of stock volatility (measured by standard deviation per day) used to construct the L&S portfolios. Stocks with volatility below the first tercile (orange line) are selected for the short portfolio of the following year, while stocks with volatility above the second tercile (blue line) are selected for the long portfolio.

3. RESULTS

First, we test whether there is evidence that the opening price gap rate is structural (ie, it can occur on any day) or market-condition-dependent (driven by macroeconomic or regulatory events). To test macroeconomic factors, we selected days following meetings of the Monetary

Policy Committee of the Central Bank of Brazil (COPOM) in which there was a surprise regarding the decision to raise or lower interest rates during the study period. The criteria for defining a surprise required that at least two out of three indicators signal unexpectedness for each meeting:[5] i) The impact on variation in the interest rate of the shortest DI future contract on the following day exceeds 13 basis points (bps);[6] ii) The impact on variation in the interest rate of the three shortest DI futures contract on the following day maturities exceeds 13 bps; and iii)The impact on the last market expectations survey after the COPOM meeting by at least 25 bps compared to the day before.[7] To test regulatory factors, all regulations issued by the Brazilian Securities Commission (CVM) during the study period that affected publicly traded companies were collected from its website.

For each day, we calculated the average daily gap return across all stocks that participate in the IBOVESPA between 2001 and 2024 and classified the day into one of six categories: i) Post-COPOM with positive surprise (9 events); ii) Post-COPOM with negative surprise (5 events); iii) Post-regulation with positive surprise (12 events); iv) Post-regulation with negative surprise (8 events); v) Other days with positive return (3,999 events); and vi) Other days with negative return (2,365 events). This classification resulted in six distinct datasets. Table 2 presents the average return, standard deviation for COPOM and CVM surprise days (categories i to iv), and the p-value from the t-test comparing these days to all other days (with positive or negative returns, categories v and vi) that did not involve either type of surprise.

Category	Average Return	Standard Deviation	p-Value
COPOM positive surprises	0.78%	0.71%	0.1642
COPOM negative surprises	-0.32%	0.15%	0.3294
CVM positive regulations	0.62%	0.67%	0.3371
CVM negative regulations	-0.51%	0.37%	0.3970
Other days with positive return	0.53%	0.57%	
Other days with negative return	-0.53%	0.78%	

Table 2 – Average Return, Standard Deviation and P-values from the t-tests. For 1st test, H0: the difference between COPOM surprises (positive or negative) mean return and the other days (positive or negative) mean return is equal to zero. For the 2nd test, H0: the difference between CVM regulations (positive or negative) mean return and the other days (positive or negative) mean return is equal to zero

[5] Poole, Rasche and Thornton (2002) measured unexpected interest rate target changes based on market consensus projections. Oliveira and Ramos (2011) identified unexpected interest rate shocks by means of DI future contracts.

[6] The futures contract for the one-day interbank deposit rate (DI Futures or DI1 Future) is the instrument on the Brazilian stock exchange where the nominal interest rate in Brazilian reais is traded.

[7] Market expectations are obtained from the Focus Report, a survey conducted by the Central Bank of Brazil among financial institutions, asset managers, and consulting firms. It gathers expectations about key economic variables, such as inflation, interest rates and exchange rates

The p-values indicate that we cannot reject the null hypothesis of equal means across the series. This suggests that the opening price gap rate puzzle may occur on any given day, regardless of news released the previous evening, signaling a structural anomaly.

Next, we present the results of the empirical exercise. As mentioned earlier, 24 portfolios were constructed, one for each year from 2001 to 2024, based on the stocks that comprised the Ibovespa in the previous year. The objective is to observe whether portfolios that are long in stocks with higher gap risk and short in those with lower gap risk yield abnormal returns. For a more comprehensive overview, Table 3 displays the returns of each year. Many negative returns can be noted in the first years, but after 2009 there are only positive returns. . The average annual return is 13.16%.

