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Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Full length article

Non-linear ESG effects on Jensen's Alpha: Evidence from a CAPM-based framework[☆]

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ARTICLE INFO

Keywords:

ESG
Alpha
Cost of capital
CAPM
Abnormal returns

ABSTRACT

This study examines the relationship between a firm's ESG performance, measured through Refinitiv ESG Scores, and its abnormal return relative to market risk (i.e., Alpha), using the Capital Asset Pricing Model (CAPM) as the benchmark for expected returns. Alpha is estimated under twelve alternative specifications, combining different estimation windows (3 and 5 years), return frequencies (daily, weekly, and monthly), and both ESG and non-ESG market benchmarks. The analysis is conducted on a sample of non-financial firms listed in the S&P 500 over the period 2015–2024. To assess the shape of the ESG-Alpha relationship, the empirical analysis relies on both a linear regression model and a quadratic specification. Across all the alternative Alpha estimation methodologies, the linear model provides evidence of a significant negative relation between ESG performance and Alpha, while the quadratic model reveals that this relationship can be better explained by a U-shaped function. More specifically, below a certain ESG score threshold, firms with weaker ESG performance tend to exhibit higher abnormal returns relative to the CAPM benchmark, while above that threshold, which occurs when the estimated Alpha reaches zero, the negative relationship gradually weakens and eventually turns positive. These findings suggest that the marginal ESG performance effect on Alpha may differ based on different levels of ESG scores, further supporting a non-linear approach.

1. Introduction

The growing interest in ESG-related issues has significantly influenced both academic research and the behavior of market participants, becoming a major topic of interest for both managerial and institutional purposes (Alves et al., 2025; Gillan et al., 2021; Pástor et al., 2022). This concern also translates into greater corporate attention to sustainability, both because of increasing regulatory constraints and the fact that negative externalities associated with non-sustainable practices can influence the market participants' perception of the firm (Gillan et al., 2021). As a consequence, the growing relevance of sustainable finance has reshaped the landscape of modern financial markets, as ESG investing has evolved into a comprehensive system that includes multiple investment strategies, regulatory requirements and sustainability valuation methodologies (Arouri et al., 2025; Cheng and Huang, 2024). However, despite the developed supporting theories on the corporate implications of sustainable practices¹ (Jain and Tripathi,

[☆] This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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¹ For example, exposure to both systematic and idiosyncratic risk (Becchetti et al., 2015; Albuquerque et al., 2019), and their implications in terms of cost of equity and cost of debt (El Ghoul et al., 2010; Ng and Rezaee, 2015).

<https://doi.org/10.1016/j.ribaf.2026.103437>

Received 25 November 2025; Received in revised form 30 March 2026; Accepted 20 April 2026

Available online 2 May 2026

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2023), the empirical contributions about how ESG performance may relate to a firm's value still presents mixed results (Postiglione et al., 2024). In this context, the relationship between a firm's sustainability performance and the Alpha of its stocks is particularly relevant, as it may affect how market participants interpret risk-adjusted performance and, more broadly, how they think about the cost of equity in valuation settings (Cornell and Damodaran, 2020). Within a CAPM framework, Alpha captures the abnormal return of an asset relative to the return predicted by its market exposure. Accordingly, a systematic association between ESG performance and Alpha would be consistent with the view that stock returns are influenced by ESG-related pricing channels. More specifically, the wedge between realized and expected returns may reflect not only the relative performance of green and brown stocks, but also investor preferences for sustainable assets and unexpected shifts in demand toward greener firms (Pástor et al., 2021, 2022; Zerbib, 2022). This distinction is especially important in light of recent research showing that green assets may earn strong realized returns following unexpected increases in climate concerns, even though their equilibrium expected returns may remain lower than those of brown assets (Pástor et al., 2022). In this theoretical framework, the relevance of the Capital Asset Pricing Model (CAPM) becomes evident, as it still represents the most widely adopted asset pricing model in professional practice for estimating the cost of capital (Graham, 2022; Pinto et al., 2019; Graham and Harvey, 2001).

Therefore, understanding how ESG performance relates to stock Alpha is relevant for both investors and firms, as it may help assess whether observed risk-adjusted returns are shaped by pricing channels beyond those captured by a standard CAPM benchmark. This issue is particularly important because the CAPM-implied expected return is widely used as the cost of equity in equity-side valuation and as a key input in the weighted average cost of capital (WACC) in firm valuation (Damodaran, 2012; Graham, 2022; Koller et al., 2020).

Adopting an Alpha-based perspective, a positive association would suggest that firms with stronger ESG profiles tend to exhibit realized returns above those predicted by the CAPM benchmark, consistent with an outperformance of greener stocks, whereas a negative association would indicate the opposite. However, while such a relation may appear comparable to the link between sustainability and firm financial performance,² its interpretation in an asset-pricing framework is more complex. The literature shows that, in equilibrium, investor preferences for sustainable assets may bid up the prices of high-ESG stocks, thereby lowering their expected returns; at the same time, firms with stronger ESG profiles may exhibit lower downside risk exposure or better hedging properties against adverse climate-related shocks (Chava et al., 2025; Pástor et al., 2021; Pedersen et al., 2021).

Starting from these considerations, this study aims to contribute to the still developing body of literature on the relationship between ESG and cost of capital by examining whether a firm's ESG score influences the Alpha of its stock within the S&P 500 index. In order to provide useful insights to both academics and market operators, we estimated Alpha as the difference between a stock's realized and expected returns (Jensen, 1968, 1969), with the latter measured through the Capital Asset Pricing Model framework (Sharpe, 1964; Lintner, 1965; Mossin, 1966). Given the extensive debate in academic literature and in professional application regarding the optimal combination of sampling frequency and time horizon for the estimation of the CAPM systematic risk exposure coefficient (i.e., Beta) (Bazhutov et al., 2023), we developed twelve different specifications that combine three sampling frequencies, namely (i) daily, (ii) weekly, and (iii) monthly, with two different observation periods, (i) three years and (ii) five years respectively, and two market benchmarks, namely (i) the S&P 500 index and (ii) the S&P 500 Scored & Screened index, with the latter also known as S&P 500 ESG.³

The results of our first-stage analysis reveal a negative linear relationship between Alpha and ESG performance across all twelve model specifications, indicating that, on average, browner stocks earned higher abnormal returns relative to the CAPM benchmark. This finding is consistent with the literature on the equity greenium, which suggests that greener assets command lower expected returns because investors derive non-pecuniary benefits from holding such assets and are willing to pay for these characteristics through lower returns. Therefore, greener assets may exhibit lower CAPM Alphas when investor demand for sustainable assets is sufficiently strong and ESG-related hedging motives are reflected in prices but not fully captured by the traditional CAPM benchmark. (Pástor et al., 2021, 2022).

Moreover, building on these results, we developed a non-linear specification to assess whether the negative association holds across all levels of ESG performance. This extension is particularly relevant because evidence based on ESG-sorted or quintile-sorted portfolios, as in Giese et al. (2019), suggests that the return implications of sustainability may vary across ESG levels, so that the marginal effect of ESG performance is unlikely to be uniform throughout the distribution. In particular, while investor preferences may compress expected returns for greener assets, the economic effects associated with very high ESG performance — such as stronger strategic positioning, stakeholder support, or downside-risk mitigation — may differ from those observed at intermediate ESG levels (Chava et al., 2025; Barnett and Salomon, 2012).

Therefore, the existence of a possible non-linear, and specifically quadratic, relationship may be explained by two complementary mechanisms. First, ESG performance may become positively associated with stock performance when it conveys information about firm fundamentals, long-term profitability, or stakeholder-related competitive advantages (Pedersen et al., 2021). Second, very high ESG engagement may operate through a risk channel that is not fully captured by a one-factor benchmark; in particular, strong ESG performance has been associated with lower downside risk and reduced exposure to downside-risk components (Hoepner et al., 2023). This intuition is also consistent with Pástor et al. (2021), who formalize an ESG-related risk factor on which green and brown

² For example, Hasan et al. (2024), Kossentini et al. (2024), Hasnaoui (2025) document a positive linear relationship between the adoption of sustainable practices or sustainable investment strategies and financial performance, while other studies report a negative relationship, suggesting an outperformance of assets that do not adopt sustainability practices (Jacobsen et al., 2019; Ji et al., 2021; Kranias et al., 2024).

³ The S&P 500 Scored & Screened Index is a broad-based, market-cap-weighted index that is designed to measure the performance of securities meeting sustainability criteria, while maintaining similar overall industry group weights as the S&P 500.

assets load with opposite signs. This implies that green assets may offer hedging benefits against sustainability-related risk events, even when their equilibrium expected returns are lower than those of brown assets.

Specifically, we tested whether the initially negative linear relationship evolves into a U-shaped function, whereby Alpha first declines and then turns positive only beyond a sufficiently high level of ESG performance. Our findings confirm this pattern across all previously discussed CAPM specifications. This evidence suggests that the association between ESG performance and CAPM-based Alpha is not constant across the ESG distribution, as it may reflect demand-based, hedging-related, or broader ESG-sensitive pricing mechanisms not directly summarized by a traditional one-factor CAPM benchmark (Cornell, 2021; Cohen, 2023; Chava et al., 2025; Priem and Gabbellone, 2024). As a consequence, firms with lower ESG scores tend to exhibit higher Alphas than firms with stronger ESG profiles; however, beyond a certain threshold, the relationship between Alpha and ESG score turns positive. This pattern is coherent with the hedging properties and information content of ESG score, as well as with the possibility that very high ESG performance is related with lower downside-risk exposure and stronger strategic benefits (Hoepner et al., 2023). Furthermore, it is also consistent with the recent evidence showing that periods of outperformance among stocks with stronger sustainability characteristics may reflect shifts in environmental concerns and sustainability-related demand (Pástor et al., 2022).

Overall, this work contributes to the empirical literature on the relationship between ESG factors and asset pricing, with implications for the interpretation of the cost of capital, by showing that ESG performance is systematically associated with CAPM Alpha across all model specifications considered. These findings have both academic and practical relevance, as they suggest that ESG-related characteristics may capture sources of risk, investor preferences, or hedging properties that are not fully reflected in traditional asset pricing models.

This study is structured as follows: Section 2 reviews the relevant academic literature and develops the research hypothesis of the present work. Section 3 outlines the methodology we use to estimate and retrieve the variables that form our dataset, as well as the regression models and robustness tests employed in the analysis. Section 4 presents the results of the models used to analyze the relationship and discusses the outcomes of the robustness tests performed to validate our model specification. Lastly, Section 5 concludes the study with a discussion of the findings and their implications.

