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# Pricing ESG factors in the brazilian market using Fama-French models

*Precificação de fatores ESG no mercado brasileiro utilizando modelos de Fama-French*

*Valoración de factores ESG en el mercado brasileño utilizando modelos Fama-French*

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# ABSTRACT

**Purpose:** To examine whether performance in the environmental, social, and governance (ESG) dimensions constitutes a meaningful risk factor in the stock-pricing process in the Brazilian market, using the Fama–French factor-model framework (1993, 2015). **Methodology/approach:** The study applies Fama and French's factor-model methodology (1993, 2015), adapted to the Brazilian context, incorporating a liquidity filter, outlier treatment, and factors constructed to be neutral with respect to firm size. Monthly portfolios of Brazilian companies listed on B3 were analyzed using Refinitiv data covering the period from September 2010 to February 2023. Estimations were carried out using Ordinary Least Squares (OLS), supported by GRS tests and White's robust standard errors. **Originality/relevance:** The research underscores the relevance and influence of non-financial information related to ESG performance on investment outcomes. **Main Findings:** Models that include green (ESG) risk factors provide a modest improvement in explaining the expected returns of stocks traded in the Brazilian market when compared to the three-and five-factor Fama–French models. This finding suggests that ESG performance constitutes information that is effectively priced by investors in Brazil. **Practical and managerial implications:** The contribution of this research lies in the potential implications of its findings for managerial decision-making. It also supports a more efficient allocation of market resources which, more broadly, may contribute to the development of society, the financial system, and the country.


**Keywords:** ESG. asset pricing. Fama–French factor models. risk factors. GRS test.


# RESUMO

**Objetivo**: Identificar se o desempenho relacionado às dimensões ambiental, social e governança (ESG) representa um fator de risco significativo no processo de precificação de ações no mercado brasileiro, por meio da abordagem dos modelos fatoriais de Fama-French. **Metodologia**: Utilizou-se a metodologia dos modelos fatoriais de Fama e French (1993, 2015), adaptada ao caso brasileiro, com filtro de liquidez, tratamento de *outliers* e fatores neutros ao efeito tamanho. Analisaram-se portfólios mensais de empresas brasileiras listadas na B3, utilizando dados da Refinitiv, para o período de setembro de 2010 a fevereiro de 2023. A estimação foi feita por Mínimos Quadrados Ordinários (MQO), com testes GRS e erros padrões robustos de White. **Originalidade/relevância**: A pesquisa lança luz sobre a relevância e o impacto que informações não financeiras relacionadas ao desempenho ESG têm sobre a performance dos investimentos. **Principais resultados**: Os modelos que incorporam os fatores de risco *green* (ESG) são capazes de fornecer (marginalmente) uma melhor representação dos retornos esperados das ações negociadas no mercado brasileiro, em comparação aos modelos de três e de cinco fatores de Fama-French, sinalizando que o desempenho ESG é uma informação precificada pelo investidor do mercado brasileiro. **Contribuições práticas e gerenciais**: A contribuição da pesquisa reside nos possíveis desdobramentos dos seus achados na tomada de decisões gerenciais, além de poder contribuir para que os recursos disponíveis no mercado sejam alocados de forma mais eficiente, o que, em uma perspectiva ampliada, pode contribuir pra o desenvolvimento da sociedade, do sistema financeiro e do país.


**Palavras-chave:** ESG. Precificação de ativos. Modelos fatoriais de Fama-French. Fatores de risco. Teste GRS.


# RESUMEM

**Objetivo:** Identificar si el desempeño relacionado con las dimensiones ESG representa un factor de riesgo significativo en el proceso de fijación de precios de acciones en el mercado brasileño, utilizando el enfoque del modelo factorial Fama-French. **Metodología:** Se utilizó la metodología de los modelos factoriales de Fama y French (1993, 2015), adaptada al caso brasileño, con filtro de liquidez, tratamiento de outliers (valores atípicos) y factores neutros al efecto tamaño. Se analizaron carteras mensuales de empresas brasileñas listadas en la B3, utilizando datos de Refinitiv, para el período de septiembre de 2010 a febrero de 2023. La estimación se realizó mediante Mínimos Cuadrados Ordinarios (MCO), con pruebas GRS y errores estándar robustos de White. **Originalidad/relevancia:** La investigación arroja luz sobre la relevancia y el impacto que la información no financiera relacionada con el desempeño ESG tiene en el desempeño de las inversiones. **Principales resultados:** Los modelos que incorporan factores ESG son capaces de proporcionar (marginalmente) una mejor representación de los rendimientos esperados de las acciones negociadas en el mercado brasileño, en comparación con los modelos Fama-French de tres y cinco factores, lo que indica que el desempeño ESG es información valorada por los inversores. **Aportes prácticos y de gestión:** El aporte de la investigación radica en las posibles consecuencias de sus hallazgos en la toma de decisiones gerenciales, además de poder contribuir que los recursos disponibles en el mercado sean asignados de manera más eficiente, lo que, en un una perspectiva más amplia puede contribuir al desarrollo de la sociedad, del sistema financiero y del país.


**Palabras clave:** ESG. Precios de activos. Modelos factoriales Fama-French. Factores de riesgo. Prueba GRS.

# INTRODUCTION

From the perspective of market efficiency (Fama, 1970) – that is, the notion that all relevant public information about a company is incorporated into its stock prices – the factors that determine the expected returns of an investment can be interpreted as the attributes investors deem relevant in their decision-making processes (Fama & French, 2015).

Within this framework of market efficiency and the evolution of asset-pricing models, these models have increasingly sought to identify potential risk factors to be incorporated into the pricing of financial assets. In this context, one potential risk factor that has gained particular prominence in recent years is corporate social responsibility (Gillan et al., 2021), captured by what has come to be known as the ESG movement ("Environmental, Social, and Governance").

Despite notable advances, the literature still lacks consensus on how the relationship between ESG performance and various measures of financial performance operates, including stock prices in capital markets (Friede et al., 2015; Atz et al., 2020; Jarjir et al., 2022).

The finance literature has expanded the empirical evidence addressing ESG performance as a relevant risk factor in stock pricing in the U.S. and European markets (Bofinger et al., 2022; Jarjir et al., 2022; Maiti, 2021). However, there remains a gap in the academic literature concerning the impact of ESG performance in the Brazilian market.

In this context, the objective of this study is to assess whether performance in the environmental, social, and governance (ESG) dimensions constitutes a significant risk factor in the stock-pricing process in the Brazilian market, using the Fama–French (FF) factor-model framework. To conduct this analysis, we adopt the methodology proposed by Fama and French (1993, 2015), in which an additional risk factor that replicates the performance of stocks with strong sustainability profiles – referred to generically in this study as the green factor – is incorporated into the authors' five-factor model.

Evidence suggests that ESG performance is a relevant risk factor in stock pricing in the U.S. and European markets. Nonetheless, a gap persists in the academic literature regarding the effects of ESG performance in the Brazilian context.

Therefore, identifying whether risk factors derived from ESG performance are able to explain expected stock returns is also an attempt to determine whether such information should be incorporated into managerial decision-making. In this regard, the proposal to include an ESG-related risk factor in pricing models that effectively capture existing patterns in expected asset returns contributes to a more efficient allocation of resources in capital markets, which, in turn, can strengthen the financial system and foster the country's economic development.

Following this introduction, Section 2 presents the theoretical framework. Section 3 describes the methodology, and Section 4 presents and discusses the results. Section 5 concludes the study.

# THEORETICAL FRAMEWORK

## The efficient market hypothesis (EMH) and asset-pricing models

The efficient market hypothesis (EMH) (Fama, 1970) posits that asset prices incorporate all available information and that investors allocate resources rationally, demanding higher returns for taking on higher levels of risk. In this sense, factors capable of explaining price behavior can be understood as measures of risk that are priced by the market (Fama & French, 1992).

