Does sustainability strengthen asset pricing models? Moderating effects in the Fama-French framework on ESG leaders

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Abstract

This research investigates the moderating role of environmental, social, and governance (ESG) risk ratings in the relationship between traditional Fama-French framework and excess stock returns among companies listed in the ESG Leaders Index for the 2021–2023 period. Using moderated regression analysis (MRA), the findings reveal that small minus big (SMB) exerts a significant positive impact on excess returns, confirming the relevance of firm size as a pricing factor even within the sustainability-focused investment universe. Meanwhile, market risk and high minus low (HML) do not show demonstrate statistical relevance direct effects, although HML is marginally significant. Furthermore, ESG risk rating demonstrates a moderating effect only in the relationship between HML and excess returns, suggesting that sustainability considerations may weaken the traditional value premium. These results highlight the partial integration of ESG risk into asset pricing dynamics and underline the essentiality of incorporating ESG factors in developing more robust, sustainable investment strategies. The study provides practical insights for market participants, fund managers, and authorities navigating the transition toward sustainable finance in emerging markets.

Introduction

Studies concerning on the framework of Fama-French three-factor and sustainability (environmental, social, and governance) integration has emerged as a critical area of inquiry due to the increasing prominence of sustainable investing and its implications for asset pricing and portfolio management (Lu, 2025; Bax et al., 2024). Since the early 2010s, ESG considerations have gained traction alongside traditional financial factors, reflecting a shift toward incorporating non-financial metrics in investment decisions (Melas et al., 2017; Debnath & Chellasamy, 2024). The global sustainable fund market has expanded rapidly, with assets under management reaching trillions of dollars, underscoring the practical and theoretical significance of ESG integration (Lu, 2025; Yunus & Nanda, 2024). This evolution has prompted the adaptation of classical valuation of financial asset models, such as the Fama-French framework, to include ESG factors as potential drivers of risk and return (Dobrick et al., 2025; Gong et al., 2024).

Despite growing interest, incorporating of ESG factors into the Fama-French three-factor model presents unresolved challenges and divergent findings. Empirical studies report mixed evidence on whether ESG scores serve as significant risk factors or merely reflect mispricing (Silva-Noreña et al., 2024). Prior studies highlights that ESG integration enhances model explanatory power and portfolio effectiveness (Mulialim & Madyan, 2023; Gong et al., 2024), while others find limited or no incremental benefit beyond traditional factors (Kumar, 2019; Nsibande & Sebastian, 2023). Moreover, discrepancies in ESG rating methodologies and data quality complicate the

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assessment of ESG's role in asset pricing (Bang et al., 2023; Cesarone et al., 2023). This knowledge gap is particularly pronounced in emerging markets, where ESG disclosure and investor adoption remain nascent (Lu, 2025; Mohanasundaram & Kasilingam, 2024; Dsouza et al., 2024). The lack of consensus on ESG's financial materiality and its incorporation into multifactor models limits investors' ability to optimize sustainable portfolios effectively (Bax et al., 2024; Géczy & Guerard, 2023).

The conceptual framework underpinning this review defines ESG integration as the deliberate incorporarion of environmental, social, and governance criteria alongside conventional financial factors in asset pricing models (Melas et al., 2017; Yunus & Nanda, 2024). The Fama-French three-factor model, encompassing market risk, size, and value factors, serves as a foundational structure to evaluate whether ESG factors constitute an additional source of systematic risk or alpha (Dobrick et al., 2025; Gong et al., 2024). Understanding the interplay between ESG and established risk factors is essential for advancing responsible investment strategies and refining asset pricing theory (Pedersen et al., 2019; Cosimato et al., 2021).

Literature Review and Hypotheses Development

The three-factor model developed by Eugene Fama and Kenneth French in 1992, both of whom are renowned economists and Nobel laureates, expands upon the traditional capital asset pricing model (CAPM) by considering two additional risk component beyond the expected market return: the size effect and the value effect. Through extensive empirical testing involving thousands of randomly selected stock portfolios, they identified two consistent patterns. First, value stocks—companies with high book-to-market ratios tend to deliver superior return compared to growth stocks, which have lower book-to-market ratios. This suggests that value stocks are typically underpriced relative to their fundamentals. Second, shares of smaller companies generally yield higher returns compared to large-cap firms, although they come with higher levels of risk.