2. Literature framework and hypothesis development

2.1. Jensen's Alpha and the CAPM

In this study we derived the expected returns of stocks utilizing the Capital Asset Pricing Model (CAPM) (Sharpe, 1964; Lintner, 1965; Mossin, 1966), a cornerstone in the literature of asset pricing theory, still widely used in both professional applications and scientific research (Fama and French, 2004; Biggestaff et al., 2025). The model is enclosed in a simple framework, where the expected return on any capital asset, over a single period, equals the risk-free rate plus the market equity risk premium multiplied by a coefficient named Beta that measures the asset sensitivity to market risk (Black, 1972), which can be measured as the covariance between the return of the asset and the market, divided by the variance of the latter (Fama and MacBeth, 1973). However, this structure also imposes several limitations, as it assumes that investors can borrow and lend unlimited amounts at a single risk-free rate, and that markets are perfectly efficient.

Therefore, soon after its introduction, other researchers developed various implementations to overcome these constraints. Among those, Black (1972) developed a model without the assumption that all market participants could borrow or lend at risk-free rate, while Merton (1973) introduced the so called "Intertemporal CAPM", a multi-period approach in which the investors are not only concerned about the expected return but about possible variations in the market conditions. Lastly, Black (1974) expanded the model demonstrating that it is still possible to achieve a market equilibrium without the free-risk rate component.

Despite these theoretical restrictions, the CAPM's relevance in both academic and professional applications is validated by both the extensive literature built on its framework (Pedersen et al., 2021; Chava et al., 2025) and its widespread use among market participants to estimate key component of the corporate valuation process (e.g. the cost of equity) (Graham, 2022). The appeal of the CAPM lies in its ability to offer powerful and intuitively pleasing predictions about the relationship between expected return and the exposure to systematic risk in a still very simple, comprehensible and applicable way (Fama and French, 2004).

Within the CAPM framework, while both the risk-free rate and the market return are exogenous inputs, with the latter being applied uniformly to all firms evaluated against the same benchmark index (Blume, 1971), Beta is a firm-specific parameter that captures the differences in each asset's exposure to systematic risk. However, the model does not provide explicit guidance regarding the sampling frequency used to estimate either the market return or the Beta coefficient, leaving these choices to the operator's discretion. This issue is a well-known bias that has been intensively studied shortly after the first definition of the model. Among these contributions, Blume (1971) and Vasicek (1973) developed an investigation process that led to a relevant sub-subject, known as "intervalling effect bias", which focuses on the variation in the estimated Beta for a stock arising from different return frequencies (Hawawini, 1980; Fung et al., 1985). As proposed by Levy et al. (2001), the choice of sampling frequency can have a significant impact on the estimation outcomes, as even a shift from weekly to quarterly data can affect the Beta coefficient substantially. The main reason underlying this issue lies in the fact that, according to the CAPM, Beta is estimated as the coefficient of a linear regression between the asset's return and the market's return, and is therefore inherently sensitive to different choices concerning the frequency of return observations. However, although its optimal sampling frequency is not yet universally agreed upon, daily and weekly data appear to yield more accurate estimates overall to date (Bazhutov et al., 2023).

Another fundamental issue for the Beta estimation is the selection of the time period over which data are measured, as the number of observations is a function of both the sampling frequency and the time-span considered. In the academic literature, there

is a consistent preference for a medium to long-term estimation window, even though [Bazhutov et al. \(2023\)](#) suggested that, while there is no optimal combination between sampling frequency and time period, a longer estimation period is more desirable within certain limitations. In particular, they showed that three and five year Betas appear more stable than those estimated using only a one year time frame. These findings are consistent with previous studies on the subject ([Ang and Bekaert, 2007](#); [Kamara et al., 2016](#)) also concluding that, in order to produce more efficient estimation of Beta, a medium-term time series (i.e., 3 or 5 years) is always preferred.

An additional limitation concerns the potential non-stationarity of Beta within the estimation window. Although the use of medium-term rolling windows is a widely adopted approach in the literature, it implicitly assumes that Beta remains approximately stable within each period. A long-standing literature has shown that Beta may vary over time ([Blume, 1971](#)), and more recent evidence confirms that sudden increases or decreases in Beta may occur even over relatively short horizons, making it difficult to estimate Beta precisely ([Bazhutov et al., 2023](#); [Becker et al., 2021](#)). This concern may be particularly relevant for firms undergoing major strategic, regulatory, or ESG-related transitions, for which exposure to systematic risk can evolve more rapidly. In these settings, rolling window Beta estimates may average different risk regimes, thereby introducing measurement error into the estimated coefficient and, mechanically, into the resulting Alpha. The literature has proposed several approaches to address this issue, including conditional CAPM models in which Beta depends on lagged information variables ([Person and Schadt, 1996](#)) and econometric specifications based on time-varying conditional correlations ([Engle, 2002](#)).

Despite the ongoing methodological debate, Beta estimated within a CAPM framework remains one of the most widely used measures of systematic risk exposure. In particular, the survey conducted by [Graham \(2022\)](#), whose results are similar to those obtained two decades earlier by [Graham and Harvey \(2001\)](#), shows that nearly 85% of large firms rely on the traditional CAPM to assess a firm's expected return and, by extension, its cost of equity.

Deriving from the expected return estimated with the CAPM, [Jensen \(1968, 1969\)](#) introduced one of the most utilized metrics in finance research, known as the Jensen's Alpha (Alpha) ([Jin, 2024](#); [Bhattacharya et al., 2025](#); [Dennis and Weston, 2025](#)). By introducing an intercept term into the CAPM model framework, [Jensen \(1968, 1969\)](#) formalized the idea that realized returns may differ from the return predicted on the basis of systematic risk exposure. In this framework, a positive Alpha indicates that a stock has outperformed its risk-adjusted expected return, while a negative Alpha indicates the opposite. As noted by [Cochrane \(2009\)](#), if the asset-pricing model fully accounts for expected returns, the regression intercept should be zero; however, in empirical applications, non-zero Alphas may reflect several factors, including omitted sources of priced risk, or equilibrium effects not fully captured by the reference model.

Building on the discussion on Beta estimation, given that Alpha is measured as the difference between realized and expected returns, its estimation is highly sensitive to the accuracy of the estimated Beta. As the literature notes, Beta estimates are subject to misspecification concerns ([Dimson, 1979](#)) and are affected by data frequency and sample-period choices ([Hawawini, 1980](#); [Kamara et al., 2016](#)). By contrast, realized returns do not face this issue: they are determined *ex-post* and computed as the closing price on the last trading day of the calendar year divided by that on the first trading day minus one ([Gormsen and Lazarus, 2023](#)). In any case, these considerations abstract from any issues inherent in market prices themselves, which, regardless of the methodology adopted for their analysis, may still be affected by additional problems, such as informational asymmetries.

2.2. Alpha and ESG performance

The growing awareness of market participants regarding Environmental, Social, and Governance (ESG) issues has encouraged investors to incorporate sustainability criteria into their investment decisions, making sustainable investing an increasingly widespread practice ([Agoraki et al., 2025](#)). Over time, this trend has contributed to develop a broader ecosystem including thematic funds, disclosure requirements, and ESG rating methodologies ([Cheng and Huang, 2024](#)). At the same time, investors' growing attention to ESG-related issues has also increased corporate incentives to improve a firm's performance integrating sustainability practices, in response to both tightening regulation and reputational effects that may affect firm value ([Gillan et al., 2021](#)).

To date, this issue has been mainly addressed by studies focused on the relationship between ESG and firms' financial performance, producing mixed findings. On the one hand, several studies document a positive association between sustainability scores and firm-level performance indicators, showing that higher ESG ratings are often linked to stronger financial performance ([Ademi and Klungseth, 2022](#); [Carlei et al., 2025](#); [Minutolo et al., 2019](#)) and higher firm valuation, as reflected in Tobin's Q ([Nguyen et al., 2022](#)). On the other hand, other studies report a negative relation between ESG factors and the financial performance of S&P 500 firms, documenting that the environmental and social dimensions are negatively associated with profitability measures such as ROA and ROE ([Alareeni and Hamdan, 2020](#)), while greener firms earn, on average, lower stock returns ([Chen et al., 2024](#); [Kranias et al., 2024](#)).

More broadly, the current literature suggests that ESG may affect stock returns through multiple channels, since its association with profitability, firm risk, and financing conditions can all shape market pricing and, therefore, observed abnormal returns ([Giese et al., 2019](#)). Consistent with this view, complementary evidence indicates that higher ESG ratings are associated with lower financing costs and lower uncertainty, including a negative relation with both the cost of debt and the cost of equity ([Goss and Roberts, 2011](#); [Chava, 2014](#); [Apergis et al., 2022](#)).

Recent research has also emphasized that ESG performance is shaped not only by firms' sustainability orientation, but also by broader organizational and financial characteristics. For example, [Zahid et al. \(2024\)](#) show that stronger managerial ability is positively associated with ESG performance, whereas financial constraints weaken the implementation of ESG initiatives. Similarly, [Hou et al. \(2025\)](#) document that digital transformation positively affects ESG performance and that this effect varies across

firm life-cycle stages. Taken together, these studies suggest that ESG scores may also embed managerial, financial, and organizational attributes, which is an important consideration when interpreting the relationship between ESG performance and Alpha.

Focusing on the relationship between ESG performance and the CAPM expected return measure, the main strand of research suggests the existence of a negative association between ESG scores and Beta, which implies that higher ESG performance is related to a lower systematic risk exposure and, given its formulations, to a lower cost of capital. Giese et al. (2019) observed that firms with high ESG performance exhibit lower Betas and therefore lower required returns, consistent with prior studies (Ng and Rezaee, 2015; Albuquerque et al., 2019). Analyzing the European context, Girerd-Potin et al. (2014) discussed that socially responsible firms exhibit a lower idiosyncratic risk exposure, suggesting the presence of a systematic risk factor ignored by traditional risk-return models. In this framework, the return of a stock could be explained by a new common factor representing the risk of not being socially responsible. This finding further supports the possible existence of a risk premium, priced by market participants and required by investors to hold stocks of firms that are exposed to ESG-related risks (Cornell, 2021). Recent empirical evidence suggest that ESG scores (Environmental and Social) do not materially affect unconditional Betas. Chava et al. (2025), studying S&P 500 firms, show that there is no significant relationship between past ESG score and Betas, even though they found that higher past ESG score can reduce the downside risk exposure for firms. Similarly, Priem and Gabellone (2024), using a sample of European firms, find that the overall ESG score do not have a statistically significant impact on Beta or on the cost of capital. This absence of a robust link between sustainability characteristics and systematic risk is corroborated also by Gutknecht (2025), who shows that media coverage of corporate social irresponsibility significantly raises total and idiosyncratic volatility while increasing negative skewness, but does not have a significant effect on stock's Beta. Consistent with this line of thought, Avramov et al. (2022) also found that expected returns for green assets are consistently lower than those for assets with weaker sustainability performance, observing that the expected returns increase with growing uncertainty about ESG risk.