Indeed, asset-pricing models have evolved from univariate formulations, such as the Capital Asset Pricing Model (CAPM) (Lintner, 1965; Mossin, 1966; Sharpe, 1964), to multivariate approaches grounded in Arbitrage Pricing Theory (APT) (Ross, 1976). A major milestone in this evolution was the introduction of Fama and French's three-factor model (1993) which added new dimensions of risk, later expanded upon in Carhart's four-factor model (1997) and Fama and French's five-factor model (2015).

In reassessing the CAPM, Fama and French (1993) incorporated two additional factors – firm size and the book-to-market ratio (B/M) – resulting in the three-factor model:

$$R_{it} - R_{ft} = a_i + b_i\left(R_{mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + \epsilon_{it} \quad (2)$$

In this model, *SMB* represents the factor that captures the risk associated with *firm size*, measured by the difference in returns between portfolios composed of small-capitalization firms and portfolios composed of large-capitalization firms. In turn, *HML* represents the factor that captures the risk associated with the *value* dimension, measured by the difference in returns between portfolios composed of companies with high versus low B/M ratios (book value divided by market price).

Prior research shows that *size* and *value* carry risk premiums, as strategies based on these characteristics yield returns above those expected under the CAPM (Fama & French, 1993, 1996). Even though the three-factor model provides a more robust explanation of expected stock returns than the CAPM, it has been criticized for failing to capture certain anomalies – particularly *momentum* (Carhart, 1997), *liquidity* (Pástor & Stambaugh, 2003), *profitability* (Novy-Marx, 2013), and *investment* (Aharoni et al., 2013).

Building on the evidence provided by Novy-Marx (2013) and Titman et al. (2004), Fama and French (2015) proposed the inclusion of two additional factors – profitability and investment – thereby resulting in the five-factor model:

$$R_{it} - R_{ft} = a_i + b_i\left(R_{mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + \epsilon_{it} \quad (3)$$

Where $RMW_t$ represents the return differential between diversified portfolios of firms with high profitability and firms with low profitability (robust minus weak), whereas $CMA_t$ represents the return differential between diversified portfolios of firms with low investment levels and firms with high investment levels (conservative minus aggressive).

In the specific context of this study, Pástor et al. (2021) incorporated variables related to ESG performance based on the understanding that firms differ in the sustainability characteristics of their activities. These differences in investor preferences are capable of influencing asset prices.

## Review of empirical literature

This subsection summarizes the findings of studies that have examined whether ESG performance is a relevant attribute for investment decisions. Lioui and Tarelli (2022), analyzing U.S. companies between 1992 and 2021, found evidence that firms with higher ESG ratings have outperformed those with lower ratings over the past three decades.

In the European market, Maiti (2021) incorporated ESG factors – both in aggregate and individually – into Fama and French's three-factor model (1993) and found that their inclusion significantly increases the model's explanatory power. Similarly, Jarjir et al. (2022) documented evidence of a risk premium associated with low ESG ratings in the European market between 2002 and 2015.

Ilhan et al. (2021) demonstrated that the risk associated with a firm's carbon emissions is incorporated into the pricing of its options, such that firms with higher emissions face greater risk and higher return volatility. Avramov et al. (2021) provided evidence that uncertainty surrounding ESG ratings may explain the heterogeneous findings of earlier studies on ESG portfolio performance, influencing investor demand and the risk–return relationship, among other implications.

Quirós et al. (2019) found that Exchange-Traded Funds (ETFs) composed of socially responsible firms can generate higher risk-adjusted returns relative to the market, particularly in funds emphasizing ESG dimensions related to working conditions, economic growth, industry, innovation, and infrastructure.

With respect to investment funds, Durán-Santomil et al. (2019) showed that U.S. and European funds classified as highly sustainable attract positive net inflows, whereas funds classified as less sustainable experience net outflows.

By contrast, some studies find no meaningful relationship between sustainable corporate practices and accounting or market metrics (Pereira et al., 2019), while meta-analytic reviews suggest that superior financial performance associated with ESG strategies is less evident than often assumed in the specialized literature (Atz et al., 2020).

Indeed, in the Brazilian context, Schleich (2021) found evidence of a possible negative relationship between ESG performance and market outcomes. Henriques et al. (2021) examining portfolios constructed according to ESG criteria and composed of equities traded on B3 (Brazil's stock exchange), found that long–short strategies – buying high-rated firms and selling low-rated firms – do not generate abnormal returns for any ESG dimension.

In summary, studies investigating the impact of ESG performance on investment decisions produce contradictory results, suggesting that the evidence remains inconclusive. This variability may stem from differences in how ESG performance is measured and disclosed, the specific ESG dimension analyzed (environmental, social, or governance), sectoral characteristics, and market-level legal or institutional factors.

# METHODS

## Sample and analysis period

The units of analysis consist of portfolios composed of Brazilian publicly traded companies with shares listed on B3 between September 2010 and February 2023, including firms that delisted during the period to minimize potential survival-bias issues. To construct the portfolios, we used accounting and market data for the shares from December 2009 to December 2021 – a period during which the number of companies listed on B3 and evaluated under ESG criteria increased substantially.

Two samples were extracted from the universe of stocks traded during the period. The first sample was used to construct Fama and French's five risk factors (2015), following these selection criteria: availability of information on (1) monthly stock returns for at least one month following portfolio formation, adjusted for dividends; (2) market capitalization as of December 31 of the year preceding portfolio formation; (3) positive book value of shareholders' equity as of that same date; (4) book value of total assets on December 31 of the two years preceding portfolio formation; (5) accounting operating profit on December 31 of the year preceding portfolio formation; and (6) average daily trading volume greater than R$ 100,000 in the year preceding portfolio formation.

The second sample was used to construct the four green risk factors. In addition to meeting the criteria listed above, each share was required to have a performance rating for the following attributes: aggregate ESG performance, Environmental (ENV), Social (SOC), and Governance (GOV). The final selection comprised 312 stocks in the first sample and 148 stocks in the second.

It is important to note that financial-sector firms were not excluded, as their omission did not materially alter the results (not reported). For firms with more than one class of shares, the class with the highest liquidity was selected. Accounting data, market data, and ESG scores were obtained from the Refinitiv platform or the B3 website. Data processing and analysis were conducted using R software.

## Treatment of asset return rates

The discrete returns of the test portfolios and risk portfolios were calculated on a monthly basis, following Fama and French (1993, 2015), as this procedure enables the exact computation of portfolio return rates (Tsay, 2010, p. 5).

$$R_{it} = \dot{R}_{it} - R_{ft} \quad (4)$$

$$R_{pt} = \sum_{i=1}^{n} \frac{F_{it}}{F_{pt}} (R_{it}) \quad (5)$$

where $R_{it}$ is the excess return of stock *i* in period *t*; $R^{*}_{it}$ is the raw return of stock *i* in period *t*; $R_{ft}$ is the risk-free rate; $R_{pt}$ is the excess return of portfolio *p* in period *t*; $F_{it}$ is the weighting factor of stock *i* in period *t* and $F_{pt}$ is the sum of the weighting factors for portfolio *p* in period *t*. The Interbank Deposit Certificate (CDI) was adopted as the proxy for the risk-free rate, consistent with the approach used by Maciel et al. (2021).

Because factor models are sensitive to extreme observations in the Brazilian market, the stock-return series were winsorized at the 1% level in order to reduce the influence of outliers on the estimation of model coefficients.

## Independent variables – risk factors

The independent variables, or right-hand-side (RHS) factors – constructed as portfolios that replicate the performance obtained by investing in stocks with a specific characteristic of interest – are divided into two groups: (1) the five risk factors from (2015), which serve as control variables in the models; and (2) four green factors, developed using the ESG, ENV, SOC, and GOV scores assigned to each stock. The construction of these risk factors follows the methodology of Fama and French (1993, 2015), incorporating the adaptations to the Brazilian context implemented by Maciel et al. (2021), as detailed below.