Fama and French argue that, over the long run, smaller firms and value-oriented stocks tend to achieve superior returns when compared to larger firms and growth stocks. When these two additional factors size and value are combined with the market factor, the model is capable of explaining approximately 90% of the return variations in a well-diversified equity portfolio, offering a more comprehensive framework than the CAPM, which only accounts for market risk through beta.

While the model was initially tailored to the U.S. equity market, subsequent studies have demonstrated that it performs reliably across international markets, suggesting its broader applicability in explaining stock returns globally. Several studies found that integrating ESG factors enhances the ability to explain the Fama-French model or its extensions, especially in emerging markets and with novel factor constructions (Lu, 2025; Dash et al., 2024). While other studies reported marginal or no significant improvement from adding ESG factors, particularly in developed markets or when using aggregate ESG scores (Silva-Noreña et al., 2024; Kumar, 2019; Nsibande & Sebastian, 2023). Some research highlights the need for non-linear or machine learning approaches to capture ESG effects beyond traditional linear models (Gong et al., 2024). ESG integration positively affects risk-adjusted returns, with strategies like excluding low ESG stocks or using ESG risk premiums enhancing performance (Lu, 2025; Mulialim & Madyan, 2023). Silva found that mixed or negative impacts, noting short-term costs or weak correlations between ESG and returns (Silva-Noreña et al., 2024; Magnani et al., 2024). Several papers emphasize that ESG effects vary by market, sector, and firm size, complicating uniform conclusions (Mohanasundaram & Kasilingam, 2024). In the ESG strategy effectiveness, most studies focus on ESG integration broadly without explicit strategy comparisons, highlighting a research gap. Some evidence suggests that combining ESG with traditional financial quality factors enhances predictive power (Rosinus & Lansky, 2025).

ESG-augmented models in emerging markets (China, India, Indonesia, Pakistan) show varying degrees of effectiveness and data challenges (Lu, 2025; Mulialim & Madyan, 2023; Mohanasundaram & Kasilingam, 2024). On developed markets (US, Europe, Sweden) with mixed results on ESG's explanatory power and financial impact (Silva-Noreña et al., 2024). Cross-market

differences underscore the importance of local ESG data quality and regulatory environments (Dsouza et al., 2024). Several papers call for standardized ESG reporting frameworks and improved data transparency to enhance research reliability (Debnath & Chellasamy, 2024; Yunus & Nanda, 2024). Some studies use advanced techniques like explainable AI or multi-agency rating reconciliation to mitigate data limitations (Dash et al., 2024; Cesarone et al., 2023).

Hypotheses Development

According to the capital asset pricing model (CAPM), market risk, captured through beta, represents the sensitivity of stock returns to market movements. Based on the Fama-French three-factor framework, this systematic risk remains a fundamental determinant of expected returns. Companies with high ESG scores tend to have lower market risk sensitivity because ESG performance can reduce systemic risk, especially in companies with certain characteristics (Gidage et al., 2024). Companies included in the ESG Leaders Index typically exhibit stronger governance, stakeholder alignment, and risk management practices, which can impact how market fluctuations are priced (Luo & Farag, 2024). Furthermore, ESG premise is more pronounced in stocks with lower liquidity, confirming the variation in effects based on market conditions (Luo, 2022), and uncertainty in ESG ratings can influence market risk and increase market premiums (Avramov et al., 2022). Furthermore, green stocks tend to have lower returns, as investors pursue not only financial returns but also non-financial benefits such as satisfaction from supporting sustainable practices (Pastor et al., 2020). However, ESG investments have the potential to create new systemic risks at the institutional level (Dong, 2025). Given that these companies are still exposed to systematic risk, market risk is expected to remain significantly and beneficially related to excess returns, although the magnitude may vary due to investor preferences regarding ESG.

H_1: Market risk has a positive effect on excess stock returns for companies listed on the ESG Leaders Index.

The size premium, represented by the SML factor, implies that smaller firms tend to generate higher average returns than larger firms, possibly due to higher risk or limited analyst coverage (Dash et al., 2024). Even among ESG-compliant firms, small-cap firms may exhibit higher growth potential and innovation in sustainability practices (Gidage et al., 2024). Investors may reward these efforts through a valuation premium, especially as ESG awareness increases. Furthermore, ESG plays a role in enhancing firm value, particularly in industries with high stakeholder pressure (Zheng et al., 2022). However, ESG data for small firms is often incomplete, which can undermine SMBs (Sahin et al., 2022). Furthermore, small firms may face different ESG pressures than larger firms (Ma et al., 2024). Thus, the traditional size effect is hypothesized to remain significant and positive in ESG-driven markets.