Year	2001	2002	2003	2004	2005	2006	2007	2008
Return	38,79%	-21,02%	-13,08%	2,63%	-15,33%	-1,67%	-17,40%	-17,72%
Year	2009	2010	2011	2012	2013	2014	2015	2016
Return	23,68%	12,08%	8,96%	24,63%	38,12%	30,68%	18,57%	72,00%
Year	2017	2018	2019	2020	2021	2022	2023	2024
Return	27,19%	38,93%	3,43%	35,15%	23,69%	10,05%	19,31%	20,20%

Table 3 – Returns for Each Year and the Average Return of the L&S Strategy, Long (Short) in Stocks with Higher (Lower) Gap Risk

To illustrate the relationship between the Long & Short (L&S) portfolio and the equity market environment, Figure 2 presents the cumulative performance of the strategy alongside the cumulative return of the Ibovespa, both normalized to start at 1. The figure highlights the non-directional nature of the L&S strategy, that is, its performance does not track the market. While both portfolios exhibit an overall upward trend, the L&S portfolio demonstrates superior performance. At the beginning of the sample period, Ibovespa outperforms; however, from 2020 onward, the L&S strategy continues to grow steadily, whereas Ibovespa shows a more stagnant behavior. The correlation between their daily returns is 0.35.

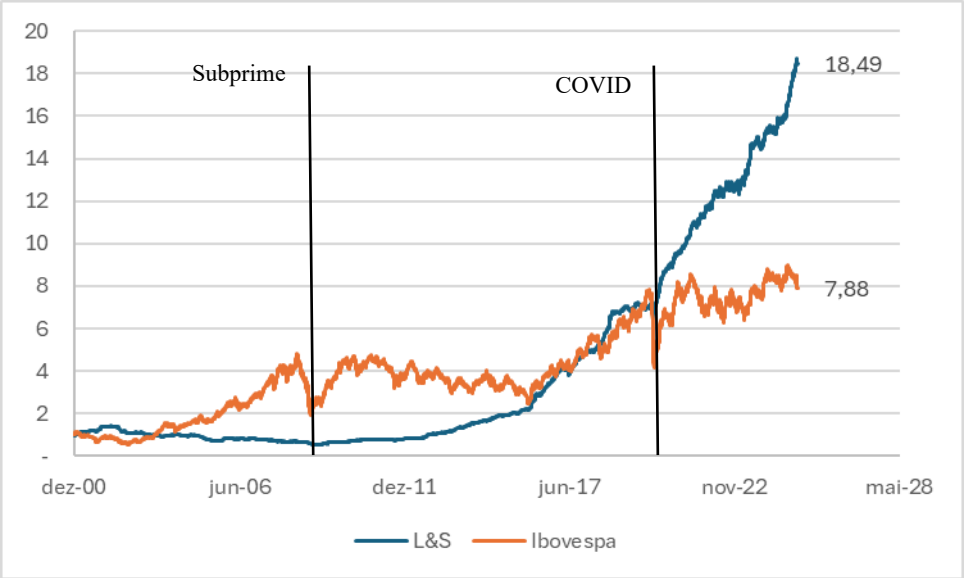

Figure 2- Ibovespa versus L&S Strategy, Long (Short) in Stocks with Higher (Lower) Gap Risk. Both portfolios start at 1.

Two extreme events were highlighted in the Figure: the subprime crisis in 2008 and the and the COVID-19 pandemic in 2020. These events represented crucial moments that substantially negatively impacted the Brazilian economy. During these periods, the L&S strategy did not have a negative performance, showing its non-directional nature. Figure 3 displays the volatility (standard deviation) of the L&S strategy's daily returns for each year. Volatility ranges from 0.33% per day in 2007 to 1.01% in 2016 and 2020. Interestingly, the level of risk did not increase during the subprime crisis in 2008.