**Table 1**

*Definition and operationalization of underlying variables*

| Variable | Formula | |
|---|---|---|
| Size (market value) | $MV_{it} = PS_{it} \times NS_{it}$ | (6) |
| Book-to-market ratio (B/M) | $\frac{B}{M_{it}} = \frac{SE_{i,dez(t-1)}}{MV_{i,dez(t-1)}}$ | (7) |
| Profitability | $PROF_{it} = \frac{OP_{i,dez(t-1)}}{NP_{i,dez(t-1)}}$ | (8) |
| Investment | $INV_{it} = \frac{(TA_{i,dez(t-1)} - TA_{i,dez(t-2)})}{AT_{i,dez(t-1)}}$ | (9) |

**Note:** $MV_{it}$: market value of share *i* in period *t*; $PS_{it}$: price of share *i* in period *t*; $NS_{it}$: number of shares outstanding for firm *i* in period *t*; B/ $MV_{it}$: book-to-market ratio of share *i* in period *t*; $SE_{i,dez(t-1)}$: shareholders' equity of firm *i* on December 31 of year *t* – 1; $MV_{i,dez(t-1)}$: market value of firm *i* on December 31 of year *t* – 1; $PROF_{it}$: profitability percentage of firm *i* in period *t*; $OP_{i,dez(t-1)}$: operating profit of firm *i* on December 31 of year *t* – 1; $NP_{i,dez(t-1)}$: net profit of firm *i* on December 31 of year *t* – 1; $INV_{it}$: investment percentage of firm *i* in period *t*; $TA_{i,dez(t-1)}$: total assets *i* on December 31 of year *t* – 1; $TA_{i,dez(t-2)}$: total assets *i* on December 31 of year *t* – 2, where t is the portfolio-formation year.

**Source:** Adapted from Fama and French (2015) and Maciel et al. (2021).

Annually, at the beginning of June between 2010 and 2022, the sample of 312 stocks was ranked in ascending order according to size, B/M ratio, profitability, and investment, as of December 31 of the preceding year. The requirement of a five-month interval between the accounting/market information date and portfolio formation serves to avoid anticipation bias and is widely used in the literature (Hou et al., 2020).

After sorting the stocks, they were divided into two groups for each attribute – firm size (market capitalization), book-to-market ratio (B/M), profitability, and investment. The median value of each variable in the period was used as the dividing threshold. Accordingly, the following portfolios were formed for analysis: low market value (small – S) and high market value (big – B); low (L) and high (H) for the B/M ratio; weak (W) and robust (R) for profitability; and conservative (C) and aggressive (A) for investment.

The five risk factors were constructed using the variables in Table 1, following the procedures summarized in Table 2. This methodology is consistent with that used by Fama and French (2015) for constructing their 2×2 factors. Each portfolio's return is computed monthly using the excess returns of its component stocks – i.e., returns net of CDI – weighted by each stock's market capitalization. The HML, RMW, and CMA factors are constructed to be partially neutral to firm size, as shown in Table 2.

**Table 2**

*Operationalization of Fama and French (2015) risk factors*

| Risk Factor | Formula | | |
|---|---|---|---|
| MKT (10): Market | $MKT = R_{MKT,t} - R_{CDI,t}$ (10) | | |
| SMB (11): Small minus Big (SMB) | $SMB = \overline{R}_S - \overline{R}_B$ (11) | $\overline{R}_S = \frac{\begin{pmatrix} SL_t + SH_t + \\ SW_t + SR_t + \\ SC_t + SA_t \end{pmatrix}}{6}$ (11.1) | $\overline{R}_B = \frac{\begin{pmatrix} BL_t + BH_t + \\ BW_t + BR_t + \\ BC_t + BA_t \end{pmatrix}}{6}$ (11.2) |
| HML (12): High minus Low (HML) | $HML = \overline{R}_H - \overline{R}_L$ (12) | $\overline{R}_H = \frac{SH_t + BH_t}{2}$ (12.1) | $\overline{R}_L = \frac{SL_t + BL_t}{2}$ (12.2) |
| RMW (13): Robust minus Weak (RMW) | $RMW = \overline{R}_R - \overline{R}_W$ (13) | $\overline{R}_R = \frac{SR_t + BR_t}{2}$ (13.1) | $\overline{R}_W = \frac{SW_t + BW_t}{2}$ (13.2) |
| CMA (14): Conservative minus Aggressive (CMA) | $CMA = \overline{R}_C - \overline{R}_A$ (14) | $\overline{R}_C = \frac{SC_t + BC_t}{2}$ (14.1) | $\overline{R}_A = \frac{SA_t + BA_t}{2}$ (14.2) |

**Note:** $R_{MKT,t}$ = market return of the stocks; $R_{CDI,t}$ = monthly CDI rate of return; $SL_t$, $SH_t$, $SW_t$, $SR_t$, $SC_t$ and $SA_t$ = returns of the six portfolios formed by intersecting small-capitalization stocks with the two breakpoints (low and high) for the book-to-market ratio, profitability, and investment, respectively; $BL_t$, $BH_t$, $BW_t$, $BR_t$, $BC_t$ and $BA_t$ = returns of the six portfolios formed by intersecting big-capitalization stocks with the same two percentile breakpoints for the book-to-market ratio, profitability, and investment, respectively; $SH_t$ and $BH_t$ = returns of the portfolios composed of small-capitalization/high book-to-market stocks and big-capitalization/high book-to-market stocks, respectively; $SL_t$ and $BL_t$ = returns of the portfolios composed of small-capitalization/low book-to-market stocks and big-capitalization/low book-to-market stocks, respectively; $SR_t$ and $BR_t$ = returns of the portfolios composed of small-capitalization/high-profitability stocks and big-capitalization/high-profitability stocks, respectively; $SC_t$ and $BC_t$ = returns of the portfolios composed of small-capitalization/low-profitability stocks and big-capitalization/low-profitability stocks, respectively; $SA_t$ and $BA_t$ = returns of the portfolios composed of small-capitalization/low-investment stocks and big-capitalization/low-investment stocks, respectively; and = returns of the portfolios composed of small-capitalization/high-investment stocks and big-capitalization/high-investment stocks, respectively. All referring to period *t*.

**Source:** Adapted from Fama and French (2015).

The SMB factor is partially neutral with respect to the three characteristics mentioned above. This approach seeks to remove, as far as possible, the influence of other firm attributes that may distort the interpretation of a given risk factor. In this study, these five factors serve as control variables in the econometric models.

The four green risk factors were constructed using the sample of 148 stocks. The goal was to replicate the performance of an investment strategy that takes long (buy) positions in companies with strong evaluations in the ENV, SOC, GOV, and aggregate ESG dimensions, and short (sell) positions in companies that receive weak evaluations in those same dimensions. The assessments of each stock in the four dimensions were produced by Refinitiv, which assigns scores ranging from 0 to 100 based on predefined methodological criteria established by the platform. The score assigned to each company was then used to determine its allocation into the respective portfolios. The returns on these portfolios were calculated according to Equation 5.

**Table 3**

*Definition of underlying green variables*

| Variable | Description |
| --- | --- |
| ESG Score: Aggregate | Assessment of the company's overall performance across the environmental, social, and governance dimensions. Computed based on results in the ten subcategories that make up the three individual dimensions. |
| ENV Score: Environmental | Assessment of the company's performance in the environmental dimension. computed based on the *emissions, resource use*, and *innovation* subcategories. |
| SOC Score: Social | Assessment of the company's performance in the social dimension. Computed based on the *community, human rights, product responsibility*, and *workforce* subcategories. |
| GOV Score: Governance | Assessment of the company's performance in the governance dimension. Computed based on the *shareholders, CSR strategy*, and *management* subcategories. |

**Source:** Adapted from Refinitiv (2022).

Because the number of companies evaluated on ESG-related attributes is limited, this study imputes each firm's average score from the years in which it was evaluated to the years for which no evaluation is available, whether earlier or later. This imputation increases the number of stocks included in each portfolio, thereby improving diversification and reducing the influence of firm-specific characteristics on portfolio performance.