H_2: Small minus large (SML) has a positive effect on excess stock returns for companies listed on the ESG Leaders Index.

The HML factor captures the incremental returns of value stocks relative to small-cap stocks, where companies with high book-to-market ratios tend to outperform growth companies. In an ESG context, companies with high book-to-market ratios and maintaining sustainable business models may appear undervalued relative to their growth potential (MSCI, 2024). Companies with good ESG scores are highly valued by the market, thus influencing the perception of a value premium (Khan et al., 2024). Furthermore, a lower cost of capital can mitigate undervaluation in stocks with high book-to-market (Postiglione et al., 2024). Furthermore, investors are increasingly paying attention to intangible factors, including ESG scores, which can potentially alter perceptions of a company's value. Therefore, even in ESG-oriented portfolios, the value effect is expected to positively impact excess returns. Furthermore, the quality of ESG disclosure improves investor confidence, thereby weakening the risk compensation typically inherent in value stocks (Maurer, 2022).

H_3: High minus low (HML) positively affects excess stock returns for firms listed in the ESG Leaders Index.

As sustainability considerations become increasingly embedded in investment decisions, ESG risk ratings provide insight into a company's exposure to and management of material ESG issues (MSCI, 2024). This moderating factor can alter the traditional relationship between market risk and stock returns. Companies with lower ESG risk may be perceived as more stable and resilient during market downturns, thus attenuating the sensitivity of their returns to market volatility, and companies with strong ESG performance may be more resilient to Systemic Shocks (Gidage et al., 2024). Conversely, higher ESG risk can amplify the impact of market risk due to perceived vulnerability. Furthermore, a bibliometric review noted that most studies find a negative relationship between ESG and market risk (De Giuli et al., 2024). Furthermore, divergence between ESG ratings and climate transition risk impacts pricing and market beta, thus moderating the influence of ESG risk ratings (Berk et al., 2023). However, the results of ESG moderation on ESG market risk and returns are not always consistent, but still show a tendency to weaken the influence of market risk (Heinelt et al., 2025; Avramov et al., 2022). This suggests a potential moderating role for ESG risk ratings.

H_4: ESG risk ratings can moderate the impact of market risk on excess stock returns for companies listed on the ESG Leaders Index.

SMB factors reflect company size, and smaller companies may face greater challenges in implementing robust ESG strategies due to resource constraints (Gidage et al., 2024). However, ESG ratings can differentiate between high-performing and low-performing small-cap companies (MSCI, 2024; Dash et al., 2024; Resende et al., 2024). The effect of ESG on returns differs for large and small companies, with small companies with strong ESG performance achieving greater returns (Asih et al., 2024). A positive ESG risk rating can increase investor confidence in smaller ESG companies, potentially amplifying the positive effect of SMB. Conversely, poor ESG performance can reduce the attractiveness of small companies, thereby moderating or reversing the size premium. Furthermore, the ESG premium is more pronounced in stocks with low liquidity, which are often found in small companies (Luo, 2022). Thus, ESG risk ratings can significantly influence the strength and direction of the SMB-return relationship.

H_5: ESG risk ratings can moderate the effect of SMB on excess stock returns for firms listed on the ESG Leaders Index.

The value effect, captured by HML, can be influenced by a company's ESG profile. Companies with high book-to-market ratios often signal undervaluation or fundamental risk (Khan et al., 2024; Postiglione et al., 2024). ESG risk ratings help clarify whether valuations reflect overlooked strengths or latent sustainability risks. Companies with strong ESG performance and high book-to-market ratios can attract ESG-conscious investors, thereby enhancing returns (Nsibande & Sebastian, 2023). ESG can mitigate the risk of distressed value companies by distinguishing between high-risk ones (Dobrick et al., 2025). Furthermore, ESG disclosure can improve investor perceptions, thereby lowering risk compensation in value stocks (Maurer, 2022). Conversely, companies with weak ESG performance may see a muted or negative HML effect. Therefore, ESG risk rating is expected to play a significant moderating role in shaping the HML-return relationship in the ESG Leaders Index.

H_6: ESG risk rating can moderate the effect of HML on excess stock returns for companies listed in the ESG Leaders Index.