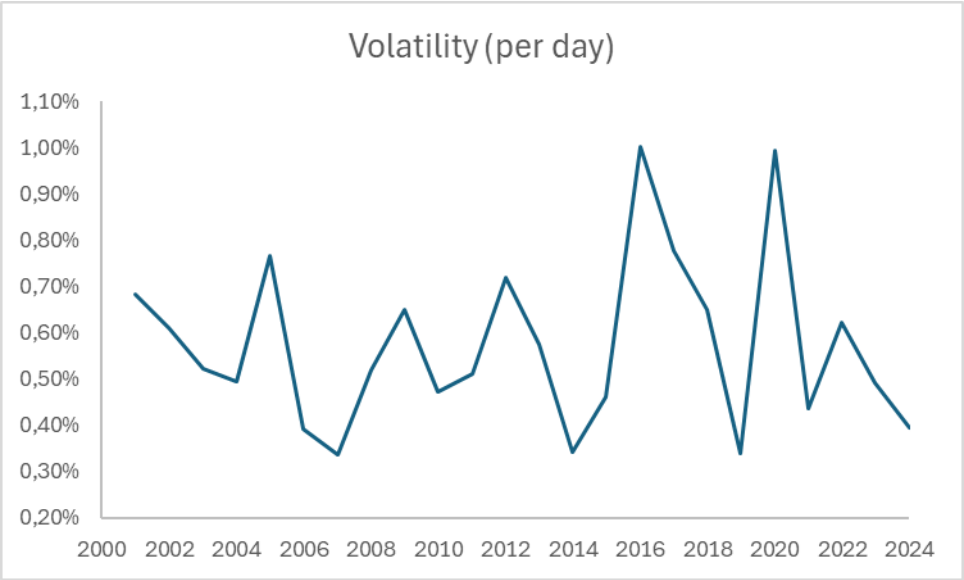

Figure 3- Volatility (Standard Deviation) of the L&S Strategy's Daily Returns for Each Year.

To assess whether the L&S strategy yields abnormal returns, we employed the three methodologies described in the previous section, represented by equations 1, 2, and 3: CAPM (single-index model), Fama-French Three Factor Model and Fama-French Extended Model. We utilized daily returns, comprising 5,946 observations from 2001 to 2024. The dependent variable (L&S daily returns) is not adjusted by the risk-free interest rate, since it is a zero-cost long and short strategy and therefore involves no opportunity cost. All regressions are controlled for HAC (Heteroscedasticity and Autocorrelation). The results are presented in Table 4.

Dependent Variable: L&S Portfolio Daily Returns			
	(1)	**(2)**	**(3)**
α	0.049% ***	0.049% ***	0.051% ***
	(6.27)	(6.28)	(6.13)
Rm - Rf	0.141 ***	0.141 ***	0.144 ***
	(8.66)	(9.00)	(7.47)
SMB		0.035 **	-0.001
		(2.64)	(-0.06)
HML		0.005	0.003
		(0.50)	(0.33)
WML			-0.034 *
			(-1.79)
IML			0.038
			(1.53)
Adjusted R^2	0.123	0.127	0.131
SIC	-7.468	-7.469	-7.471
Observations	5946	5946	5946

t-statistic in parentheses (computed using the Newey–West HAC variance estimator)

*** p < 0.01, ** p < 0.025, * p < 0.05

Table 4 – Results of Single-Index Model Regression (Equation 1), Fama-French Three Factor Model Regression (Eqaution 2) and Fama-French Extended Model Regression (Equation 3)

Regression 1 (Single-Index Model regression) reveals a positive abnormal return (α) and a statistically significant coefficient for the market risk factor. The low R^2 is typical for L&S strategies, as noted by Liu (2021) and Tang (2023). The statistically significant abnormal return suggests that the risk of differences (gaps) between the closing price and the opening price of the subsequent day is not priced into the Brazilian stock market.