The green portfolios, or green risk factors – derived from the underlying variables in Table 3 – are constructed based on the return differential between specific portfolios, following the steps detailed in Table 4 and the methodology proposed by Fama and French (2015).

**Table 4**

*Operationalization of ESG risk factors*

| Fator de Risco | Fórmula | | |
|---|---|---|---|
| ESG (15): Fator *high minus low* ESG | $ESG = \overline{R}_{HESG} - \overline{R}_{LESG}$ (15) | $\overline{R}_{HESG} = \frac{SH_{ESG,t} + BH_{ESG,t}}{2}$ (15.1) | $\overline{R}_{LESG} = \frac{SL_{ESG,t} + BL_{ESG,t}}{2}$ (15.2) |
| ENV (16): Fator *high minus low* ENV | $ENV = \overline{R}_{HENV} - \overline{R}_{LENV}$ (16) | $\overline{R}_{HENV} = \frac{SH_{ENV,t} + BH_{ENV,t}}{2}$ (16.1) | $\overline{R}_{LENV} = \frac{SL_{ENV,t} + BL_{ENV,t}}{2}$ (16.2) |
| SOC (17): Fator *high minus low* SOC | $SOC = \overline{R}_{HSOC} - \overline{R}_{LSOC}$ (17) | $\overline{R}_{HSOC} = \frac{SH_{SOC,t} + BH_{SOC,t}}{2}$ (17.1) | $\overline{R}_{LSOC} = \frac{SL_{SOC,t} + BL_{SOC,t}}{2}$ (17.2) |
| GOV (18): Fator *high minus low* GOV | $GOV = \overline{R}_{HGOV} - \overline{R}_{LGOV}$ (18) | $\overline{R}_{HGOV} = \frac{SH_{GOV,t} + BH_{GOV,t}}{2}$ (18.1) | $\overline{R}_{LGOV} = \frac{SL_{GOV,t} + BL_{GOV,t}}{2}$ (18.2) |

**Note:** $\overline{R}_{HESG}$ = average return of the portfolios composed of small-cap stocks with high ESG ratings and big-cap stocks with high ESG ratings, weighted by the ESG score; $\overline{R}_{LESG}$ = average return of the portfolios composed of small-cap stocks with low ESG ratings and big-cap stocks with low ESG ratings, weighted by the ESG score. $\overline{R}_{HENV}$ = average return of the portfolios composed of small-cap stocks with high ENV ratings and big-cap stocks with high ENV ratings, weighted by the ENV score; $\overline{R}_{LENV}$ = average return of the portfolios composed of small-cap stocks with low ENV ratings and big-cap stocks with low ENV ratings, weighted by the ENV score; $\overline{R}_{HSOC}$ = average return of the portfolios composed of small-cap stocks with high SOC ratings and big-cap stocks with high SOC ratings, weighted by the SOC score; $\overline{R}_{LSOC}$ = average return of the portfolios composed of small-cap stocks with low SOC ratings and big-cap stocks with low SOC ratings, weighted by the SOC score; $\overline{R}_{HGOV}$ = average return of the portfolios composed of small-cap stocks with high GOV ratings and big-cap stocks with high GOV ratings, weighted by the GOV score; $\overline{R}_{LGOV}$ = average return of the portfolios composed of small-cap stocks with low GOV ratings and big-cap stocks with low GOV ratings, weighted by the GOV score.

**Source:** Prepared by the authors.

Lioui and Tarelli (2022) and Maiti (2021) use a comparable approach to construct green factors for the North American and European markets. However, in this study, the returns of individual stocks are weighted by the company's score in the attribute used to form each portfolio, following the criteria adopted by Pástor et al. (2021). This procedure is particularly advantageous in markets with a relatively small number of publicly traded companies, such as Brazil.

The ESG risk factor replicates the performance of a long (buy) strategy in stocks with high ESG scores and a short (sell) strategy in stocks with low scores. Likewise, the ENV, SOC, and GOV risk factors replicate long–short strategies based on high and low scores in the environmental, social, and governance dimensions, respectively. It is important to emphasize that the ESG, ENV, SOC, and GOV factors are all constructed to be partially neutral with respect to firm size.

## Dependent variables – test portfolios

To form the test portfolios, stocks were first allocated into three portfolios based on firm size. These same stocks were then independently allocated into three additional portfolios based on a second classification attribute (B/M ratio, profitability, investment, ESG, ENV, SOC, or GOV). This procedure produced nine portfolios (3 × 3) for each pair of variables. Given the limited number of stocks in the Brazilian market, portfolio formation followed the same logic described earlier, with the distinction that test portfolios use a 3 × 3 classification, whereas the risk factors are constructed using a 2 × 2 allocation.

### Econometric models

To evaluate the importance of ESG factors and the effectiveness of the pricing models, the following specifications were estimated:

$$R_{pt} = a_p + b_p MKT_t + s_p SMB_t + h_p HML_t + \varepsilon_{pt} \quad (19)$$

$$R_{pt} = a_p + b_p MKT_t + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + \varepsilon_{pt} \quad (19.1)$$

$$R_{pt} = a_p + b_p MKT_t + s_p SMB_t + h_p HML_t + g_p GREEN + \varepsilon_{pt} \quad (19.2)$$

$$R_p t = a_p + b_p MKT_t + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + g_p GREEN + \varepsilon_{pt} \quad (19.3)$$

Where, $a_p$ is the intercept for test portfolio *p*; $b_p$, $s_p$, $h_p$, $r_p$, $c_p$ and $g_p$ are the exposure coefficients to the MKT, SMB, HML, RMW, CMA, and GREEN risk factors, respectively, for the test portfolio *p* and $\varepsilon_{pt}$ is the model's error term. Equations (19) and (19.1) represent the three- and five-factor Fama–French models, whereas Equations (19.2) and (19.3) include the green factor in the benchmark specifications.

If the parameters of the equations represent true values rather than estimates, and if the coefficients $b_p$, $s_p$, $h_p$, $r_p$, $c_p$ and $g_p$ capture all variation in expected returns, then the intercept  should be equal to zero for all test portfolios (Fama & French, 2015).

Following Fama and French (2020), ordinary least squares (OLS) was employed to estimate the coefficients, as the models generally satisfy the assumptions of this method. To adopt a conservative inference strategy, we use  based on robust standard errors  (1980), which address heteroscedasticity and autocorrelation in the residuals.

The GRS test proposed by Gibbons, Ross and Shanken (1989) was applied to assess whether the intercepts in each model are jointly equal to zero, which would indicate that the model provides an adequate representation of expected returns on financial assets. This test is particularly informative when evaluating models that incorporate additional risk factors – such as the green factors – into the standard Fama–French three- or five-factor frameworks.

## RESULTS AND DISCUSSION

### Descriptive statistics

As shown in Table 5, all portfolios exhibit positive arithmetic mean returns, with the exception of the RMW and GOV portfolios. The highest Sharpe ratios are observed for the CMA, HML, and ESG portfolios (0.20, 0.11, and 0.10, respectively).

One noteworthy point is the higher return variability of the market portfolio (MKT) compared to the other factors. Although this may seem inconsistent with the assumptions of Modern Portfolio Theory, it is explained by the substantial number of small-cap stocks traded on B3, whose performance naturally reflects the size effect.