Research Methods

This investigation utilizes quantitative approach using secondary data to examine whether sustainability factors strengthen asset pricing models within the Fama-French framework, specifically by assessing the moderating effects on stocks listed in the ESG Leaders Index. The data utilized in this research are derived from publicly available financial reports, monthly stock prices, and ESG scores of companies included in the ESG Leaders Index on the Indonesia Stock Exchange from 2021 to 2023 with 29 company as sample. The analytical method applied is moderated regression analysis (MRA), which allows the researcher to identify the extent to which

sustainability factors (ESG) moderate the relationship between the Fama-French model variables: market factor, firm size, and book-to-market ratio and excess returns. The operational definitions outlined in Table 1 are essential for measuring the ramification of ESG factors on asset pricing models, providing a clear framework for analysis. The operational definitions established in this study will facilitate a robust analysis of the interplay between ESG factors and asset pricing models, ultimately contributing to more informed investment strategies.

Table 1. Operational Variables

Variables	Operational Definition	Indicator	Source
Excess return (R_{it}–R_{ft})	The difference between the individual stock return and the risk-free rate, representing abnormal return.	Stock return – risk-free rate	(Wang et al., 2024)
Market (R_M–R_F)	The excess return of the market over the risk-free rate (Fama-French market factor).	Market index return – risk-free rate	(Fama & French, 2018)
Small minus big (SMB)	The size factor in the Fama-French model represents the return spread between small and large firms.	Return of small-cap portfolio – large-cap portfolio	(Fama & French, 2018)
High minus low (HML)	Value factor in the Fama-French model, representing the return spread between high and low book-to-market firms.	Return of high B/M portfolio – low B/M portfolio	(Fama & French, 2018)
ESG (Z)	A measure of a firm's sustainability performance based on environmental, social, and governance criteria.	ESG risk rating	(Wang et al., 2024)

Source: Authors own creation

To analyze the moderating effect of sustainability on asset pricing, we constructed equity portfolios based on the Fama-French three-factor model (FF3FM). The portfolio construction process involved several key steps:

1. Sample selection and data sources
   The present study utilizes secondary data from the ESG Leaders Index on the Indonesia Stock Exchange (IDX) during the period of January 2021 to December 2023. Monthly data on stock prices, market capitalization, book-to-market ratios, and financial statements were collected from reliable databases such as refinitive, and IDX official sources. Market return and risk-free rate data were obtained from Bank Indonesia and IHSG.
2. Factor formation procedure
   Portfolios were formed based on the methodology developed by Eugene and French (1992), involving the following steps:
   a. Sorting by size (market capitalization):
      All firms in the ESG Leaders Index were ranked and split into two groups: small (S) and big (B), using the median market capitalization as the breakpoint at the end of each June.
   b. Sorting by value (book-to-market ratio):
      Simultaneously, firms were sorted into three groups based on their book-to-market (B/M) ratios: high (H), medium (M), and low (L). Breakpoints were defined using the 30th and 70th percentiles of the B/M distribution.
   c. Forming six portfolios:
      By intersecting the size and value groups, six value-weighted portfolios were constructed.
      1) S/L (small and low B/M),
      2) S/M (small and medium B/M),
      3) S/H (small and high B/M),
      4) B/L (big and low B/M),
      5) B/M (big and medium B/M),
      6) B/H (big and high B/M).

3. Factor calculation
   a. Small minus big (SMB):
   $$SMB = \frac{1}{3}(S/L + S/M + S/H) - \frac{1}{3}(B/L + B/M + B/H)$$
   b. High minus low (HML):
   $$HML = \frac{1}{2}(S/H + B/H) - \frac{1}{2}(S/L + B/L)$$
4. Regression estimation

   A moderated regression analysis (MRA) was conducted by introducing sustainability scores as moderating variables in the regression model. Interaction terms between ESG scores and each of the three Fama-French factors were included to assess their moderating effects. The regression model will be formulated to evaluate the impact of ESG factors on asset pricing, incorporating key variables such as excess return, market return, SMB, HML, and ESG scores. The regression analysis will reveal how ESG scores interact with traditional factors, ultimately assessing their collective impact on asset pricing within the Fama-French framework.

$$(R_{it} - R_{ft}) = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_2(SMB_t) + \beta_3(HML_t) + eit \quad 1)$$