While expected returns models, like the CAPM, are theoretical measures, realized returns derive from actual investment decisions observed *ex-post* on the market (Barka et al., 2023; Cao et al., 2019). In this sense, Alpha can be a useful metric in ESG-related research, as it captures the gap between realized returns and the returns predicted by a standard asset-pricing model. If ESG characteristics are systematically associated with Alpha, this may indicate that ESG-related channels affect stock returns in ways that are not fully captured by the benchmark model.

Consistent with the scope of the present study, previous research has already employed Alpha as a measure of risk-adjusted excess return in ESG settings. The empirical evidence, however, remains mixed. A first group of studies documents a negative relation between ESG characteristics and Alpha. For instance, Kranias et al. (2024) examined the effect of the Environmental pillar on Alpha for S&P 500 firms and documented a negative linear relation with the E score, suggesting that firms with stronger environmental performance exhibited lower abnormal returns. Similarly, Cohen (2023) found that, for S&P 500 constituents, stock excess returns are negatively related to the Social score and positively related to the Governance score, while the Environmental score did not show any significant impact on the excess returns. Similar results are reported also by Jacobsen et al. (2019), who suggested that non-ESG stocks are more likely to achieve a positive excess return compared to stocks with higher ESG performance, finding a lower return to risk ratios for ESG investments. From a theoretical perspective, Pedersen et al. (2021) formalized the cost of ESG preferences as the loss in Sharpe ratio that an investor incurs when choosing portfolios with higher ESG profiles than the unconstrained maximum Sharpe ratio portfolio.

This negative ESG-Alpha relation can also be interpreted within an equilibrium framework. Cornell (2021) argue that, to the extent that ESG-related risk is priced, firms with higher ESG ratings and lower exposure to such risk should be associated with lower expected returns because of their hedging properties. This interpretation is consistent with the broader equilibrium literature on sustainable investing and helps reconcile lower expected returns for greener firms with episodes of strong realized outperformance.

These theoretical implications are also coherent with Avramov et al. (2022), who related this effect to the ESG uncertainty grade. This approach is also consistent with another measure of ESG-related risk known as "ESG score disagreement", which is a measure of the disagreement on the ESG score of a stock between different rating providers. A positive relation between ESG score disagreement and stock returns was found in the S&P 500 index between 2010 and 2017 by Gibson Brandon et al. (2021); in their study, the authors demonstrated that stock returns are positively related to ESG rating disagreement, supporting the evidence of a risk premium required from market participants for stocks of firms with a higher exposure to ESG-related risks. Recent studies further indicate that excess returns decline in the presence of lower environmental risks, with higher environmental pillar scores corresponding to lower Alphas in US-listed firms (Horn et al., 2025).

Further support for a negative Alpha-ESG proposition can also be found in studies involving markets outside the United States, even though these contributions mainly focus on investment funds: Ji et al. (2021) found that, within the Eurozone, traditional funds generated positive Alphas, whereas renewable-energy funds exhibited, on average, negative Alphas over the same period. Consistent with this evidence, Jelasi et al. (2018) found that European sustainable and ethical investment funds generated negative Alphas between 1996 and 2015. These findings suggest the existence of a premium that investors are willing to pay in order to invest in environmentally friendly investment funds (Ji et al., 2021).

At the same time, another strand of the literature reports positive ESG-related abnormal performance. Pástor et al. (2022) provided evidence that green stocks strongly outperformed brown ones in the U.S. market between 2012 and 2020 after controlling for industry effects; however, they also argue that this pattern largely reflected an unanticipated increase in environmental concerns rather than structurally higher expected returns for green assets. Similarly, Sherwood and Pollard (2018) found significant over-performance for investment strategies based on ESG integration, arguing that integrating ESG factors into investment strategies may provide opportunities for higher returns and lower downside risk compared to more traditional investment approaches. Similar evidence is reported outside the United States. Kossentini et al. (2024) reported that, in Europe, sustainable indices outperform their

conventional counterparts, exhibiting positive Alphas in most years from 2008 to 2020. Coherently, [Hasan et al. \(2024\)](#) compared ESG indices from India, China, the United States, and the United Kingdom with non-ESG benchmarks, finding positive Alphas in almost all countries analyzed. Consistent with these results, [Hasnaoui \(2025\)](#) observed a positive association between ESG ratings and fund performance in the European technology sector over the period from 2013 to 2022, suggesting the existence of heterogeneity across sectors.

Beyond sectoral differences, the relation between ESG characteristics and Alpha also appears to vary across geographical regions. [Horn and Oehler \(2024\)](#) show that the relationship between the Alphas of equally weighted and market-capitalization-weighted portfolios and ESG rating quintiles differs markedly across regional samples. In the Asia-Pacific and North American markets, portfolio Alphas are negatively related to ESG ratings. By contrast, the opposite pattern emerges in Japan, where higher ESG ratings are associated with higher Alphas.

Finally, some contributions suggest that the relation between ESG characteristics and Alpha may be non-linear rather than monotonic. Earlier studies had already proposed the idea that the economic effects of sustainability-related characteristics may follow a non-linear pattern, showing that the relation between corporate social performance and corporate financial performance can be U-shaped ([Barnett and Salomon, 2012](#)). More recently, using Chinese data, [Zhang et al. \(2022\)](#) and [Wang et al. \(2024\)](#) investigated whether and how ESG investing works, suggesting the existence of a non-linear relationship with both high- and low-ESG portfolios generating higher Alphas and a convex parabolic relation for firms operating in the Internet sector, respectively.

The existing literature describes the relationship between ESG performance and Alpha as mixed and complex. Therefore, in order to contribute to both the stream of research on the CAPM framework and the literature on the link between sustainability performance and abnormal returns, there is a need for a comprehensive analysis of this relationship that reduces the sensitivity to the sampling choices involved in the estimation of the variables. For this purpose this study adopts multiple approaches to the calculation of Beta coefficients, consistent with prior research on the topic ([Bazhutov et al., 2023](#)). Furthermore, we derived two variety of Beta coefficient: an ESG Beta estimated using the S&P 500 ESG as the market benchmark and a traditional Beta estimated using the S&P 500, consistent with the differences documented in the literature between traditional and ESG market indices ([Banerjee et al., 2025](#)). Prior studies concluded that ESG-based indices differ in volatility compared to their conventional counterparts ([Moalla and Dammak, 2023](#)). It appears to be the case also for the S&P 500 ESG index, as it has been proved to be more sensitive to investor sentiment than the S&P 500: [Banerjee et al. \(2025\)](#) demonstrated that incorporating ESG information into a stock's price significantly enhances forecast accuracy for the S&P 500 ESG index, while also showing that the prices of its constituents are highly influenced by the so called "sentiment factors". The literature further suggests the role of the S&P 500 ESG index as a transmitter of volatility, particularly during periods of financial crisis ([Arouri et al., 2025](#); [Bhattacharjee et al., 2024](#)), as empirical evidence also proved its superior hedging capabilities compared to traditional equity assets ([Arouri et al., 2025](#); [Bhattacharjee et al., 2024](#)).

Based on the existing scientific literature and the identified research gaps, the relationship between Alpha and ESG carries relevant implications not only for academic research but also for multiple stakeholders, as understanding whether ESG performance affects abnormal returns is particularly relevant for investors, policymakers, and corporate decision-makers. Therefore, given the current state of academic research, this study assumes the following hypothesis:

H₁: There is a significant negative relationship between ESG scores and Alphas in a CAPM framework.

Given that Alpha measures the excess return of a stock relative to a CAPM benchmark, this hypothesis is grounded in the literature showing that ESG characteristics may affect expected returns through several pricing channels. In particular, high-ESG assets may command lower expected returns because investors derive non-pecuniary benefits from holding them and may value their hedging properties against sustainability-related risks ([Cornell, 2021](#); [Pedersen et al., 2021](#); [Pástor et al., 2021](#)). More broadly, prior studies also suggest that ESG factors can influence stock returns through their effects on expected returns and firm-specific risk exposures ([El Ghouli et al., 2010](#); [Albuquerque et al., 2019](#); [Giese et al., 2019](#); [Cohen, 2023](#)). In this framework, if a traditional CAPM benchmark does not fully capture these ESG-related pricing channels, firms with stronger ESG profiles may exhibit lower Alphas, while firms with poorer ESG performance may exhibit higher Alphas.

H₂: The relationship between Alpha and ESG scores is U-shaped, such that beyond a sufficiently high level of ESG performance, Alpha becomes positively associated with ESG scores.

If ESG performance is associated with lower exposure to sustainability-related risks and with firm characteristics that are valued by the market, ESG attributes may influence not only expected returns but also realized abnormal performance relative to a standard CAPM benchmark. To account for this possibility, the present study adopts a quadratic specification, which provides a parsimonious way to test for a non-monotonic relationship between ESG scores and Alpha. This hypothesis is consistent with several mechanisms emphasized in the sustainable-investing literature. On the one hand, equilibrium models suggest that investor preferences for sustainability can increase the demand for high-ESG assets, pushing up their prices and lowering their expected returns ([Pástor et al., 2021](#); [Zerbib, 2022](#)). Under this preference-based channel, greener assets may therefore exhibit lower abnormal returns than their brown counterparts, helping explain why the initial portion of the ESG-Alpha relation may be negative. On the other hand, at very high levels of ESG performance, the relationship may weaken or even reverse. Exceptionally high ESG scores may capture information about managerial quality, governance, organizational resilience, or long-term strategic positioning ([Pedersen et al., 2021](#)). In this case, firms located in the upper tail of the ESG distribution may exhibit positive Alpha relative to a standard one-factor benchmark. Moreover, very high ESG performance may be associated with lower downside risk, reduced exposure to adverse sustainability-related shocks, and, more generally, a more resilient risk profile, effects that may not be fully summarized by a standard one-factor asset-pricing model ([Hoepner et al., 2023](#); [Giese et al., 2019](#); [Luo and Balvers, 2017](#)).

Taken together, these arguments provide a theoretical rationale for a convex ESG-Alpha relation in which Alpha declines over intermediate ESG levels but increases again among firms with exceptionally strong ESG performance.

3. Method and data

3.1. Data

The following analysis covers a ten year period from 2015 to 2024, investigating a sample composed of non-financial companies listed on the S&P 500 index as of 2024. For each of these firms, daily closing prices were retrieved from Refinitiv Datastream and used to estimate the dependent variables as will be explained in Section 3.1.1. The methodology consists of a two-step fixed effects regression approach from linear to non-linear, which involves, together with the ESG scores, a set of firm-level annual variables employed as control variables that will be described in detail in Section 3.1.2.