**Table 5**

*Descriptive statistics of risk portfolios*

| Factor | N | Mean | Min | Max | Median | IQR | SD | SR | t |
|---|---|---|---|---|---|---|---|---|---|
| *MKT* | 149 | 0,16 | –28,96 | 15,56 | 0,14 | 6,98 | 5,86 | 0,03 | 0,33 |
| *SMB* | 149 | 0,32 | –12,11 | 8,48 | 0,50 | 4,15 | 3,52 | 0,09 | 1,12 |
| *HML* | 149 | 0,41 | –9,29 | 13,72 | 0,55 | 4,60 | 3,91 | 0,11 | 1,28 |
| *RMW* | 149 | –0,04 | –9,97 | 8,43 | –0,04 | 3,85 | 2,98 | –0,01 | –0,18 |
| *CMA* | 149 | 0,52 | –7,35 | 7,27 | 0,35 | 3,09 | 2,57 | 0,20 | 2,48 |
| *ESG* | 149 | 0,21 | –5,07 | 7,25 | 0,20 | 2,98 | 2,11 | 0,10 | 1,20 |
| *ENV* | 149 | 0,18 | –6,72 | 7,32 | –0,15 | 3,04 | 2,44 | 0,07 | 0,88 |
| *SOC* | 149 | 0,18 | –5,84 | 7,14 | 0,21 | 2,68 | 2,03 | 0,09 | 1,10 |
| *GOV* | 149 | –0,10 | –7,14 | 4,90 | –0,16 | 2,58 | 2,02 | –0,05 | –0,58 |

**Note:** IQR, SD, SR, and t refer to the interquartile range, standard deviation, Sharpe Ratio, and t-statistic, respectively.

**Source:** Prepared by the authors.

This pattern does not appear in the other portfolios because they were intentionally designed to be partially neutral with respect to size. It is also important to note that winsorizing MKT returns had no meaningful effect; thus, this procedure was not applied to the market portfolio.

Variance Inflation Factors (VIFs) were subsequently computed for the six-factor models. The values (not reported) ranged from 1.06 to 2.24, indicating no evidence of multicollinearity.

Next, the FF risk factors were regressed on the green factors (results not reported). The adjusted $R^2$ values were low – ranging from 0.02 to 0.13 – showing that the FF factors explain little of the variation in the green factors. For the ESG and SOC portfolios, the SMB coefficient was negative and statistically significant, indicating that firms with stronger ESG and social practices tend to exhibit return patterns similar to large firms.

For the ENV portfolio, none of the FF factors were statistically significant. For the GOV portfolio, the HML coefficient was positive and significant at the 5% level, suggesting that firms with stronger governance profiles display return patterns associated with high B/M stocks. Even with low adjusted R2 values, the intercepts of all regressions were statistically indistinguishable from zero, indicating that the FF factors adequately capture any linear component present in the green factors.

Regarding the GRS test (results not reported), the model that includes a green factor provides a more efficient representation of expected returns than the FF three-factor model for most portfolios examined. Compared with the three-factor model, the four green factors appear to improve overall model fit, yielding average and maximum reductions in the GRS statistic of 4.12% and 12.50%, respectively. However, when added to the five-factor model, the green factors do not yield as clear or consistent an improvement; the average and maximum reductions in the GRS statistic in this case are 0.17% and 13.22%, respectively.

When analyzed separately, the ESG factor is the one that contributes most to enhancing model efficiency. The ENV, SOC, and GOV factors each strengthen the three-factor model but appear to add little incremental explanatory power to the five-factor model.

These findings are consistent with the evidence reported by Maiti (2021) for the European market, suggesting that ESG performance – for the European market, suggesting that ESG performance – whether considered in aggregate form or disaggregated into its environmental, social, and governance dimensions – functions as a priced risk factor in the Brazilian stock market. As Cornell (2021) notes, incorporating ESG information into investment decisions tends to reflect investor preferences for firms with stronger ESG profiles and may also serve as a hedge against climate-related shocks or regulatory uncertainty.

## Regressions of the five-and six-factor models

### Regressions for the nine size × B/M portfolios

Table 6 shows that the FF five-factor model produces intercepts statistically indistinguishable from zero for all nine regressions, with adjusted $R^2$ values ranging from 71% to 89%. The largest intercepts occur in the small-cap portfolio with a medium B/M ratio ($t$ = 1.45) and the large-cap portfolio with a high B/M ratio ($t$ = 1.24).

Adding the ESG factor slightly reduces the intercepts in six of the nine regressions. In all cases, the intercepts remain statistically equal to zero. The ESG coefficient is positive and statistically significant only in the portfolio composed of large-cap firms with a high B/M ratio ($t$ = 2.14).

Adding the SOC factor does not meaningfully reduce the intercepts, with improvements observed in only four of the nine regressions. As for the factor's coefficient, it is statistically significant for the medium-cap, high-B/M portfolio ($t$ = 3.67)

Finally, adding the GOV factor leads to small reductions in intercept estimates for six of the nine regressions. The GOV coefficient is statistically significant for the small-cap, low-B/M portfolio ($t$ = –3.25) and the medium-cap, high-B/M portfolio ($t$ = –2.01).

### Table 6

*Regressions for the nine size × B/M portfolios*

| B/M → | $B/M_1$ | $B/M_2$ | $B/M_3$ | $B/M_1$ | $B/M_2$ | $B/M_3$ | $B/M_1$ | $B/M_2$ | $B/M_3$ |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A:** | $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + \varepsilon_{pt}$ | | | | | | | | |
| | | *a* | | | *t(a)* | | | *$R^2$adj* | |
| *Small* | −0,10 | 0,39 | 0,10 | −0,28 | 1,45 | 0,40 | 0,71 | 0,84 | 0,87 |
| *Mid* | −0,07 | −0,07 | 0,01 | −0,30 | −0,35 | 0,03 | 0,81 | 0,89 | 0,80 |
| *Big* | −0,02 | −0,01 | 0,34 | −0,14 | −0,07 | 1,24 | 0,81 | 0,88 | 0,89 |
| **Panel B:** | $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + esg_pESG + \varepsilon_{pt}$ | | | | | | | | |
| | | *a* | | | *t(a)* | | | *$R^2$adj* | |
| *Small* | −0,08 | 0,45 | 0,09 | −0,24 | 1,67 | 0,37 | 0,71 | 0,84 | 0,87 |
| *Mid* | −0,06 | −0,07 | −0,03 | −0,26 | −0,38 | −0,10 | 0,81 | 0,88 | 0,80 |
| *Big* | −0,01 | 0,01 | 0,25 | −0,05 | 0,05 | 0,95 | 0,81 | 0,88 | 0,90 |
| | | *esg* | | | *t(esg)* | | | | |
| *Small* | −0,07 | −0,25 | 0,03 | −0,32 | −1,93 | 0,25 | | | |
| *Mid* | −0,04 | 0,02 | 0,13 | −0,28 | 0,26 | 1,01 | | | |
| *Big* | −0,06 | −0,08 | 0,35 | −0,60 | −0,62 | 2,14* | | | |
| **Panel C:** | $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + env_pENV + \varepsilon_{pt}$ | | | | | | | | |
| | | *a* | | | *t(a)* | | | *$R^2$adj* | |
| *Small* | −0,08 | 0,42 | 0,09 | −0,24 | 1,60 | 0,39 | 0,71 | 0,84 | 0,87 |
| *Mid* | −0,02 | −0,06 | 0,00 | −0,07 | −0,32 | 0,01 | 0,82 | 0,88 | 0,80 |
| *Big* | −0,02 | −0,02 | 0,33 | −0,09 | −0,12 | 1,19 | 0,81 | 0,88 | 0,89 |
| | | *env* | | | *t(env)* | | | | |
| *Small* | −0,08 | −0,19 | 0,01 | −0,43 | −1,62 | 0,13 | | | |
| *Mid* | −0,27 | −0,04 | 0,02 | −2,69 * | −0,44 | 0,18 | | | |
| *Big* | −0,04 | 0,05 | 0,05 | −0,52 | 0,47 | 0,35 | | | |
| **Panel D:** | $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + soc_pSOC + \varepsilon_{pt}$ | | | | | | | | |
| | | *a* | | | *t(a)* | | | *$R^2$adj* | |
| *Small* | −0,08 | 0,40 | 0,12 | −0,22 | 1,49 | 0,51 | 0,71 | 0,83 | 0,87 |
| *Mid* | −0,09 | −0,07 | −0,06 | −0,41 | −0,37 | −0,23 | 0,82 | 0,88 | 0,82 |
| *Big* | −0,02 | −0,01 | 0,31 | −0,09 | −0,04 | 1,12 | 0,81 | 0,88 | 0,90 |
| | | *soc* | | | *t(soc)* | | | | |
| *Small* | −0,16 | −0,09 | −0,19 | −0,28 | 1,45 | 0,40 | | | |
| *Mid* | 0,18 | 0,02 | 0,49 | −0,30 | −0,35 | 0,03 | | | |
| *Big* | −0,06 | −0,04 | 0,25 | −0,14 | −0,07 | 1,24 | | | |
| **Panel E:** | $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + gov_pGOV + \varepsilon_{pt}$ | | | | | | | | |
| | | *a* | | | *t(a)* | | | *$R^2$adj* | |
| *Small* | −0,14 | 0,39 | 0,08 | −0,41 | 1,46 | 0,35 | 0,72 | 0,83 | 0,87 |
| *Mid* | −0,06 | −0,06 | −0,01 | −0,27 | −0,33 | −0,04 | 0,81 | 0,88 | 0,81 |
| *Big* | −0,02 | −0,01 | 0,33 | −0,10 | −0,06 | 1,20 | 0,81 | 0,88 | 0,89 |
| | | *gov* | | | *t(gov)* | | | | |
| *Small* | −0,53 | −0,01 | −0,19 | −3,25 *** | −0,06 | −1,21 | | | |
| *Mid* | 0,08 | 0,05 | −0,25 | 0,74 | 0,52 | −2,01 * | | | |
| *Big* | 0,09 | 0,01 | −0,13 | 0,89 | 0,08 | −0,79 | | | |