Model 1 represents the standard Fama-French three-factor model, where excess stock returns ($R_{it}-R_{ft}$) are explained by market risk premium ($R_{mt}-R_{ft}$), SMB (size factor), and HML (value factor).

$$(R_{it} - R_{ft}) = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_2(SMB_t) + \beta_3(HML_t) + \beta_4(ESG_t) + eit \quad 2)$$

Model 2 extends model 1 by including the ESG risk rating as an additional independent variable (ESG_t), aiming to identify its direct effect on excess returns.

$$(R_{it} - R_{ft}) = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_2(SMB_t) + \beta_3(HML_t) + \beta_4(ESG_t) + \beta_5(R_{mt} - R_{ft}) * (ESG_t) + \beta_6(SMB_t) * (ESG_t) + \beta_7(HML_t) * (ESG_t) + eit \quad 3)$$

Model 3 introduces interaction terms between ESG and each of the three Fama-French factors. This model tests whether ESG risk rating moderates the impact of market risk, size, and value factors on excess returns. All regressions include a constant term α and an error term e_{it}, and are estimated using panel data over the 2021–2023 period for companies listed in the ESG Leaders Index.

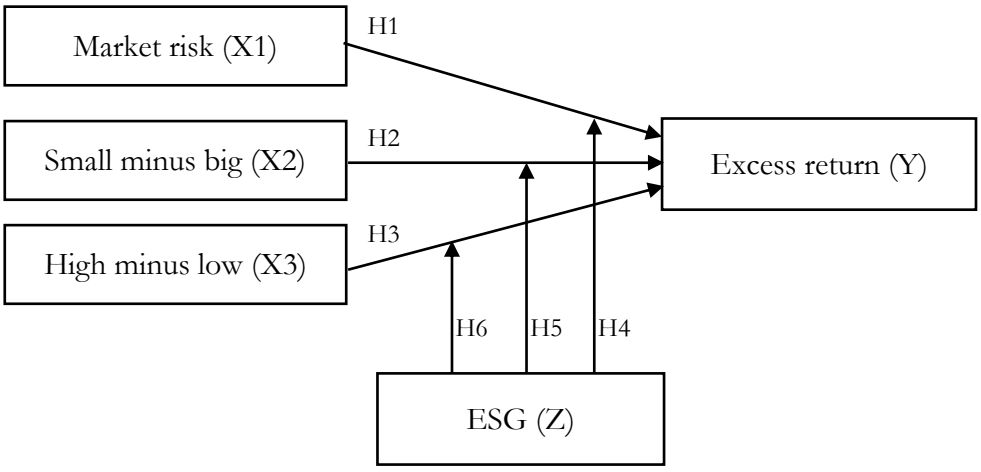

Figure 1. Research Framework
Source: Authors conceptualization

Results and Discussion

Portfolio Construction

The portfolio, created using the Fama-French three-factor model, shows a distribution of ESG

Leader stocks that reflects the fundamental characteristics of each group. The S/H portfolio appears densest, reflecting the large number of undervalued stocks in the small-cap group. The small-high (S/H) group is dominated by undervalued, small-cap stocks such as ERAA, SMRA, and CTRA, indicating high rebound potential but with relatively high risk. Conversely, the small-low (S/L) group contains a few stocks such as SMSM and MAPI, reflecting the limited number of small companies with high valuations (growth). Conversely, the big-high (B/H) and big-medium (B/M) groups consist of undervalued and stable blue-chip stocks such as BMRI, ASII, and BBCA, reflecting the dominance of large-cap stocks with reasonable valuations in the Indonesian market. The big-low (B/L) group, such as UNVR and ISAT, indicates high market expectations for growth. This composition reflects the diversity of risk and return characteristics in the portfolio, and provides a strong foundation for calculating the SMB and HML factors, which can later be used in a regression model to test the effect of sustainability factors on excess stock returns within the Fama-French framework.