Regression 2 (Fama-French Three Factor Model regression) also indicates that the gap risk is not priced. Among the additional factors, SMB is statistically significant at the 5% level,

while HML is not. Both α and the market risk coefficient are very similar to those in Regression 1, reinforcing the robustness of the results.

Regression 3 (Fama-French Extended Model Regression) continues to support the conclusion that gap risk is not priced in the Brazilian market (the abnormal return is statistically significant). While the SMB factor loses statistical significance in this specification, WML show significance, suggesting it captures relevant dimensions of risk. The abnormal return and the market beta remain consistent with previous regressions, reinforcing the robustness of the findings across different model specifications.

All regressions indicate that stocks with higher gap risk (greater volatility between closing and opening prices) generate higher risk-adjusted performance compared to stocks with lower gap risk: The regressions produced significant abnormal returns of approximately 0.05% per day (more than 13% per year), indicating that the gap risk is not priced.

4 FINAL REMARKS

In this study, we examine whether gap risk is priced in the Brazilian market. Here, “gap” refers to the disparity between the closing price and the subsequent day's opening price. We construct Long and Short portfolios with long positions taken in stocks exhibiting higher gap risks and short positions in those with lower gap risks. To observe if these portfolios yield risk-adjusted abnormal returns, three models are utilized: CAPM (Single-Index Model), the Fama-French Three-Factor Model, and an Extended Fama-French Model (incorporating momentum and liquidity factors).

The database contains the closing and opening prices of each business day over 25 years for the stocks that comprised the Bovespa index (Ibovespa) at the end of each year. The daily risk factors used were calculated using stocks from the Brazilian stock exchange.

The results suggest that gap risk is not priced in the Brazilian stock market: portfolios with long positions in high gap-risk stocks and short positions in low gap-risk stocks generate positive abnormal returns of approximately 13% per year. This finding is robust across all three asset pricing models.

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APPENDIX A – METHODOLOGY FOR CONSTRUCTING THE RISK FACTORS

(The content of this appendix comes from the Nefin/FEA-USP website, https://nefin.com.br.

A. Eligibility criteria

- A stock traded in BOVESPA is considered eligible for year t if it meets 3 criteria:
- The stock is the most traded stock of the firm (the one with the highest traded volume during last year);
- The stock was traded in more than 80% of the days in year t-1 with volume greater than R$ 500.000,00 per day. In case the stock was listed in year t-1, the period considered goes from the listing day to the last day of the year;
- The stock was initially listed prior to December of year t-1.

B. Small Minus Big (SMB)

The Small Minus Big Factor (SMB) is the return of a portfolio long on stocks with low market capitalization ("Small") and short on stocks with high market capitalization ("Big").

Every January of year t, the eligible stocks are sorted according to their December of year t-1 market capitalization and separate them into 3 quantiles. Then, the equal-weighted returns of the first portfolio ("Small") and the third portfolio ("Big") are computed. The SMB Factor is the return of the "Small" portfolio minus the return of the "Big" portfolio.

C. High Minus Low (HML)

The High Minus Low Factor (HML) is the return of a portfolio long on stocks with high book-to-market ratio ("High") and short on stocks with low book-to-market ratio ("Low").

Every January of year t, the eligible stocks are sorted into 3 quantiles (portfolios) according to the book-to-market ratio of the firms in June of year t-1. Then, the equal-weighted returns of the first portfolio ("Low") and the third portfolio ("High") are computed. The HML Factor is the return of the "High" portfolio minus the return of the "Low" portfolio.

D. Winners Minus Losers (WML)

The Winners Minus Losers Factor (WML) is the return of a portfolio long on stocks with high past returns ("Winners") and short on firms with low past returns ("Losers").

Every month t, the eligible stocks are sorted into 3 quantiles (portfolios) according to their cumulative returns between month t-12 and t-2. Then the equal-weighted returns of the

first portfolio (“Losers”) and the third portfolio (“Winners”) are computed. The WML Factor is the return of the “Winners” portfolio minus the return of the “Losers” portfolio.