3.1.1. Dependent variables

The dependent variable is the Jensen's Alpha (*Alpha*), estimated as follows:

$$Alpha_i = R_{i,t} - (R_f + Beta_i \cdot (ERP)) \quad (1)$$

where $R_{i,t}$ denotes the stock's realized return over year t , while $R_f + Beta_i \cdot (ERP)$ is the expected return calculated through the CAPM. Starting from the daily closing price series, we computed the yearly realized return of a stock $R_{i,t}$ as:

$$R_{i,t} = \frac{P_{12.31.t} - P_{12.31.t-1}}{P_{12.31.t-1}} \quad (2)$$

where $P_{12.31.t}$ is the closing price of the stock i at the end of the year t and $P_{12.31.t-1}$ correspond to the same value but referred to the last day of the previous year (Gormsen and Lazarus, 2023).

Once realized returns are computed, we estimated expected returns through the CAPM framework. In doing so, three inputs are required: (i) Beta; (ii) Equity Risk Premium (*ERP*); and (iii) Risk-free Rate (R_f).

Starting from the Beta, in order to estimate each stock's sensitivity to systematic risk, we built three different specification deriving from daily, weekly, and monthly returns computed as:

$$R_{i,n}^{(f)} = \frac{P_{i,n} - P_{i,n-1}}{P_{i,n-1}} \quad (3)$$

where $P_{i,n}$ denotes the closing price of stock i in the period n and $P_{i,n-1}$ the closing price in the previous period. Here, the index n denotes consecutive periods at the chosen sampling frequency: trading days for daily (D), last trading day of the week (i.e., Friday) for weekly (W) (Baumöhl and Lyócsa, 2012), and last trading day of the month for monthly (M).

Based on these return series, we estimate the Beta coefficients as follows:

$$Beta_i^{(f,T)} = \frac{Cov(R_i^{(f,T)}, R_m^{(f,T)})}{Var(R_m^{(f,T)})} \quad (4)$$

where $R_i^{(f,T)}$ refers to the series of return for the stock i and $R_m^{(f,T)}$ refers to the series of return for the market benchmark; f indicates the sampling frequency which could be: daily, weekly or monthly respectively (i.e., D , W , M). Estimates are computed over rolling windows of two different lengths T : 3 and 5 years. Given that Beta is an *ex-ante* measure of risk, the time series used to compute a period's Beta are those available at the beginning of that period⁴ (Jensen, 1968).

In order to fully investigate the ESG-Alpha relationship, we calculated two different Beta configuration, namely conventional and ESG, based on both 3 and 5 years observations for each of the three frequency sampling adopted (i.e., daily, weekly and monthly), whereas conventional Betas are built with the S&P 500 as the market benchmark (Dungey et al., 2022; Ardia et al., 2023; Minutolo et al., 2019; Patel, 2025), while ESG Betas use the S&P 500 ESG index. This process yields twelve Beta estimates per stock: six with the S&P 500 as the market benchmark ($3D$, $3W$, $3M$, $5D$, $5W$ and $5M$), and six with the S&P 500 ESG as the market benchmark ($3DESG$, $3WESG$, $3MESG$, $5DESG$, $5WESG$ and $5MESG$).⁵

Having obtained Betas under the twelve specifications, the second input needed to compute expected returns in the CAPM framework is the equity risk premium (ERP). To maintain consistency with the classical methodology for computing Alpha, the two inputs needed to estimate the equity risk premium (i.e., R_m and R_f) are defined following Jensen (1968). In this framework, the market return (R_m) is the realized return on the benchmark index over the calendar year (n),

$$R_{m,n} = \frac{P_{31.12.n} - P_{1.1.n}}{P_{1.1.n}} \quad (5)$$

Based on the Jensen's *ex-post* Alpha, adopting realized market returns instead of the expected ones avoids the additional forecast error that would arise from the employment of the previous year market return. The risk-free rate, R_f , is the market yield on U.S. treasury securities at 1-year constant maturity, taken on the first day of the corresponding year and retrieved from the Federal Reserve Bank of St. Louis (Jensen, 1968).

⁴ For example, the three-year Beta for 2015 is estimated from returns over January 1, 2012 through December 31, 2014, at the chosen sampling frequency (daily, weekly, or monthly); the three-year Beta for 2016 from January 1, 2013 through December 31, 2015, and so on.

⁵ In line with prior research, we did not implement a one-year estimation window specification, since a medium-term estimation window is more desirable for Beta estimation (Kamara et al., 2016; Bazhutov et al., 2023).

To ensure that Equity Risk Premium estimates are consistent with the Beta methodology outlined above, we construct two market-return series, hence two equity risk premium: a conventional one based on the S&P 500 and an ESG-adjusted one based on the S&P 500 ESG.

$$ERP_n = R_{S\&P500,n} - R_{f,n} \quad (6)$$

$$ERP_n^{ESG} = R_{S\&P500ESG,n} - R_{f,n} \quad (7)$$

Consequently, we obtained twelve expected returns based on the CAPM methodology for each firm: six derived from the conventional approach and six from the ESG-adjusted approach:

$$Alpha_i^{(f,T)} = R_{i,y}^{(f,T)} - \left(R_f + Beta_i^{(f,T)} \cdot ERP \right) \quad (8)$$

This approach makes it possible to assess the differences between realized and expected returns for a given stock while controlling for both the sampling choices and the use of an ESG-inclusive market benchmark, and while allowing to examine whether firms with stronger (or weaker) ESG performance exhibit more pronounced abnormal returns as measured by both the conventional Alpha and the ESG-adjusted Alpha.

3.1.2. Treatment and control variables

The treatment variable is represented by the ESG Score, hereafter referred to as *ESG*, which, in order to improve the interpretability of its regression coefficient, was scaled to a range from 0 to 1 for the analysis (Zhang et al., 2025).

In addition to the treatment variable, we included a set of control variables to isolate the effect of different ESG profiles on stock abnormal returns. First, we controlled for firm size, as firms of different dimensions exhibit varying degrees of idiosyncratic risk exposure (Fama and French, 1992). Accordingly, the natural logarithm of total assets was used as a proxy for firm size (*SIZE*), a widely adopted measure in ESG-related academic studies (Kranias et al., 2024; Rahman et al., 2023).

Second, since differences in financial structure may result in different levels of financial risk exposure, we included a measure of financial leverage, proxied by the debt-to-equity ratio (*LEV*) (Khanchel et al., 2023; Sandberg et al., 2023).

Third, we controlled for the fiscal dimension. The tax component was measured using the effective tax rate provided by Refinitiv (*TAX*). For firms exhibiting low variability in their effective tax rate over a five-year period, the tax rate was defined as the median value over that interval. For firms with higher volatility, the measure used was a weighted combination of the firm-level values and the effective tax rate of the corresponding country (Adeneye et al., 2022; Postiglione et al., 2025).

Fourth, we include pre-tax return on assets (*ROA*) as a measure of firm operating efficiency (Alareeni and Hamdan, 2020; Kranias et al., 2024), computed as the ratio of income before taxes to total assets. This specification avoids overlap with the fiscal dimension, which is separately controlled for through the *TAX* variable. While *ROA* is commonly used in related empirical settings, it is also closely related to contemporaneous stock performance and may therefore absorb part of the explanatory variation in returns, potentially reducing the estimated magnitude of the ESG effect. To address this concern, we first assess multicollinearity using variance inflation factors and then re-estimate all specifications excluding *ROA* as an additional robustness check. The corresponding results are reported in Section 4.3.

Finally, we included the price-to-book value per share (*P/BV*). This metric is necessary to capture the documented *book-to-market effect* identified by Fama and French (1992) and analyzed by Daniel and Titman (1997). A market price close to book value typically signals weaker growth opportunities compared to firms whose market prices trade significantly above book value (Fama and French, 1992). In this context, including *LEV* becomes especially important to mitigate potential confounding effects related to capital structure (Fama and French, 1992).

3.1.3. Normalization and final sample

A preliminary inspection of the raw sample obtained after data retrieval revealed an unbalanced distribution across all Beta specifications, suggesting the presence of outlier issues for the analysis. Therefore, we normalized the data sample adopting the Inter Quartile Range method (Aggarwal, 2016):

$$IQR = Q_3 - Q_1 \quad (9)$$

$$\text{Upper Bound} = Q_3 + 1.5 \times IQR \quad (10)$$

$$\text{Lower Bound} = Q_1 - 1.5 \times IQR \quad (11)$$

This process has been applied to all twelve Beta specifications, significantly adjusting the data distribution toward normality. The distributions of the observations in the raw and in the normalized sample are reported in Fig. 1.

The final sample obtained through this process consisted of 3385 observations for a total of 422 companies distributed between nine economic sectors (Table 1). This set of data has then been converted into a panel dataset and then used for the following analysis.