Table 2. Formed Portfolio Structure

S/H	S/M	S/L	B/H	B/M	B/L
ERAA	ACES	SMSM	JSMR	INTP	UNVR
SMRA	SCMA	MAPI	PGAS	AKRA	HMSP
CTRA	DMAS			BMRI	TBIG
BBTN	RALS			ASII	BBCA
WOOD	PWON			EXCL	TOWR
BSDE				BBNI	TLKM
MNCN					ISAT

Source: Data processed, 2025

Table 3. Formed Factors based on Portfolio

Portfolio		Number of Stock	Average Portfolio Return	Std. Dev
SMB	HML			
Small	High	7	-7%	11%
Small	Medium	5	-14%	9%
Small	Low	2	27%	18%
Big	High	2	0%	12%
Big	Medium	6	9%	19%
Big	Low	7	4%	16%

Source: Data processed, 2025

Regression Model 1

The regression output presents a standard Fama-French three-factor model analysis. The R-squared of 0.43 suggests that roughly 43% of the variation in stock returns can be explained by the three independent variables: Market (Rm-Rf), SMB (size), and HML (value). The F-statistic of 7.92 with a p-value of 0.00 indicates that the overall model is demonstrate statistical relevance at the 1% level, meaning the three factors collectively have explanatory power for return variation.

Table 3. Model 1 Regression Result

Variables	Coefficient	t-statistics	P-value
Alpha	0.019	1.556	0.1299
Market	0.425	2.153	0.0391
SMB	0.209	1.752	0.0896
HML	0.251	2.376	0.0238
R^2: 0.43			
F Stats: 7.92			
Prob(F-statistics): 0.00			
Durbin Watson: 1.99			

Source: Data processed, 2025

The market factor (β = 0.425, p = 0.0391) is demonstrate statistical relevance at the 5% level, denoting that market excess return positively influences stock returns. This aligns with traditional asset pricing theory. The SMB factor (β = 0.209, p = 0.0896) is marginally significant at the 10% level, suggesting that the size effect (small minus big) might have a weak impact on return behavior in the sample. The HML factor (β = 0.251, p = 0.0238) is demonstrate statistical relevance at the 5% level, showing that value oriented securities generated superior return than growth stocks during the observed period. The Durbin-Watson statistics of 1.99 suggests no autocorrelation problems, indicating the regression residuals are independent and the model is robust for inference.

Regression Model 2

The results from the panel regression using the fixed effect model demonstrate that the combination of traditional Fama-French factors and ESG scores yields a demonstrate statistical relevance model, as indicated by the F-statistics (1.88) with a p-value of 0.02. This suggests that, jointly, the variables included in the model contribute meaningfully to explaining variations in stock returns of ESG Leaders during the 2021–2023 period. The coefficient of determination (R^2) is 0.53, which implies that the model explains 53% of the variation in returns — a moderate to strong explanatory power within financial return studies.

Table 4. Model 2 Regression Result

Variables	Coefficient	t-statistics	P-value
Alpha	-22.917	-3.492	0.001
Market	0.664	0.154	0.878
SMB	4.977	3.537	0.001
HML	0.129	0.273	0.785
Z (ESG)	0.392	0.264	0.792
R^2: 0.53			
F Stats: 1.88			
Prob(F-statistics): 0.02			
Durbin Watson: 2.88			

Source: Data processed, 2025

Individually, the SMB factor remains highly significant (p = 0.001), reaffirming the influence of firm size in asset pricing, especially in the context of ESG-oriented stocks. This indicates that smaller ESG leaders may still command a return premium in the market. In contrast, the market and HML factors, along with the ESG variable (Z), show no statistical significance (p > 0.7). This finding implies that, when considered independently, ESG scores do not significantly affect returns, and neither do value-based characteristics or market beta in this specific sample. The Durbin-Watson statistic of 2.88 suggests strong negative autocorrelation in the residuals. While not common, this could indicate model misspecification or the omission of relevant dynamic factors, which may distort standard error estimates and weaken inference validity. Further diagnostic checks and application of robust error estimators such as Driscoll and Kraay (1998) or heteroskedasticity-consistent standard errors are recommended.

Overall, the results suggest that while ESG scores alone do not exert a direct influence on returns, their interaction with size-based dynamics may deserve further exploration. The findings reinforce the persistent role of firm size in asset pricing, even in sustainability-oriented investment universes. When interaction terms were tested in the moderated regression model, the ESG variable was analyzed as a moderator specifically a pure moderator (Baron & Kenny, 1986), where Z is not a significant predictor on its own but may still influence the strength or direction of the relationship between predictors (Market, SMB, HML) and the dependent variable (returns).