E. lliquid Minus Liquid (IML)

The Illiquid Minus Liquid Factor (IML) is the return of a portfolio long on stocks with high illiquidity (“Illiquid”) and short on stocks with low illiquidity (“Liquid”).

Every month t, the eligible stocks are sorted into 3 quantiles (portfolios) according to their previous twelve month illiquidity moving average (stock illiquidity is computed as in Acharya and Pedersen 2005). Then the equal-weighted returns of the first portfolio (“Liquid”) and the third portfolio (“Illiquid”) are computed. The IML Factor is the return of the “Illiquid” portfolio minus the return of the “Liquid” portfolio.

APPENDIX B – TABLES OF ANNUAL LONG & SHORT PORTFOLIOS – For each year, stocks in long positions are highlighted in blue, while those in short positions are highlighted in salmon.

2001 portfolio	2002 portfolio	2003 portfolio	2004 portfolio	2005 portfolio
CRTP5	CRTP5	EBTP4	NETC4	NETC4
TNEP4	VIVO4	CMIG3	EGIE3	BRTP3
TCSL4	EGIE3	NETC4	BRTP3	EGIE3
TMCP4	LIGT3	BRTP3	LIGT3	LIGT3
TCOC4	TCOC4	LIGT3	KLBN4	ELET3
ISAE4	ELPL5	CSNA3	ELPL5	ELPL5
TLCP4	TIMS3	INEP4	TLCP4	PTIP4
PTIP4	BRDT4	ELPL5	CRTP5	CRTP5
CSTB4	BRTP3	TIMS3	CGAS5	ABEV3
BRDT4	PTIP4	PTIP4	EBTP4	TLCP4
ABEV3	TMCP4	KLBN4	BRAP4	CESP5
USIM5	TLCP4	BRKM5	CESP5	TIMS3
ELET3	CESP5	EGIE3	PTIP4	EBTP4
TNLP4	BRKM5	ELET3	TIMS3	VIVT4
CMIG4	ABEV3	BBAS3	CSTB4	TCOC4
ARCZ6	KLBN4	CGAS5	CRUZ3	TCSL4
VALE5	ELET3	CRTP5	CMIG4	CSTB4
SBSP3	USIM5	TCOC4	BBAS3	CSNA3
BRAP4	ARCZ6	TNEP4	CSNA3	BBAS3
BBDC4	ACES4	OIBR4	SBSP3	OIBR4
PETR4	SBSP3	USIM5	OIBR4	GGBR4
ITUB4	CSNA3	BRAP4	ACES4	VCPA4
	EMBR4	CPLE6	TNLP4	CLSC4
	BBAS4	ACES4	ITUB4	CMET4
	CMIG4	GGBR4	GGBR4	ACES4
	GGBR4	ABEV3	BBDC4	TNLP4
	CRUZ3	TNLP4	PETR4	ARCZ6
	BRAP4	BBDC4		PETR4
	TNLP4	PETR4		BBDC4
	PETR4	CRUZ3		ITUB4
	BBDC4	ITUB4		VALE5
	ITUB4	EMBR4		
	VALE5	VALE5		