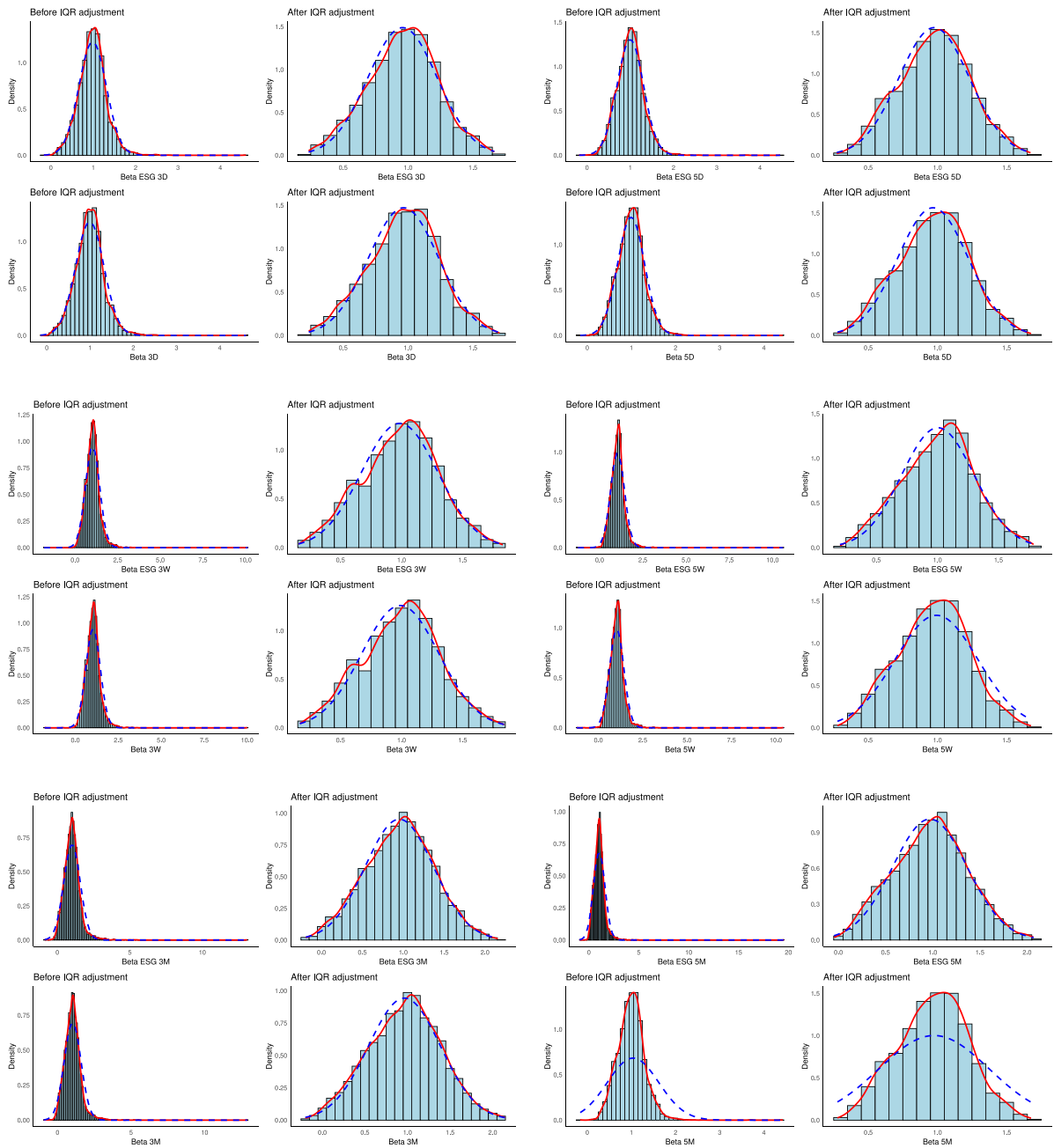


Fig. 1. IQR Sample Normalization.

This figure reports the distribution of the Beta coefficients for the sample. Betas are estimated using daily (D), weekly (W) and monthly (M) observations, each based on 3-year (3) and 5-year (5) windows. We also report ESG and non-ESG versions using, respectively, the S&P 500 index and the S&P 500 Scored and Screened index.

Table 1
Company distribution across sectors.

Sector	Companies	Freq. %
Technology	94	22.3%
Industrials	68	16.1%
Consumer Cyclical	60	14.2%
Healthcare	58	13.7%
Consumer Non-Cyclicals	37	8.8%
Utilities	31	7.3%
Real Estate	28	6.6%
Basic Materials	23	5.5%
Energy	23	5.5%
Total (9)	422	100%

Note: This table reports the distribution of companies across sectors in the sample. Percentages are calculated relative to the total number of firms.

3.2. Methodology

The first step of the analysis was to investigate whether a causal relationship could be examined through a multivariate linear regression, with Alpha as the dependent variable, the ESG score as the treatment variable, and the previously identified set of control variables. Accordingly, we developed a linear regression model that incorporates industry-level fixed effects together with temporal fixed effects.⁶

$$\text{Alpha}_{it} = \beta_1 \text{ESG}_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 \text{LEV}_{it} + \beta_4 \text{TAX}_{it} + \beta_5 \text{ROA}_{it} + \beta_6 \text{P/BV}_{it} + \gamma_i + \lambda_t + \varepsilon_{it} \quad (12)$$

where γ_i represents the industry fixed-effects for each firm i and λ_t represents the time fixed-effect for each year t (Zahid et al., 2024). Including both industry and time fixed effects allows us to control for time-invariant differences across industries and for shocks common to all firms in a given year. Under this specification, identification primarily relies on differences in ESG performance across firms operating in the same sector and facing the same time-specific conditions. This choice is consistent with the perspective of the present study, as ESG investment strategies are often implemented on a relative basis across peer firms within the same industry. By contrast, implementing firm fixed effects would absorb all time-invariant firm heterogeneity and identify the relation exclusively from within-firm changes in ESG over time (Khan et al., 2016). In addition, because ESG scores embed a strong industry component, industry and year fixed effects help make comparisons more meaningful by controlling for systematic sectoral differences and common time shocks (Kotsantonis and Serafeim, 2019).

Moreover, all regression models in the present study are estimated using the correction proposed by MacKinnon and White (1985), which allows for the estimation of a heteroskedasticity-robust variance-covariance matrix.⁷ The list of industries considered for industry level fixed-effect is reported in Table 2.

The descriptive statistics for dependent and independent variables are reported in Tables 3 and 4.

The second step of the analysis was to examine the potential non-linear relationship between the previously estimated Alphas and ESG scores, under the assumption of a U-shaped quadratic pattern in which the Alpha-ESG relationship is expected to turn positive beyond a sufficiently high level of sustainability performance (H_2). To test this hypothesis, the square of the ESG score was added to the model as an additional explanatory variable (Bagh et al., 2024).

It is important to clarify that the term non-linear does not imply that the regression model becomes non-linear in the econometric sense. The specification remains a linear regression because the parameters are estimated linearly; however, the functional relationship between the dependent variable and the explanatory variable becomes non-linear due to the inclusion of the squared treatment variable term (i.e., ESG) (Wooldridge, 2019). Thus, although the model is linear in its coefficients, it generates a non-linear (quadratic) relationship between Alpha and ESG.

In this specification, the treatment variables (i.e., ESG and ESG^2) were centered. The rationale for this choice is that variables exhibiting inherently high multicollinearity, as in the case of quadratic regressions, may create technical difficulties in estimating regression coefficients (Aiken et al., 1991). Although centering typically reduces the risk of multicollinearity, we further assess the presence of potential issues by conducting a VIF robustness test.

$$\text{Alpha}_{it} = \beta_1 \text{ESG}_{it} + \beta_2 \text{ESG}_{it}^2 + \beta \text{Controls}_{it} + \gamma_i + \lambda_t + \varepsilon_{it} \quad (13)$$

⁶ The use of fixed-effect regression models is well established in the analysis of Alpha: Gormsen and Lazarus (2023) employed various types of fixed effects in their regression analysis, whereas Boyer et al. (2023) relied solely on temporal fixed effects. In line with prior ESG-related literature (Khan et al., 2016; Gibson Brandon et al., 2021; Serafeim and Yoon, 2022), we adopted both temporal and industry-level fixed effects.

⁷ We implement the HC_1 estimator for heteroskedasticity-consistent covariance matrices. This approach adjusts for degrees of freedom and is among the most commonly used robust standard error corrections in empirical research (Hausman and Palmer, 2012). As an additional robustness test, we also estimate firm-level clustered standard errors, which provide a more conservative inference in our panel setting. Importantly, our main conclusions remain unchanged under this alternative variance-covariance specification whose results are reported in Appendix.

Table 2
List of industries.

Sector	Industry	Freq. %
Basic Materials	Commodity Chemicals	1.4%
	Agricultural Chemicals	0.7%
	Non-Paper Containers & Packaging	0.7%
	Specialty Chemicals	0.7%
	Construction Materials	0.5%
	Iron & Steel	0.5%
	Paper Packaging	0.5%
	Gold	0.2%
	Specialty Mining & Metals	0.2%
Consumer Cyclical	Discount Stores	1.2%
	Hotels, Motels & Cruise Lines	1.2%
	Restaurants & Bars	1.2%
	Broadcasting	0.9%
	Casinos & Gaming	0.9%
	Homebuilding	0.9%
	Auto, Truck & Motorcycle Parts	0.7%
	Advertising & Marketing	0.5%
	Apparel & Accessories	0.5%
	Apparel & Accessories Retailers	0.5%
	Auto & Truck Manufacturers	0.5%
	Auto Vehicles, Parts & Service Retailers	0.5%
	Construction Supplies & Fixtures	0.5%
	Consumer Publishing	0.5%
	Entertainment Production	0.5%
	Footwear	0.5%
	Home Improvement Products & Services Retailers	0.5%
	Leisure & Recreation	0.5%
	Miscellaneous Specialty Retailers	0.5%
	Computer & Electronics Retailers	0.2%
Department Stores	0.2%	
Home Furnishings	0.2%	
Home Furnishings Retailers	0.2%	
Recreational Products	0.2%	
Toys & Children's Products	0.2%	
Consumer Non-Cyclical	Food Processing	3.6%
	Consumer Goods Conglomerates	0.9%
	Non-Alcoholic Beverages	0.9%
	Personal Products	0.9%
	Food Retail & Distribution	0.7%
	Brewers	0.5%
	Household Products	0.5%
	Distillers & Wineries	0.2%
	Drug Retailers	0.2%
	Tobacco	0.2%
Energy	Oil & Gas Exploration and Production	2.1%
	Oil & Gas Refining and Marketing	0.9%
	Oil & Gas Transportation Services	0.9%
	Oil Related Services and Equipment	0.7%
	Renewable Energy Equipment & Services	0.5%
	Integrated Oil & Gas	0.2%
Healthcare	Pharmaceuticals	4.0%
	Medical Equipment, Supplies & Distribution	3.6%
	Advanced Medical Equipment & Technology	2.6%
	Healthcare Facilities & Services	1.4%
	Managed Healthcare	1.4%
	Biotechnology & Medical Research	0.7%
Industrials	Industrial Machinery & Equipment	2.8%
	Aerospace & Defense	2.6%
	Electrical Components & Equipment	2.6%
	Business Support Services	2.1%
	Ground Freight & Logistics	1.4%
	Professional Information Services	1.4%

(continued on next page)

Table 2 (continued).

Sector	Industry	Freq. %
	Heavy Machinery & Vehicles	0.9%
	Airlines	0.7%
	Courier, Postal, Air Freight & Land-based Logistics	0.5%
	Environmental Services & Equipment	0.5%
	Construction & Engineering	0.2%
	Employment Services	0.2%
Real Estate	Specialized REITs	3.1%
	Commercial REITs	1.7%
	Residential REITs	1.7%
	Real Estate Services	0.2%
Technology	Software	5.0%
	IT Services & Consulting	3.3%
	Online Services	3.1%
	Semiconductors	2.8%
	Electronic Equipment & Parts	1.9%
	Computer Hardware	1.7%
	Communications & Networking	1.2%
	Semiconductor Equipment & Testing	0.9%
	Wireless Telecommunications Services	0.7%
	Financial Technology (Fintech)	0.5%
	Integrated Telecommunications Services	0.5%
	Integrated Hardware & Software	0.2%
	Office Equipment	0.2%
	Phones & Handheld Devices	0.2%
Utilities	Electric Utilities	5.2%
	Multiline Utilities	1.7%
	Natural Gas Utilities	0.2%
	Water & Related Utilities	0.2%

Note: This table reports the distribution of companies across industries, indicating the economic sector to which each industry belongs. The industry category is the one used for the fixed effects within the regression analysis. Percentages are calculated relative to the total number of firms.