Regression Model 3

The coefficient of the market variable is negative (–20.847) with a p-value of 0.392 (> 0.10),

denoting that market risk does not have a significant positive effect on excess returns. Thus, hypothesis 1 is not supported in the ESG Leaders context. The coefficient of the SMB variable is 8.149 and demonstrate statistical relevance at the 1% level (p = 0.001), denoting that smaller firms tend to earn higher excess returns in the ESG Leaders Index. Hence, hypothesis 2 is supported. The coefficient of the HML variable is 3.889 with a p-value of 0.096 (< 0.10), which suggests a weak but demonstrate statistical relevance positive effect at the 10% level. Thus, hypothesis 3 is marginally supported. The interaction term market × ESG exhibits a coefficient value of 32.351 with a p-value of 0.329 (> 0.10), denoting that ESG risk rating does not significantly moderate the relationship between market risk and excess returns. The interaction term SMB × ESG exhibits a coefficient value of –3.582 with a p-value of 0.153 (> 0.10), suggesting no significant moderating effect of ESG risk rating on the relationship between SMB and excess returns. Explanation: the interaction term HML × ESG exhibits a coefficient value of –4.849 with a p-value of 0.100, which is significant at the 10% level. This indicates that ESG risk rating marginally moderates the relationship between value factor (HML) and excess returns, possibly weakening the positive effect of high book-to-market characteristics.

Table 5. Model 3 Regression Result

Variables	Coefficient	t-statistics	P-value
Alpha	-41.370	-3.336	0.001
Market	-20.847	-0.862	0.392
SMB	8.149	3.288	0.001
HML	3.889	1.693	0.096
Z (ESG)	22.008	1.689	0.097
Market*Z	32.351	0.984	0.329
SMB*Z	-3.582	-1.449	0.153
HML*Z	-4.849	-1.671	0.100
R^2: 0.56			
F Stats: 1.87			
Prob(F-statistics): 0.02			
Durbin Watson: 2.92			

Source: Data processed, 2025

The experimental outcome from the panel data regression using the fixed effect model indicate that the model is demonstrate statistical relevance, as evidenced by the F-statistics p-value of 0.02. This suggests that the combination of Fama-French factors, the ESG Score (Z), and their interaction terms collectively contribute to explaining variations in stock returns among ESG Leaders during the 2021–2023 period. The R-squared value of 0.56 demonstrates that the model accounts for more than half of the variability in stock returns, representing a strong explanatory power in the context of financial asset pricing, particularly for firms with sustainability-oriented profiles.

Hypothesis Testing

Table 6. Hypothesis Testing Result

Hypothesis	Variable/Interaction	Coefficient	t-statistics	P-value
H1	Market → Excess Return	-20.847	-0.862	0.392
H2	SMB → Excess Return	8.149	3.288	0.001***
H3	HML → Excess Return	3.889	1.693	0.096*
H4	Market*Z → Excess Return	32.351	0.984	0.329
H5	SMB*Z → Excess Return	-3.582	-1.449	0.153
H6	HML*Z → Excess Return	-4.849	-1.671	0.100*

Source: Data processed, 2025

The regression analysis was conducted to examine the effects of the Fama–French factors and ESG risk ratings on excess stock returns of firms listed in the ESG Leaders Index. For hypothesis

1, which posits a positive effect of market risk on excess returns, the results are not supported (β = -20.847, t = -0.862, p = 0.392). The coefficient is negative and statistically insignificant, leading to the rejection of H1.

Hypothesis 2, which examines the effect of the size factor (SMB) on excess returns, is strongly supported (β = 8.149, t = 3.288, p = 0.001). This indicates that smaller firms tend to generate higher excess returns compared to larger firms, consistent across 1%, 5%, and 10% significance thresholds.

For hypothesis 3, the value factor (HML) demonstrates a positive but weak effect (β = 3.889, t = 1.693, p = 0.096). The result is only marginally significant at the 10% level, suggesting limited support for the hypothesis.

Turning to the moderating role of ESG risk ratings, hypothesis 4 (Market*Z) and hypothesis 5 (SMB*Z) are all rejected, as none of the interaction terms are statistically significant (p-values of 0.329 and 0.153). This implies that ESG risk ratings do not moderate the relationships between the market and SMB factors and excess returns.

For hypothesis 6 (HML*Z) demonstrates a negative but weak effect (β = -4.849, t = -1.671, p = 0.100). The result is only marginally significant at the 10% level, suggesting limited support for the hypothesis. This implies that ESG risk ratings can moderate the relationships between the HML factor and excess returns.