2006 portfolio	2007 portfolio	2008 portfolio	2009 portfolio	2010 portfolio
TLCP4	LIGT3	SYNE3	B3SA3	TIMS3
ARCE3	BRFS3	CESP6	BNCA3	DXCO3
TCOC4	ARCE3	PETR4	JBSS3	OIBR3
CRTP5	TIMS3	AMER3	RSID3	RSID3
LIGT3	SBSP3	CYRE3	CYRE3	MMXM3
TIMS3	CGAS5	BRTP4	CSNA3	GFSA3
ELPL5	ACES4	LREN3	SDIA4	CYRE3
CESP5	ABEV3	VALE5	BRAP4	GGBR4
ISAE4	EMBR3	GFSA3	ITUB4	B3SA3
OIBR4	ELPL4	USIM5	GGBR4	GOLL54
ABEV3	ELET3	BRFS3	GOAU4	CSNA3
CPLE6	BRTP4	NATU3	CESP6	BRAP4
BRTP4	VIVO4	TIMS3	VALE5	USIM5
ELET3	VIVT4	BRAP4	ARCZ6	VALE5
CGAS5	USIM5	GOLL54	BBAS3	GOAU4
VIVO4	ISAE4	ISAE4	LREN3	AMER3
SDIA4	VCPA4	CSAN3	USIM5	EMBR3
CMET4	NETC4	ALLL11	LAME4	JBSS3
GGBR4	MOTV3	PTIP4	PETR4	TAMM4
CTAX4	CLSC4	NETC4	NETC4	SBSP3
CLSC4	TCSL4	CGAS5	KLBN4	CESP6
VIVT4	UBBR11	TMCP4	BRKM5	BBDC4
CSNA3	CMIG4	TNLP4	TMAR5	TCSL4
UBBR11	VALE5	ELPL4	VIVO4	UGPA4
VCPA4	TNLP4	CPLE6	PCAR4	FIBR3
VALE5	ITUB4	UBBR11	LIGT3	CLSC4
ARCZ6	OIBR4	ELET3	BRTP3	NATU3
TMAR5	SDIA4	CLSC4	EMBR3	MOTV3
PETR4	CPFE3	BNCA3	NATU3	ELET3
ITUB4	PCAR4	BBDC4	CMIG4	ISAE4
TNLP4	BBDC4	PCAR4	TNLP4	ELPL4
BBDC4	PETR4	SDIA4	ABEV3	CGAS5
	BRKM5	ITUB4	UGPA4	CRUZ3
		CMIG4	CRUZ3	CPFE3
		CPFE3	CLSC4	CMIG4
		EMBR3	ISAE4	VIVT4
		TCSL4	CPFE3	LIGT3
		ARCZ6	CGAS5	
		ACES4	VIVT4	

2011 portfolio	2012 portfolio	2013 portfolio	2014 portfolio	2015 portfolio
ALLL3	OGXP3	OGXP3	MMXM3	PETR4
PRML3	MMXM3	ISAE4	PRML3	OIBR4
PRTX3	GOLL54	ELET3	GOLL54	BBAS3
MMXM3	MRVE3	PRML3	OIBR4	RLOG3
PDGR3	RSID3	GFSA3	CPLE6	ELET3
MRVE3	PDGR3	PDGR3	CSNA3	B3SA3
GFSA3	GFSA3	MMXM3	GFSA3	SANB11
BISA3	HYPE3	CESP6	PDGR3	BBDC4
OIBR4	CYRE3	GOLL54	MBRF3	ITUB4
SLCE3	BISA3	MRVE3	USIM5	ALLL3
TAMM4	MBRF3	BISA3	MRVE3	TIMS3
OGXP3	SLCE3	MBRF3	RSID3	CMIG4
TIMS3	BRFS3	RSID3	PETR4	PDGR3
GOLL54	AMER3	AMER3	BISA3	CSNA3
B3SA3	OIBR4	USIM5	EMBR3	GOLL54
RSID3	USIM5	CSNA3	DASA3	BRML3
GGBR4	B3SA3	CMIG4	AEDU3	CPLE6
FIBR3	CSNA3	SANB11	ELPL4	EVEN3
USIM5	JBSS3	OIBR3	ELET3	JBSS3
CYRE3	SANB11	CYRE3	COGN3	MBRF3
SANB11	PRML3	HYPE3	AMER3	CSAN3
ELET3	KLBN4	LAME4	VALE5	ENBR3
RDCD3	PCAR4	B3SA3	HYPE3	HYPE3
KLBN4	RDCD3	CIEL3	DXCO3	EMBR3
ABEV3	PETR4	BBDC4	BRML3	BRFS3
TCSL4	TNLP4	BRML3	MOTV3	UGPA3
VIVT4	BRML3	OIBR4	B3SA3	NATU3
PCAR4	LIGT3	DXCO3	SLCE3	EGIE3
EMBR3	CIEL3	RENT3	ITUB4	BBSE3
BBAS3	HGTX3	KLBN4	NATU3	CESP6
CIEL3	NATU3	CSAN3	VIVT4	PCAR4
MOTV3	SBSP3	BRFS3	RENT3	ELPL4
CMIG4	CESP6	LIGT3	ISAE4	ECOR3
NATU3	CPLE6	MOTV3	CIEL3	QUAL3
ISAE4	VIVT4	CPFE3	LREN3	YDUQ3
BBDC4	ELET3	SBSP3	BBDC4	GOAU4
TNLP4	MOTV3	CTIP3	UGPA3	POMO4
UGPA4	CPFE3	UGPA3	BRFS3	ABEV3
CPFE3	CRUZ3	NATU3	PCAR4	GGBR4
CRUZ3	ELPL4	PCAR4	CSAN3	CIEL3
LIGT3	CMIG4	VIVT4	CPFE3	CRUZ3
ELPL4	ISAE4	CRUZ3	CTIP3	BRKM5
			ABEV3	FIBR3
			CRUZ3	SUZB5