Table 3
Descriptive statistics.

Dependent Variables					
Variables	Obs.	Mean	Std. Dev.	Min	Max
<i>Alpha 3D</i>	3385	0.009	0.297	-0.893	5.539
<i>Alpha 3W</i>	3385	0.006	0.300	-0.873	5.637
<i>Alpha 3M</i>	3385	0.005	0.304	-0.909	5.620
<i>Alpha 5D</i>	3385	0.007	0.296	-0.882	5.496
<i>Alpha 5W</i>	3385	0.003	0.299	-0.853	5.529
<i>Alpha 5M</i>	3385	0.006	0.302	-0.947	5.559
<i>Alpha ESG 3D</i>	3385	0.004	0.297	-0.877	5.527
<i>Alpha ESG 3W</i>	3385	0.000	0.301	-0.859	5.630
<i>Alpha ESG 3M</i>	3385	0.000	0.304	-0.899	5.618
<i>Alpha ESG 5D</i>	3385	0.002	0.296	-0.869	5.478
<i>Alpha ESG 5W</i>	3385	-0.003	0.299	-0.843	5.514
<i>Alpha ESG 5M</i>	3385	0.000	0.302	-0.925	5.545
Independent Variables					
Variables	Obs.	Mean	Std. Dev.	Min	Max
<i>ESG</i>	3385	62.091	16.703	10.867	93.382
<i>SIZE</i>	3385	45.909	81.266	0.275	1153.881
<i>LEV</i>	3385	1.658	8.253	0.000	422.100
<i>TAX</i>	3385	0.235	0.084	0.000	0.479
<i>ROA</i>	3385	0.093	0.088	-0.496	0.565
<i>P/BV</i>	3385	10.388	39.374	0.284	1290.720

Note: This table reports descriptive statistics for the variables used in this study. Jensen's Alphas are estimated using daily (D), weekly (W) and monthly (M) observations, each based on time series of three years (3y) and five years (5y). In this framework, we also estimate two specifications of each variable: an ESG version, where the market return is represented by the S&P500 Scored and Screened index, and a non-ESG version, where the market return is represented by the S&P500 index. For all independent variables, we recall the explanation given in Section 3.1.2. Values for the *SIZE* variable are expressed in billions. All values are rounded to three decimal places.

Table 4
Correlation matrix.

	A3D	A3W	A3M	A5D	A5W	A5M	AE3D	AE3W	AE3M	AE5D	AE5W	AE5M	ESG	SIZE	LEV	TAX	ROA	P/BV
A3D	1.00	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	-0.13	-0.04	0.01	0.06	0.20	0.07
A3W	0.99	1.00	0.98	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	-0.14	-0.04	0.01	0.06	0.20	0.07
A3M	0.98	0.98	1.00	0.98	0.98	0.99	0.98	0.98	0.99	0.98	0.98	0.99	-0.14	-0.03	0.01	0.05	0.19	0.07
A5D	0.99	0.99	0.98	1.00	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	-0.14	-0.04	0.01	0.06	0.20	0.07
A5W	0.99	0.99	0.98	0.99	1.00	0.98	0.99	0.99	0.98	0.99	0.99	0.98	-0.14	-0.04	0.01	0.06	0.20	0.07
A5M	0.98	0.98	0.99	0.98	0.98	1.00	0.98	0.98	0.99	0.98	0.98	0.99	-0.14	-0.03	0.01	0.06	0.20	0.07
AE3D	0.99	0.99	0.98	0.99	0.99	0.98	1.00	0.99	0.98	0.99	0.99	0.98	-0.14	-0.04	0.01	0.07	0.19	0.07
AE3W	0.99	0.99	0.98	0.99	0.99	0.98	0.99	1.00	0.98	0.99	0.99	0.98	-0.14	-0.04	0.01	0.07	0.20	0.07
AE3M	0.98	0.98	0.99	0.98	0.98	0.99	0.98	0.98	1.00	0.98	0.98	0.99	-0.14	-0.04	0.00	0.06	0.19	0.07
AE5D	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	1.00	0.99	0.98	-0.14	-0.04	0.01	0.07	0.20	0.07
AE5W	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	0.99	1.00	0.98	-0.14	-0.04	0.01	0.07	0.20	0.07
AE5M	0.98	0.98	0.99	0.98	0.98	0.99	0.98	0.98	0.99	0.98	0.98	1.00	-0.15	-0.04	0.01	0.06	0.19	0.07
ESG	-0.13	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.15	1.00	0.17	0.03	-0.24	-0.02	0.03
SIZE	-0.04	-0.04	-0.03	-0.04	-0.04	-0.03	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	0.17	1.00	-0.01	-0.03	-0.07	-0.04
LEV	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.03	-0.01	1.00	0.00	0.00	0.73
TAX	0.06	0.06	0.05	0.06	0.06	0.06	0.07	0.07	0.06	0.07	0.07	0.06	-0.24	-0.03	0.00	1.00	0.08	0.01
ROA	0.20	0.20	0.19	0.20	0.20	0.20	0.19	0.20	0.19	0.20	0.20	0.19	-0.02	-0.07	0.00	0.08	1.00	0.14
P/BV	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.03	-0.04	0.73	0.01	0.14	1.00

Note: A = Alpha, AE = Alpha ESG. This table report pairwise Pearson correlations among the variables rounded to the second decimal. The correlation coefficients among the various estimated Alpha are extremely close to 1. Therefore, different Beta estimation frequency (i.e., 3D, 3W, 3M, 5D,5W, 5M) does not substantially modify the pricing error estimated through the Alpha. Similarly, the correlation between conventional and ESG Alphas remains close to 1, suggesting that the integration of a ESG market benchmark in the estimation process does not alter significantly the Alpha distribution across firms. The ESG score shows a negative correlation with both the conventional and the ESG-adjusted Alpha indicating a possible negative relationship that will be analyzed more in-depth in the regression model.

Finally, to assess the results obtained from the second-stage model (Eq. (13)), we examined the fitted relationship between Alpha and the ESG score by plotting the predicted values implied by the quadratic specification.

$$\widehat{Alpha}_{i,y} = \hat{\beta}_1 ESG_{i,y} + \hat{\beta}_2 ESG_{i,y}^2 \tag{14}$$

where $\hat{\beta}_1$ and $\hat{\beta}_2$ denote the estimated coefficients for the selected Alpha specification, and \widehat{Alpha} represents the predicted values of Jensen’s Alpha from the previous model. This approach allows to construct the prediction curve for all Alpha specifications in order to assess whether the relationship turn positive at a certain level of the ESG score. Such verification is necessary to evaluate the validity and internal consistency of the second hypothesis, H_2 .

3.3. Robustness tests

To assess the robustness of the regression results, six diagnostic and supplementary tests are employed: (i) the Variance Inflation Factor (VIF) test; (ii) the Hausman test; (iii) the Two-Stage Least Squares (2SLS) estimator; (iv) the Control Function Approach (CFA); (v) a Propensity Score Matching (PSM) approach; and (vi) a re-estimation of the main specifications excluding ROA.

The Variance Inflation Factor assesses the presence of multicollinearity among the explanatory variables included in the model. For each independent variable, the test provides an indicator of how much the variance of the estimated coefficient is inflated because of its linear correlation with the other regressors. In line with established practice in the literature, values below the threshold of 5 are generally interpreted as indicating the absence of significant multicollinearity, thereby supporting the reliability of the estimated coefficients (Dutordoir et al., 2024; Meng et al., 2024).

The Hausman test is used to evaluate the appropriateness of the fixed-effects specification relative to the alternative random-effects model (Hausman, 1978). More specifically, the test examines whether the coefficients estimated under the fixed-effects (FE) and random-effects (RE) estimators differ systematically. Under the null hypothesis, the RE estimator is consistent and both estimators should converge to the same true coefficients, with any differences attributable only to sampling variation. A statistically significant test therefore suggests that the RE model is inconsistent and that the FE specification is more appropriate.

To investigate the possible presence of endogeneity in the model, we employ several complementary methodologies, as endogeneity may arise from a variety of sources, including omitted variables, reverse causality, simultaneity, and sample-selection issues. This concern is reinforced by recent evidence showing that ESG performance is systematically related to managerial ability, financial constraints, digital transformation, and firm life-cycle stage, all of which may be only imperfectly captured in return regressions and may therefore contribute to residual endogeneity or model misspecification (Zahid et al., 2024; Hou et al., 2025).

First, omitted variable bias associated with time-invariant unobserved heterogeneity is mitigated through the inclusion of industry and time fixed effects in the regression specification. Second, to address potential simultaneity and reverse-causality concerns, we rely on both the two-stage least squares (2SLS) estimator and the Control Function Approach (CFA), using first- and second-lagged ESG scores as instruments. The use of both methods is also motivated by the quadratic specification of the regression model: while 2SLS is commonly applied in linear settings, the Control Function Approach is better suited to models that include non-linear transformations of potentially endogenous regressors (Wooldridge, 2015). At the same time, because ESG scores tend to be persistent

Table 5
Fixed-effects regression with Jensen's Alpha.

	<i>Alpha 3D</i>	<i>Alpha 3W</i>	<i>Alpha 3M</i>	<i>Alpha 5D</i>	<i>Alpha 5W</i>	<i>Alpha 5M</i>
<i>ESG</i>	−0.172*** (0.043)	−0.177*** (0.043)	−0.197*** (0.044)	−0.175*** (0.043)	−0.179*** (0.043)	−0.199*** (0.043)
<i>SIZE</i>	−0.007 (0.006)	−0.006 (0.006)	−0.005 (0.006)	−0.007 (0.006)	−0.005 (0.006)	−0.005 (0.006)
<i>LEV</i>	−0.002* (0.001)	−0.002* (0.001)	−0.002* (0.001)	−0.002* (0.001)	−0.002* (0.001)	−0.002* (0.001)
<i>TAX</i>	0.037 (0.078)	0.021 (0.077)	−0.007 (0.079)	0.036 (0.077)	0.023 (0.077)	0.005 (0.078)
<i>ROA</i>	0.630*** (0.084)	0.648*** (0.084)	0.658*** (0.087)	0.634*** (0.083)	0.648*** (0.083)	0.650*** (0.086)
<i>P/BV</i>	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)
Observations	3385	3385	3385	3385	3385	3385
R^2	0.167	0.177	0.174	0.174	0.183	0.180
Adj. R^2	0.140	0.151	0.147	0.148	0.158	0.154

Note: This table reports fixed-effects regressions where the dependent variable is the *Alpha* estimated under six specifications (3y/5y; daily/weekly/monthly). Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

over time, lagged ESG variables may constitute relatively weak internal instruments, and the results should therefore be interpreted with appropriate caution.