**Nota:** ***; **; * indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively. Regressions estimated using models 19.1 and 19.3 to explain the returns of nine test portfolios formed by Size × B/M. September 2010 to February 2023 (149 months). t-statistics based on Huber–White robust standard errors.

**Source:** Prepared by the authors.

### Regressions for the nine size × profitability portfolios

Table 7 shows that the FF five-factor model produces intercepts statistically indistinguishable from zero in seven of the nine regressions, with adjusted $R^2$ values between 72% and 94%. The only exceptions are the small- and mid-cap portfolios with intermediate profitability ($PROF_2$) whose intercepts deviate from zero ($t$ = 2.86 and $t$ = 2.03, respectively).

There is no evidence that adding the ESG factor materially reduces the nonzero intercepts obtained under the five-factor model. The ESG coefficient is positive and statistically significant only in the large-cap portfolio with intermediate profitability ($t$ = 2.11).

Relative to the five-factor model, incorporating the ENV factor reduces intercept magnitudes in six of the nine regressions and yields intercepts statistically equal to zero in seven of the nine portfolios. The ENV coefficient is significant in the small-cap, high-profitability portfolio ($t$ = –2.85) and in the mid-cap, intermediate-profitability portfolio ($t$ = –2.18).

By contrast, adding the SOC or GOV factors does not meaningfully improve model performance: the intercepts remain essentially unchanged relative to the five-factor specification. Although the SOC and GOV coefficients are statistically significant in several portfolios, the inclusion of these factors does not translate into a more efficient model overall. These findings are consistent with the GRS test results discussed earlier.

**Table 7**

*Regressions for the nine size × profitability portfolios*

| PROF → | $PROF_1$ | $PROF_2$ | $PROF_3$ | $PROF_1$ | $PROF_2$ | $PROF_3$ | $PROF_1$ | $PROF_2$ | $PROF_3$ |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A:** | $R_{pt} = a_p + b_p\left(R_{mt} - R_{ft}\right) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | −0,33 | 0,78 | −0,15 | −1,13 | 2,86 *** | −0,49 | 0,83 | 0,83 | 0,72 |
| *Mid* | −0,13 | 0,35 | −0,34 | −0,51 | 2,03 * | −1,91 | 0,84 | 0,89 | 0,85 |
| *Big* | −0,32 | 0,21 | 0,02 | −1,00 | 0,91 | 0,15 | 0,77 | 0,82 | 0,94 |
| **Panel B:** | $R_{pt} = a_p + b_p\left(R_{mt} - R_{ft}\right) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + esg_pESG + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | −0,32 | 0,81 | −0,10 | −1,12 | 2,96 *** | −0,32 | 0,82 | 0,83 | 0,72 |
| *Mid* | −0,14 | 0,36 | −0,37 | −0,54 | 2,12 * | −2,00 * | 0,84 | 0,88 | 0,85 |
| *Big* | −0,28 | 0,15 | 0,03 | −0,86 | 0,62 | 0,24 | 0,77 | 0,82 | 0,94 |
| *Small* | −0,02 | −0,12 | −0,20 | −0,11 | −0,97 | −1,15 | | | |
| *Mid* | 0,03 | −0,04 | 0,12 | 0,27 | −0,35 | 1,18 | | | |
| *Big* | −0,18 | 0,26 | −0,04 | −1,00 | 2,11 * | −0,62 | | | |
| **Panel C:** | $R_{pt} = a_p + b_p\left(R_{mt} - R_{ft}\right) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + env_pENV + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | −0,34 | 0,79 | −0,07 | −1,18 | 2,92 *** | −0,25 | 0,82 | 0,83 | 0,74 |
| *Mid* | −0,11 | 0,38 | −0,35 | −0,41 | 2,28 * | −1,88 | 0,84 | 0,89 | 0,84 |
| *Big* | −0,29 | 0,19 | 0,00 | −0,90 | 0,80 | 0,02 | 0,77 | 0,82 | 0,94 |
| *Small* | 0,09 | −0,08 | −0,40 | 0,72 | −0,70 | −2,85 *** | | | |
| *Mid* | −0,15 | −0,17 | 0,02 | −1,41 | −2,18 * | 0,22 | | | |
| *Big* | −0,17 | 0,11 | 0,08 | −0,99 | 1,03 | 1,62 | | | |
| **Panel D:** | $R_{pt} = a_p + b_p\left(R_{mt} - R_{ft}\right) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + soc_pSOC + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | −0,28 | 0,78 | −0,15 | −1,00 | 2,90 *** | −0,50 | 0,83 | 0,83 | 0,72 |
| *Mid* | −0,16 | 0,32 | −0,37 | −0,60 | 1,89 | −2,04 * | 0,84 | 0,89 | 0,85 |
| *Big* | −0,28 | 0,21 | 0,01 | −0,87 | 0,89 | 0,11 | 0,78 | 0,82 | 0,94 |
| *Small* | −0,31 | −0,05 | 0,03 | −2,39 * | −0,39 | 0,20 | | | |
| *Mid* | 0,16 | 0,21 | 0,19 | 1,31 | 2,57 ** | 2,09 * | | | |
| *Big* | −0,31 | 0,04 | 0,03 | −2,00 * | 0,38 | 0,57 | | | |
| **Panel E:** | $R_{pt} = a_p + b_p\left(R_{mt} - R_{ft}\right) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + gov_pGOV + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | −0,34 | 0,77 | −0,17 | −1,18 | 2,84 ** | −0,58 | 0,83 | 0,83 | 0,73 |
| *Mid* | −0,14 | 0,34 | −0,32 | −0,51 | 1,95 * | −1,86 | 0,84 | 0,89 | 0,85 |
| *Big* | −0,33 | 0,21 | 0,02 | −1,03 | 0,90 | 0,23 | 0,77 | 0,82 | 0,94 |
| *Small* | −0,20 | −0,07 | −0,33 | −1,35 | −0,50 | −2,26 * | | | |
| *Mid* | −0,03 | −0,15 | 0,24 | −0,23 | −1,42 | 2,72 ** | | | |
| *Big* | −0,16 | −0,05 | 0,12 | −0,92 | −0,50 | 1,89 | | | |

**Nota:** ***; **; * indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively. Regressions estimated using models 19.1 and 19.3 to explain the returns of nine test portfolios formed by Size × B/M. September 2010 to February 2023 (149 months). t-statistics based on Huber–White robust standard errors.