2016 portfolio	2017 portfolio	2018 portfolio	2019 portfolio	2020 portfolio
PETR4	USIM5	CMIG4	BHIA3	QUAL3
OIBR3	PETR4	ELET3	ELET3	VALE3
CSNA3	GOAU4	BHIA3	SMLS3	SMLS3
COGN3	RUMO3	MGLU3	PETR4	BHIA3
USIM5	VALE5	RAIL3	SUZB3	BRKM5
VALE5	CSNA3	BRAP4	CMIG4	BRAP4
RUMO3	BRAP4	BBAS3	GOLL54	CSNA3
GOAU4	GGBR4	JBSS3	BRKM5	GOLL54
BRAP4	BBAS3	USIM5	BBAS3	AMER3
HYPE3	YDUQ3	GOAU4	QUAL3	BPAC11
GGBR4	JBSS3	CYRE3	BRFS3	JBSS3
BRKM5	COGN3	CSNA3	USIM5	ELET3
MBRF3	CMIG4	PETR4	CSNA3	MGLU3
BBAS3	CYRE3	GGBR4	MGLU3	PETR4
BRML3	BBDC4	BRML3	AMER3	CIEL3
QUAL3	ITUB4	SBSP3	SBSP3	SBSP3
SANB11	ELET3	B3SA3	SANB11	YDUQ3
CMIG4	B3SA3	SANB11	BBDC4	BRFS3
RENT3	BBSE3	ITUB4	LREN3	AZUL4
EMBR3	MULT3	BBDC4	RENT3	USIM5
CPFE3	MRVE3	CIEL3	B3SA3	CVCB3
CIEL3	PCAR4	BRKM5	MOTV3	MBRF3
NATU3	CPFE3	NATU3	JBSS3	BRML3
PCAR4	ENBR3	FIBR3	RAIL3	SANB11
SMLS3	BRFS3	IGTA3	CSAN3	LREN3
UGPA3	VIVT4	TIMS3	ECOR3	BBSE3
EGIE3	WEGE3	FLRY3	ENBR3	CMIG4
CTIP3	CSAN3	TAEE11	FLRY3	HYPE3
CYRE3	LAME4	VIVT4	PCAR4	SUZB3
BRFS3	MBRF3	EQTL3	IGTA3	TIMS3
ABEV3	UGPA3	WEGE3	FIBR3	ECOR3
RADL3	EQTL3	UGPA3	RADL3	IRBR3
SUZB5	KLBN11	ENBR3	BBSE3	CSAN3
EQTL3	ABEV3	RADL3	ABEV3	WEGE3
FIBR3	EGIE3	EMBR3	WEGE3	IGTA3
KLBN11	RADL3	ABEV3	CPLE6	VIVT4
	CTIP3	EGIE3	EQTL3	GNDI3
		KLBN11	KLBN11	EQTL3
		SUZB3	LOGG3	EGIE3
		CPFE3	VIVT4	FLRY3
			EGIE3	KLBN11
			TAEE11	ENBR3
				TAEE11