To further mitigate potential selection effects, and as an additional robustness test, we implement a propensity score matching (PSM) design (Rosenbaum and Rubin, 1983; Caliendo and Kopeinig, 2008; Hou et al., 2025). The rationale is to construct comparable portfolios of firms that are highly similar in terms of observable firm characteristics, while differing in their ESG performance. Specifically, firms are classified into *HIGH* and *LOW* ESG groups according to the LSEG methodology, under which scores above 50 indicate an above-average level of sustainability performance (LSEG, 2024). Importantly, this cutoff is not an arbitrary partition, but a threshold embedded in the provider's own scoring methodology. Its use is therefore coherent with the way ESG information is actually structured and transmitted to market participants, shaping their investment preferences. Observations are then matched using the full set of firm-specific controls, allowing us to compare firms with different ESG profiles but similar observable characteristics. This procedure complements the fixed-effects and instrumental-variable approaches by assessing whether the documented relationship also holds within a matched sample of comparable firms.

As a final robustness exercise, we re-estimate all main specifications excluding *ROA*. Although *ROA* is commonly used as a control for firm operating efficiency, it is also closely related to contemporaneous stock performance and may therefore absorb part of the variation otherwise attributed to ESG in explaining Alpha. Re-estimating the models without *ROA* allows us to assess whether the main findings remain qualitatively unchanged when this control is omitted.

4. Results and discussion

4.1. The linear fixed-effects regression

The first step of the analysis was developed as a linear regression between Alpha, as the dependent variable, ESG scores as the treatment variable and the other control variable presented in Section 3.1.2, employing time and industry-level fixed-effects. Results are shown in Table 5 for the six specifications of traditional Alphas and in Table 6 for the six specifications of ESG Alphas.

Compatible with the first hypothesis (H_1), the ESG score displays a negative and statistically significant coefficient across all specifications ($p < 0.01$ in every model). This indicates that firms with higher ESG scores tend to exhibit lower Alpha, after controlling for conventional determinants of risk-adjusted excess returns. The consistency of this result across all Alpha specifications supports the robustness of the estimated relationship, as the effect does not depend on alternative estimation choices (e.g., daily, weekly, or monthly frequencies; three- to five-year windows). Moreover, incorporating ESG information into the estimation of systematic risk exposure through the S&P 500 ESG benchmark does not alter either the sign or the statistical significance of the ESG coefficient. This suggests that using an ESG-based benchmark to estimate expected returns does not materially affect the documented negative association between ESG performance and abnormal returns relative to the CAPM benchmark.

Analyzing the coefficients of the control variables, we observe a positive and statistically significant relationship between *ROA* and Alpha. This finding is consistent with previous studies (Yadav et al., 2025), as higher end-of-year profitability tends to be reflected in higher stock prices (i.e., realized returns), although it does not necessarily imply higher expected returns under the CAPM framework. A negative relationship is found between *SIZE* and *LEV* and the dependent variable; however, only the coefficient of *LEV* is statistically significant ($p < 0.1$ across all models), in line with prior research on the relationship between Alpha and financial leverage (García-Feijóo and Jansen, 2023). No clear association emerges between the firm's tax rate (*TAX*) and Alpha, as the coefficients are uniformly statistically insignificant. Lastly, we find a positive relationship between the price-to-book ratio

Table 6
Fixed-effects regression with ESG Jensen's Alpha.

	<i>Alpha</i> <i>ESG 3D</i>	<i>Alpha</i> <i>ESG 3W</i>	<i>Alpha</i> <i>ESG 3M</i>	<i>Alpha</i> <i>ESG 5D</i>	<i>Alpha</i> <i>ESG 5W</i>	<i>Alpha</i> <i>ESG 5M</i>
<i>ESG</i>	-0.173*** (0.043)	-0.178*** (0.043)	-0.198*** (0.044)	-0.175*** (0.043)	-0.180*** (0.043)	-0.201*** (0.043)
<i>SIZE</i>	-0.007 (0.006)	-0.006 (0.006)	-0.005 (0.006)	-0.007 (0.006)	-0.005 (0.006)	-0.005 (0.006)
<i>LEV</i>	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)
<i>TAX</i>	0.038 (0.078)	0.021 (0.077)	-0.010 (0.079)	0.037 (0.077)	0.023 (0.077)	0.003 (0.078)
<i>ROA</i>	0.626*** (0.084)	0.645*** (0.084)	0.657*** (0.087)	0.631*** (0.083)	0.646*** (0.083)	0.649*** (0.086)
<i>P/BV</i>	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)
Observations	3385	3385	3385	3385	3385	3385
R^2	0.166	0.179	0.174	0.172	0.184	0.181
Adj. R^2	0.139	0.153	0.148	0.146	0.158	0.155

Note: This table reports fixed-effects regressions where the dependent variable is the *Alpha* estimated by employing the ESG benchmark (*Alpha ESG*) under six specifications (3y/5y; daily/weekly/monthly). Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

(*P/BV*) and *Alpha* ($p < 0.1$ in all models). This result is consistent with the book-to-market effect documented by Fama and French (1992): a higher price-to-book ratio corresponds to a lower book-to-market ratio, which is typically associated with stronger growth opportunities and higher realized returns, an effect not captured by the CAPM. Therefore, including *P/BV* in the model allows us to control for this effect.

A comparative analysis of both the R^2 and adjusted R^2 values denotes that the model returns a slightly better explanation of the *Alpha* estimate with a 5-year time-frame compared to the 3-year one. In addition, the model explains a higher percentage of variability for the *Alphas* estimated utilizing weekly and monthly returns. Although the detected difference is marginal, this finding supports the already existing literature, suggesting that the use of a medium-term horizon for the estimation yields more reliable results (Bazhutov et al., 2023).

These findings are consistent with prior literature documenting a negative association between ESG performance and abnormal returns. In particular, they support the idea that ESG-related characteristics may capture return differentials that are not fully accounted for by the standard one-factor CAPM (Cornell, 2021; Priem and Gabellone, 2024; Chava et al., 2025). They are also in line with the equilibrium literature on sustainable investing. As shown by Pástor et al. (2021), investor preferences for greener assets can bid up the prices of high-ESG stocks and, all else equal, lower their expected returns. Accordingly, the negative ESG-*Alpha* relationship documented in our results suggests that firms with stronger ESG performance earn lower abnormal returns relative to a traditional CAPM benchmark. Moreover, the fact that this pattern remains unchanged when systematic risk is estimated using the S&P 500 ESG benchmark indicates that simply replacing the market proxy with an ESG-oriented index is not sufficient to absorb ESG-related return differentials.

4.2. The quadratic fixed-effects regression

The second step of the analysis was developed through a quadratic regression between *Alpha*, as the dependent variable, *ESG* and *ESG*² scores as treatment variables and the other control variables employing time and industry-level fixed-effects. Results are shown in Table 7 for the six specifications of traditional *Alphas* and in Table 8 for the six specifications of ESG *Alphas*.

In order to test our second hypothesis (H_2), we augment the baseline linear model with a quadratic ESG term. Under this hypothesis, the negative association between ESG and *Alpha* documented in the linear specification is expected to weaken as ESG performance increases and, at sufficiently high levels of ESG, potentially reverse. In this sense, the quadratic specification allows us to assess whether abnormal returns relative to the CAPM benchmark follow a non-linear pattern across the ESG distribution.

The coefficient analysis confirms that the non-linear approach provides a positive and significant relationship between the centered squared term of the ESG score (*ESG*²) and *Alpha* in each specification ($p < 0.05$ for all estimated models), while the linear term maintains a significant negative relationship with the dependent variable ($p < 0.01$ for all estimated models), confirming the existence of a U-shaped relationship, which appears to be strongest for the 5-year monthly model, both with the traditional and the ESG-adjusted approach (*Alpha 5M*, *Alpha ESG 5M*). Moreover, the analysis of the control variables' coefficients reveals relationship patterns consistent with those observed in the linear models.

Accordingly, the estimated quadratic specification implies the existence of a turning point beyond which the marginal association between ESG and *Alpha* changes sign. This suggests that the negative ESG-*Alpha* relation documented in the linear model may characterize a broad portion of the ESG distribution, while becoming weaker and eventually positive among firms with exceptionally

Table 7
Fixed-effects quadratic regression with Jensen's Alpha.

	<i>Alpha 3D</i>	<i>Alpha 3W</i>	<i>Alpha 3M</i>	<i>Alpha 5D</i>	<i>Alpha 5W</i>	<i>Alpha 5M</i>
<i>ESG</i>	-0.135*** (0.041)	-0.137*** (0.042)	-0.151*** (0.042)	-0.136*** (0.041)	-0.136*** (0.041)	-0.152*** (0.042)
<i>ESG</i> ²	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004*** (0.002)
<i>SIZE</i>	-0.007 (0.006)	-0.006 (0.006)	-0.005 (0.006)	-0.007 (0.006)	-0.006 (0.006)	-0.005 (0.006)
<i>LEV</i>	-0.002 (0.001)	-0.002 (0.001)	-0.002* (0.001)	-0.002 (0.001)	-0.002* (0.001)	-0.002* (0.001)
<i>TAX</i>	0.041 (0.078)	0.025 (0.077)	-0.002 (0.079)	0.040 (0.077)	0.027 (0.077)	0.010 (0.078)
<i>ROA</i>	0.632*** (0.084)	0.650*** (0.084)	0.661*** (0.087)	0.636*** (0.083)	0.650*** (0.083)	0.652*** (0.086)
<i>P/BV</i>	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)
Observations	3385	3385	3385	3385	3385	3385
<i>R</i> ²	0.168	0.178	0.175	0.175	0.185	0.182
Adj. <i>R</i> ²	0.141	0.152	0.149	0.149	0.159	0.156

Note: This table reports fixed-effects regressions where the dependent variable is *Alpha* under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared *ESG* score. *ESG* and *ESG*² are centered. Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 8
Fixed-effects quadratic regression with ESG Jensen's Alpha.