**Source:** Prepared by the authors.

### Regressions for the nine size × investment portfolios

Initially, it was observed that the FF five-factor model adequately explained the returns of the test portfolios in eight of the nine cases analyzed. The only exception was the portfolio composed of big firms with low investment ($t$ = 2.21). Adjusted $R^2$ values range from 78% to 93%.

When the ESG factor is added, the intercept of this specific portfolio is no longer statistically significant ($t$ = 1.78) suggesting that ESG may capture part of the unexplained variation in this segment of the market. Indeed, the impact of including ESG is most notable among large-cap portfolios. The ESG coefficient is also economically meaningful and highly significant in the large-cap ($INV_1$) low-investment portfolio ($t$ = 4.46).

In contrast, adding the ENV, SOC, or GOV factors does not eliminate the nonzero intercept for this portfolio. Although some of these factors show significance in isolated cases – particularly ENV (t = 3.48) and SOC (t = 2.85) for large-cap, low-investment stocks – there is no consistent pattern suggesting that any of them reliably generate a return premium in the period analyzed. Notably, the ENV and SOC factors exhibit statistically significant coefficients in the portfolio of big firms with low investment ($t$ = 3.48 and $t$ = 2.85, respectively).

### Table 8

*Regressions for the nine size × investment portfolios*

| INV → | $INV_1$ | $INV_2$ | $INV_3$ | $INV_1$ | $INV_2$ | $INV_3$ | $INV_1$ | $INV_2$ | $INV_3$ |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A:** | $R_{pt} = a_p + b_p (R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2$adj | |
| *Small* | 0,15 | −0,11 | 0,29 | 0,55 | −0,43 | 0,93 | 0,85 | 0,85 | 0,78 |
| *Mid* | −0,31 | 0,16 | −0,01 | −1,40 | 0,83 | −0,07 | 0,84 | 0,87 | 0,85 |
| *Big* | 0,40 | −0,21 | 0,22 | 2,21 * | −1,60 | 1,17 | 0,88 | 0,93 | 0,85 |
| **Panel B:** | $R_{pt} = a_p + b_p (R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + esg_p ESG + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2$adj | |
| *Small* | 0,19 | −0,12 | 0,33 | 0,70 | −0,47 | 1,06 | 0,85 | 0,85 | 0,78 |
| *Mid* | −0,32 | 0,14 | −0,01 | −1,43 | 0,74 | −0,04 | 0,84 | 0,87 | 0,85 |
| *Big* | 0,31 | −0,20 | 0,21 | 1,78 | −1,45 | 1,14 | 0,89 | 0,93 | 0,85 |
| *Small* | −0,17 | 0,03 | −0,15 | −1,19 | 0,29 | −0,93 | | | |
| *Mid* | 0,02 | 0,07 | −0,02 | 0,21 | 0,70 | −0,17 | | | |
| *Big* | 0,37 | −0,07 | 0,03 | 4,46 *** | −1,05 | 0,35 | | | |
| **Panel C:** | $R_{pt} = a_p + b_p (R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + env_p ENV + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2$adj | |
| *Small* | 0,19 | −0,11 | 0,30 | 0,69 | −0,45 | 0,95 | 0,85 | 0,85 | 0,78 |
| *Mid* | −0,27 | 0,16 | 0,00 | −1,22 | 0,82 | 0,01 | 0,85 | 0,87 | 0,85 |
| *Big* | 0,36 | −0,21 | 0,24 | 2,08 * | −1,56 | 1,27 | 0,88 | 0,93 | 0,85 |
| *Small* | −0,21 | 0,03 | −0,03 | −1,74 | 0,25 | −0,27 | | | |
| *Mid* | −0,25 | 0,01 | −0,08 | −2,91 *** | 0,08 | −0,90 | | | |
| *Big* | 0,24 | −0,03 | −0,09 | 3,48 *** | −0,47 | −1,15 | | | |
| **Panel D:** | $R_{pt} = a_p + b_p (R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + soc_p SOC + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2$adj | |
| *Small* | 0,19 | −0,10 | 0,31 | 0,72 | −0,40 | 0,97 | 0,85 | 0,85 | 0,78 |
| *Mid* | −0,34 | 0,13 | −0,03 | −1,56 | 0,68 | −0,16 | 0,84 | 0,87 | 0,85 |
| *Big* | 0,37 | −0,21 | 0,21 | 2,09 * | −1,56 | 1,14 | 0,88 | 0,93 | 0,85 |
| *Small* | −0,30 | −0,05 | −0,12 | −2,52 ** | −0,43 | −0,74 | | | |
| *Mid* | 0,21 | 0,24 | 0,13 | 1,84 | 2,83 ** | 0,90 | | | |
| *Big* | 0,24 | −0,04 | 0,07 | 2,85 ** | −0,68 | 0,85 | | | |
| **Panel E:** | $R_{pt} = a_p + b_p (R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + gov_p GOV + \varepsilon_{pt}$ | | | | | | | | |
| | | α | | | t(α) | | | $R^2$adj | |
| *Small* | 0,12 | −0,10 | 0,28 | 0,45 | −0,39 | 0,90 | 0,85 | 0,85 | 0,78 |
| *Mid* | −0,32 | 0,15 | −0,01 | −1,41 | 0,81 | −0,04 | 0,84 | 0,87 | 0,85 |
| *Big* | 0,41 | −0,22 | 0,22 | 2,26 * | −1,61 | 1,16 | 0,88 | 0,93 | 0,85 |
| *Small* | −0,37 | 0,10 | −0,10 | −2,87 *** | 0,84 | −0,64 | | | |
| *Mid* | −0,04 | −0,05 | 0,06 | −0,38 | −0,49 | 0,62 | | | |
| *Big* | 0,06 | −0,03 | −0,00 | 0,64 | −0,41 | −0,03 | | | |

**Nota:** ***; **; * indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively. Regressions estimated using models 19.1 and 19.3 to explain the returns of nine test portfolios formed by Size × B/M. September 2010 to February 2023 (149 months). t-statistics based on Huber–White robust standard errors.

**Source:** Prepared by the authors.

### Regressions for nine size × ESG portfolios

The results in Table 9 indicate that the FF five-factor model yields intercepts statistically equal to zero in eight of the nine regressions, with adjusted R2 values ranging from 57% to 94%. The only intercept that differs significantly from zero is observed in the large-cap portfolio with low ESG scores, with a t-statistic of −3.70.