2021 portfolio	2022 portfolio	2023 portfolio	2024 portfolio
PRIO3	PCAR3	MGLU3	BHIA3
AZUL4	CASH3	HAPV3	HAPV3
GOLL54	EMBR3	CASH3	BRKM5
BHIA3	PETR4	LWSA3	PCAR3
IRBR3	BHIA3	NATU3	BRAV3
CVCB3	CSNA3	AMER3	MGLU3
LCAM3	LAME4	BHIA3	AZUL4
PETR4	BPAN4	BRAV3	NATU3
MGLU3	CMIN3	CSNA3	ALPA4
JHSF3	USIM5	PRIO3	GOLL54
COGN3	BIDI11	CVCB3	BEEF3
BRKM5	BRAV3	GOLL54	BRFS3
BPAC11	GOLL54	AZUL4	YDUQ3
RENT3	PRIO3	VALE3	CVCB3
CSNA3	ELET3	CPLE6	CSNA3
MBRF3	POSI3	BRKM5	LWSA3
CYRE3	GNDI3	CMIN3	COGN3
GOAU4	LWSA3	USIM5	SOMA3
JBSS3	CVCB3	PETR4	JBSS3
ELET3	VBBR3	PETZ3	RDOR3
USIM5	VALE3	SBSP3	IRBR3
LREN3	HAPV3	SOMA3	LREN3
EMBR3	GGBR4	BRFS3	MBRF3
SULA11	AZUL4	BRAP4	VALE3
GNDI3	RENT3	COGN3	PRIO3
BBAS3	CRFB3	B3SA3	PETZ3
HGTX3	BRAP4	LREN3	ASAI3
UGPA3	SOMA3	PCAR3	MRVE3
MOTV3	AMER3	CIEL3	FLRY3
ITUB4	MGLU3	CSAN3	HYPE3
WEGE3	CSAN3	ITUB4	ABEV3
CMIG4	RAIL3	ALPA4	SBSP3
SBSP3	MULT3	ECOR3	MOTV3
TIMS3	SBSP3	MOTV3	ITUB4
ALPA4	MRVE3	ASAI3	CIEL3
ECOR3	ITUB4	CMIG4	GOAU4
EQTL3	SUZB3	HYPE3	MULT3
HYPE3	EZTC3	CPFE3	RAIZ4
CPLE6	HYPE3	EQTL3	EMBR3
ENBR3	RDOR3	CRFB3	CSAN3
FLRY3	LREN3	JBSS3	WEGE3
BBSE3	MBRF3	WEGE3	SUZB3
ENGI11	WEGE3	SMTO3	SANB11
ABEV3	SANB11	SANB11	CPLE6
KLBN11	CMIG4	AZZA3	RADL3
CPFE3	ECOR3	BEEF3	SLCE3
CRFB3	JBSS3	SUZB3	BBAS3
RADL3	EQTL3	ABEV3	CMIG4
EGIE3	ALPA4	ENGI11	EQTL3
SUZB3	CPLE6	SLCE3	VIVT3
VIVT3	ENGI11	TIMS3	CPFE3
TAEE11	CPFE3	BBSE3	TIMS3
	SULA11	KLBN11	KLBN11
	FLRY3	ENBR3	BBSE3
	KLBN11	VIVT3	EGIE3
	VIVT3	EGIE3	TAEE11
	TAEE11	TAEE11	
	ENBR3		
	BBSE3		
	EGIE3		