Interestingly, the direct effect of ESG risk ratings (Z) shows marginal significance (β = 22.008, t = 1.689, p = 0.097). Based on these findings, ESG risk ratings are more appropriately categorized as a quasi moderator. This indicates that ESG factors may function more as an additional explanatory driver rather than a true moderating mechanism within the Fama–French framework (Morri et al., 2024; Zeng et al., 2025).

In summary, the hypothesis testing reveals that the size factor (SMB) is the only robust predictor of excess returns in the ESG Leaders Index across all conventional significance levels. The value factor (HML) and ESG risk ratings exhibit weak effects at the 10% level, while the market factor and all moderation hypotheses are not supported. These findings suggest that ESG considerations function more as an additional explanatory factor rather than a moderating mechanism within the Fama–French framework.

Among the explanatory variables, the small minus big (SMB) factor shows a demonstrate statistical relevance and positive effect on returns (p = 0.001), reaffirming the size effect as a robust determinant in the ESG segment. The ESG score (Z) and its interaction with the high minus low (HML) factor are marginally significant (p ≈ 0.10), suggesting a weak but emerging moderating role of sustainability in influencing the value premium. Meanwhile, the interaction terms between ESG and the market factor (MarketZ) and between ESG and SMB (SMBZ) are not demonstrate statistical relevance , implying that ESG characteristics do not meaningfully alter the effects of market risk and size on returns in this model specification.

The findings suggest that the positive influence of the HML factor on stock returns tends to weaken among firms with high ESG performance. In other words, higher ESG scores reduce the return premium typically associated with value stocks (Muñoz et al., 2021). Value stocks (high book-to-market) are usually seen as undervalued and risky, leading to higher returns as compensation for risk. However, if those companies also exhibit strong ESG practices, investors may perceive them as less risky. As a result, the expected return premium associated with HML may diminish, thus weakening the explanatory power of HML in the presence of ESG. This aligned with (Nsibande & Sebastian, 2023).

Overall, these results support the notion that integrating ESG considerations into the Fama-French asset pricing framework can enhance its predictive capability, particularly in the context of long-term, value-based investment strategies, this aligned with (Luo, 2022). Similar with (Naffa & Fain, 2022) Although the moderating role of ESG is not consistently significant across all factors, the model presents meaningful insights into how sustainability may interact with traditional risk factors, warranting further investigation with extended data periods or alternative model specifications.

Conclusion and Implication

The research result shows that market risk does not significantly influence excess stock returns for companies listed in the ESG Leaders Index, as indicated by its negative coefficient and lack of statistical significance. In contrast, the SMB factor demonstrates a significant positive effect, suggesting that lower capitalization firm tend to yield higher returns compared to larger firms (Gavrilakis & Floros, 2024). The HML factor exhibits a weak positive impact on excess returns, with marginal significance, implying that the value effect remains relevant, though not particularly strong. The ESG risk rating does not moderate the relationship between market risk or SMB and excess returns, as the interaction terms are statistically insignificant. However, the interaction between HML and the ESG risk rating shows a marginally significant moderating effect, denoting that sustainability considerations may weaken the influence of the book-to-market ratio on excess stock returns.

ESG-aware investors may no longer associate value stocks with high risk and high return, as sustainability practices reduce perceived risk. The traditional Fama-French model may be less accurate without incorporating ESG, especially when analyzing the performance of value stocks. The research result suggests that sustainability (as measured by ESG performance) moderates the relationship between book-to-market ratio and stock returns. Specifically, the positive impact of value characteristics (HML) on returns is dampened in firms with higher ESG ratings. These findings imply that the traditional value premium may be reduced due to lower perceived risk in the context of sustainable firms. Consequently, integrating ESG factors into asset pricing models is increasingly relevant, as it enhances the model's ability to capture nuanced investor behavior and return dynamics in sustainability-oriented markets.

This study has several limitations that pave the way for future research. A sample focused solely on ESG leaders limits the generalizability of the results. The use of the Fama-French three-factor model also limits explanatory power. Furthermore, the moderating role of ESG risk ratings is weak, which may reflect measurement limitations. Therefore, future research should utilize alternative or multi-source ESG metrics and employ dynamic approaches such as rolling regression or time-varying models to capture evolving relationships. Future research should expand to include companies with different ESG ratings in various indices and suggesting that incorporating additional factors such as profitability (RMW), investment (CMA), momentum, or liquidity may provide deeper insights.

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