**Table 9**

*Regressions for the nine size × ESG portfolios*

| ESG → | $ESG_1$ | $ESG_2$ | $ESG_3$ | $ESG_1$ | $ESG_2$ | $ESG_3$ | $ESG_1$ | $ESG_2$ | $ESG_3$ |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A:** $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + \varepsilon_{pt}$ | | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | 0,18 | 0,47 | −0,25 | 0,89 | 1,72 | −0,50 | 0,89 | 0,83 | 0,65 |
| *Mid* | −0,28 | −0,22 | 0,22 | −1,21 | −0,90 | 0,89 | 0,82 | 0,81 | 0,82 |
| *Big* | −1,70 | 0,28 | −0,07 | −3,70 *** | 1,00 | −0,54 | 0,57 | 0,74 | 0,94 |
| **Panel B:** $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + esg_pESG + \varepsilon_{pt}$ | | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | 0,29 | 0,41 | −0,51 | 1,46 | 1,54 | −1,08 | 0,91 | 0,83 | 0,68 |
| *Mid* | −0,21 | −0,21 | 0,12 | −0,88 | −0,83 | 0,51 | 0,83 | 0,81 | 0,83 |
| *Big* | −1,46 | 0,30 | −0,13 | −3,33 *** | 1,07 | −1,07 | 0,62 | 0,74 | 0,94 |
| *Small* | −0,44 | 0,23 | 1,01 | −4,48 *** | 1,59 | 4,05 *** | | | |
| *Mid* | −0,30 | −0,07 | 0,38 | −2,71 ** | −0,56 | 3,74 *** | | | |
| *Big* | −0,94 | −0,10 | 0,25 | −4,18 *** | −0,67 | 3,38 *** | | | |
| **Panel C:** $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + env_pENV + \varepsilon_{pt}$ | | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | 0,27 | 0,43 | −0,42 | 1,42 | 1,56 | −0,89 | 0,91 | 0,83 | 0,69 |
| *Mid* | −0,24 | −0,21 | 0,20 | −1,03 | −0,84 | 0,80 | 0,83 | 0,81 | 0,82 |
| *Big* | −1,59 | 0,29 | −0,10 | −3,61 *** | 1,03 | −0,78 | 0,60 | 0,74 | 0,94 |
| *Small* | −0,45 | 0,25 | 0,90 | −5,62 *** | 2,37 * | 4,21 *** | | | |
| *Mid* | −0,24 | −0,10 | 0,11 | −2,52 * | −0,79 | 1,16 | | | |
| *Big* | −0,59 | −0,07 | 0,15 | −3,01 *** | −0,61 | 2,28 * | | | |
| **Panel D:** $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + soc_pSOC + \varepsilon_{pt}$ | | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | 0,23 | 0,48 | −0,35 | 1,18 | 1,78 | −0,72 | 0,90 | 0,83 | 0,66 |
| *Mid* | −0,28 | −0,25 | 0,16 | −1,21 | −1,03 | 0,67 | 0,82 | 0,81 | 0,84 |
| *Big* | −1,64 | 0,29 | −0,10 | −3,68 *** | 1,05 | −0,82 | 0,58 | 0,74 | 0,94 |
| *Small* | −0,38 | −0,06 | 0,71 | −4,07 *** | −0,50 | 3,06 *** | | | |
| *Mid* | −0,01 | 0,20 | 0,45 | −0,09 | 1,74 | 4,38 *** | | | |
| *Big* | −0,43 | −0,07 | 0,22 | −1,86 | −0,55 | 3,48 *** | | | |
| **Panel E:** $R_{pt} = a_p + b_p(R_{mt} - R_{ft}) + s_pSMB_t + h_pHML_t + r_pRMW_t + c_pCMA_t + gov_pGOV + \varepsilon_{pt}$ | | | | | | | | | |
| | | α | | | t(α) | | | $R^2adj$ | |
| *Small* | 0,18 | 0,45 | −0,19 | 0,90 | 1,70 | −0,39 | 0,89 | 0,83 | 0,67 |
| *Mid* | −0,30 | −0,22 | 0,22 | −1,28 | −0,90 | 0,91 | 0,83 | 0,81 | 0,82 |
| *Big* | −1,71 | 0,28 | −0,06 | −3,71 *** | 1,03 | −0,49 | 0,57 | 0,74 | 0,94 |
| *Small* | 0,00 | −0,35 | 0,86 | 0,03 | −2,46 * | 3,17 *** | | | |
| *Mid* | −0,21 | −0,00 | 0,03 | −1,86 | −0,02 | 0,27 | | | |
| *Big* | −0,25 | 0,11 | 0,10 | −1,09 | 0,72 | 1,39 | | | |

**Nota:** ***; **; * indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively. Regressions estimated using models 19.1 and 19.3 to explain the returns of nine test portfolios formed by Size × B/M. September 2010 to February 2023 (149 months). t-statistics based on Huber–White robust standard errors.

**Source:** Prepared by the authors.

ESG ($t$ = −3.70). This result may be explained by the portfolio's low level of diversification, as it contains the smallest number of stocks among all portfolios considered in the study.

The inclusion of the ESG factor in the five-factor model only partially reduces the statistical significance of this portfolio's intercept ($t$ = −3.33). The ESG coefficients are negative and significant for portfolios composed of stocks with low ESG scores ($ESG_1$) and positive and significant for portfolios composed of stocks with high ESG scores ($ESG_3$). This pattern is expected, given that ESG is constructed as a high-minus-low factor, defined as the return differential between high-ESG and low-ESG stocks.

Similarly, models that incorporate the ENV, SOC, and GOV factors do not alter the intercept pattern produced by the FF five-factor model. However, the factor coefficients exhibit a pattern comparable to that of the ESG factor for ENV and SOC: portfolios of stocks with high (low) scores tend to present positive (negative) coefficients.

This pattern is less evident in the model that includes the GOV factor. One possible explanation lies in the weights assigned by the rating provider to each component of the aggregate ESG score, with environmental and social dimensions playing a more prominent role than governance in the final assessment. In addition, this empirical distinction may reflect theoretical ambiguity in the relationship between these fields, as the literature notes a lack of consensus and conceptual clarity regarding how Corporate Governance (CG) integrates with, or complements, Corporate Social Responsibility (CSR) (Cunha et al., 2015).

In summary, the regressions for the four groups of test portfolios indicate that adding a green factor can contribute to lower intercepts relative to the FF five-factor model, thereby providing a better fit to the data. This reduction is most evident in the specification that includes the ESG risk factor. With respect to the coefficients of the green factors, however, no uniform pattern emerges across test portfolios. As Cornell (2021) and Pástor et al. (2021) argue, the heightened attention devoted to ESG in recent years has led to shifts in investor preferences regarding ESG, which helps to explain the ambiguous regression results observed in this and other studies.

## CONCLUDING REMARKS

The objective of this study was to examine whether the ESG performance of companies traded on B3 constitutes information that is priced by investors and whether the inclusion of a green factor in the Fama–French (FF) models yields a more efficient pricing framework for explaining expected stock returns.

In summary, the findings indicate that models incorporating a green risk factor provide a better representation of the expected returns of Brazilian stocks between 2010 and 2023 than the traditional three- and five-factor FF models. These results suggest that ESG performance is indeed priced by investors in the Brazilian market. Nonetheless, it is important to emphasize that the three- and five-factor Fama and French models (1993, 2015) already offer adequate representations of expected returns, as their intercepts are statistically indistinguishable from zero in most regressions.

The GRS test results further indicate that incorporating a green factor (ESG, ENV, SOC, or GOV) improves model efficiency for most of the panels analyzed. However, the findings suggest that the gains in explanatory power are marginal, particularly when compared with the five-factor FF model. The models that include the ESG risk factor achieve the most substantial efficiency improvements, whereas the ENV, SOC, and GOV factors contribute less meaningfully to the reference specifications. Regressions of the green factors on FF risk factors reinforce this conclusion, as FF factors appear capable of capturing any linear patterns present in the returns of the green factors.

One important consideration is that the Brazilian market is still at an early stage in adopting and valuing firms that prioritize ESG practices. Brazilian investors' preferences lag behind those observed in developed markets (Farias & Barreiros, 2021). Indeed, this perception is consistent with studies on the national context (Silva & Santos, 2010), which highlight obstacles such as an individualistic mindset and low levels of social capital in business cooperation.

Regarding the coefficients of the green factors, no consistent pattern emerges. Some regressions indicate a positive premium, while others show a negative average return over the historical period analyzed. A possible explanation lies in the argument advanced by Pástor et al. (2021) according to which the direction of the sustainability premium depends on the period under analysis and on shifts in investor preferences. Nonetheless, additional research is warranted. The analyses proposed in this study are particularly useful for assessing the performance of portfolio managers but may also provide valuable insights for corporate managers developing ESG strategies.

As Cornell (2021) notes, ESG studies face challenges related to evaluation methodology and data limitations. These limitations are especially pronounced in the Brazilian context, given the small number of agencies evaluating Brazilian companies. Future research should therefore consider using additional ESG rating providers for constructing risk factors, as well as extending the time horizon to broaden and deepen the analyses.

Finally, although the findings are not yet as conclusive as one might hope, they represent a crucial step toward understanding how the market perceives a complex issue that increasingly occupies the agendas of companies, legislators, and regulatory institutions. This topic will undoubtedly grow in relevance given the social, market, and especially environmental context, marked by ongoing debates about – and the far-reaching consequences of – global climate change. In this scenario, corporations are expected to face mounting pressure to reassess governance practices and to deliver socially and environmentally responsible outcomes.

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