	<i>Alpha ESG 3D</i>	<i>Alpha ESG 3W</i>	<i>Alpha ESG 3M</i>	<i>Alpha ESG 5D</i>	<i>Alpha ESG 5W</i>	<i>Alpha ESG 5M</i>
<i>ESG</i>	-0.135*** (0.041)	-0.137*** (0.042)	-0.152*** (0.042)	-0.136*** (0.041)	-0.136*** (0.041)	-0.153*** (0.042)
<i>ESG</i> ²	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.005*** (0.002)
<i>SIZE</i>	-0.008 (0.006)	-0.007 (0.006)	-0.005 (0.006)	-0.008 (0.006)	-0.006 (0.006)	-0.005 (0.006)
<i>LEV</i>	-0.002 (0.001)	-0.002 (0.001)	-0.002* (0.001)	-0.002 (0.001)	-0.002* (0.001)	-0.002* (0.001)
<i>TAX</i>	0.042 (0.078)	0.025 (0.077)	-0.005 (0.079)	0.041 (0.077)	0.027 (0.077)	0.008 (0.078)
<i>ROA</i>	0.628*** (0.084)	0.648*** (0.084)	0.660*** (0.087)	0.633*** (0.083)	0.649*** (0.083)	0.652*** (0.086)
<i>P/BV</i>	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)
Observations	3385	3385	3385	3385	3385	3385
<i>R</i> ²	0.167	0.180	0.176	0.174	0.186	0.183
Adj. <i>R</i> ²	0.140	0.154	0.150	0.147	0.160	0.157

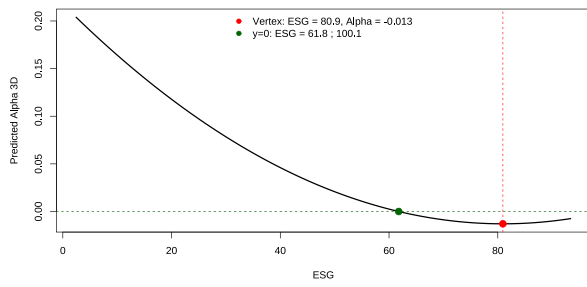
Note: This table reports fixed-effects regressions where the dependent variable is *Alpha ESG* under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared *ESG* score. *ESG* and *ESG*² are centered. Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

high ESG scores. Such a pattern is consistent with the idea that ESG-related return differentials are not fully captured by a standard CAPM benchmark and, more broadly, with the non-linear mechanisms discussed in the sustainable-investing literature.

To assess whether this threshold is consistent with our second hypothesis H_2 , we computed the predicted values of Alpha using the estimated coefficients on the treatment variables (*ESG* and *ESG*²) and plotted the fitted relationship (Eq. (14)). This procedure builds a prediction curve for each Alpha specification and allows us to assess whether the relation becomes flatter and eventually turns positive beyond a given ESG level, thereby identifying the level of ESG performance at which the marginal ESG-Alpha association changes sign. The graphic representations of the relationship between predicted Alphas and ESG scores are reported in the following figures, which are based, respectively, on the combination of conventional Alpha and ESG Alpha based on the 3 year daily (Fig. 2), 3 year weekly (Fig. 3), 3 year monthly (Fig. 4), 5 year daily (Fig. 5), 5 year weekly (Fig. 6) and 5 year monthly (Fig. 7) specifications.

The fitted predictions are consistent with both H_1 and H_2 . Across specifications, the estimated ESG-Alpha relationship is negative over a broad portion of the ESG distribution and becomes progressively weaker as ESG performance increases. In other terms, predicted Alpha is positive for relatively low ESG scores, crosses zero at approximately $ESG \approx 61.5$, and reaches its minimum

(a) Estimated Relationship: *ESG Score* and *Alpha 3D*



(b) Estimated Relationship: *ESG Score* and *Alpha ESG 3D*

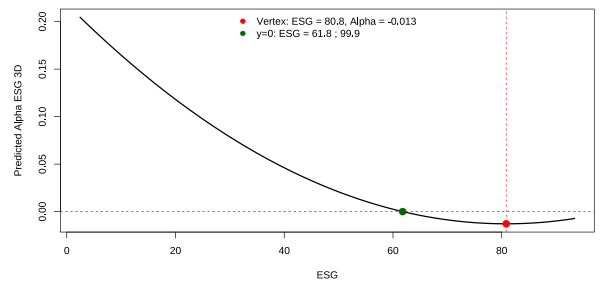
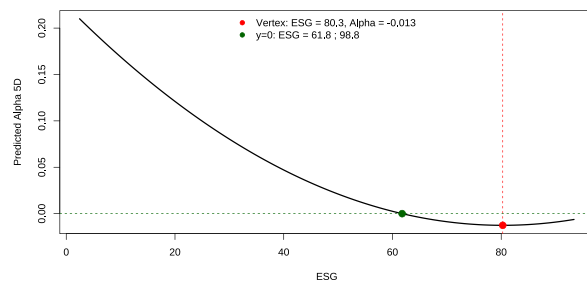


Fig. 2. Estimated relationship between ESG scores and predicted Alphas (3 years daily). This figure reports the predicted values of *Alpha*, estimated using daily returns in a 3-year time window, for each ESG score from 1 to 100, under two specifications (ESG/non-ESG). The red vertical line represents the vertex; the green horizontal line indicates a predicted *Alpha* equal to zero.

(a) Estimated Relationship: *ESG Score* and *Alpha 5D*



(b) Estimated Relationship: *ESG Score* and *Alpha ESG 5D*

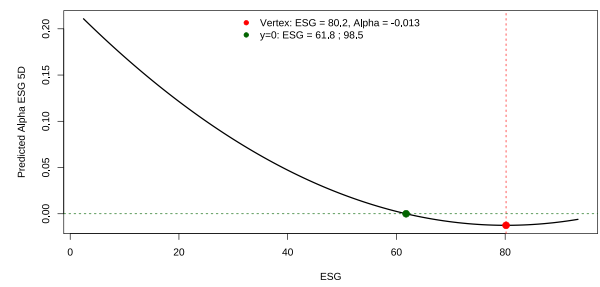
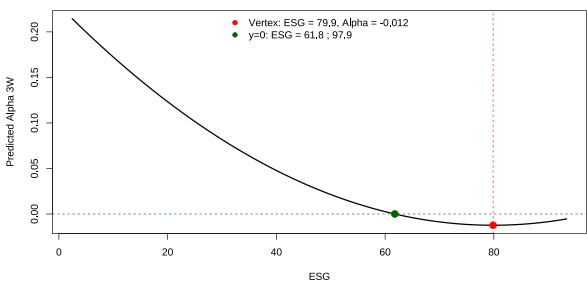


Fig. 3. Estimated relationship between ESG scores and predicted Alphas (5 years daily). This figure reports the predicted values of *Alpha*, estimated using daily returns in a 5-year time window, for each ESG score from 1 to 100, under two specifications (ESG/non-ESG). The red vertical line represents the vertex; the green horizontal line indicates a predicted *Alpha* equal to zero.

(a) Estimated Relationship: *ESG Score* and *Alpha 3W*



(b) Estimated Relationship: *ESG Score* and *Alpha ESG 3W*

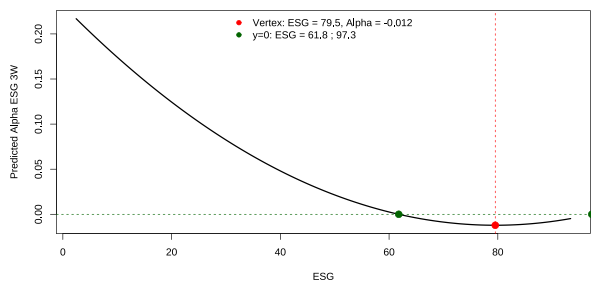
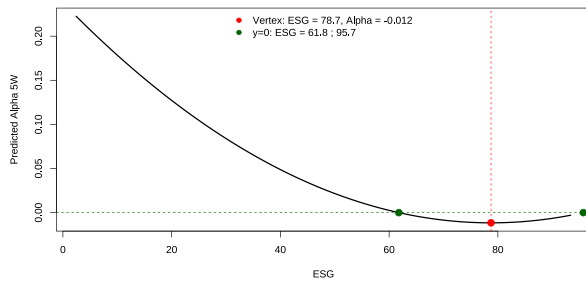


Fig. 4. Estimated relationship between ESG scores and predicted Alphas (3 years weekly). This figure reports the predicted values of *Alpha*, estimated using weekly returns in a 3-year time window, for each ESG score from 1 to 100, under two specifications (ESG/non-ESG). The red vertical line represents the vertex; the green horizontal indicates a predicted level of *Alpha* equal to zero.

around $ESG \approx 80.0$, where predicted *Alpha* is close to -0.01 . Beyond this turning point, the slope becomes positive and predicted *Alpha* gradually increase as ESG approaches its upper bound. This pattern is observed across all Beta specifications, both under the traditional and ESG-adjusted market benchmarks, and across alternative sampling choices (daily, weekly, and monthly frequencies over three- and five-year estimation windows), although small cross-specification differences remain.

The downward portion of the fitted curve is consistent with the sustainable-investing literature. When a non-trivial fraction of investors derives utility from holding sustainable assets, demand shifts toward high-ESG stocks and away from brown stocks. In equilibrium, this preference-based demand raises the prices of greener firms and, all else equal, lowers their expected returns (Pástor et al., 2021; Zerbib, 2022). Under this interpretation, firms with relatively weak ESG performance may display higher abnormal returns relative to the CAPM benchmark, whereas firms with stronger ESG profiles tend to exhibit lower *Alpha*.

(a) Estimated Relationship: *ESG Score* and *Alpha 5W*



(b) Estimated Relationship: *ESG Score* and *Alpha ESG 5W*

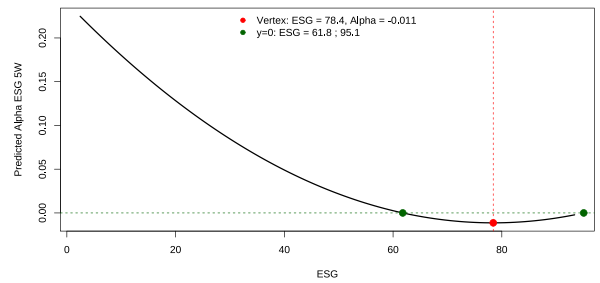
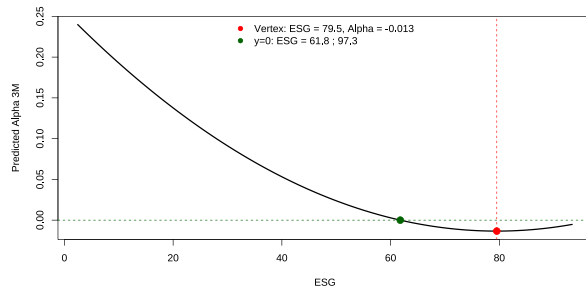


Fig. 5. Estimated relationship between ESG scores and predicted Alphas (5 years weekly).

This figure reports the predicted values of *Alpha*, estimated using weekly returns in a 5-year time window, for each ESG score from 1 to 100, under two specifications (ESG/non-ESG). The red vertical line represents the vertex; the green horizontal indicates a predicted level of *Alpha* equal to zero.

(a) Estimated Relationship: *ESG Score* and *Alpha 3M*



(b) Estimated Relationship: *ESG Score* and *Alpha ESG 3M*

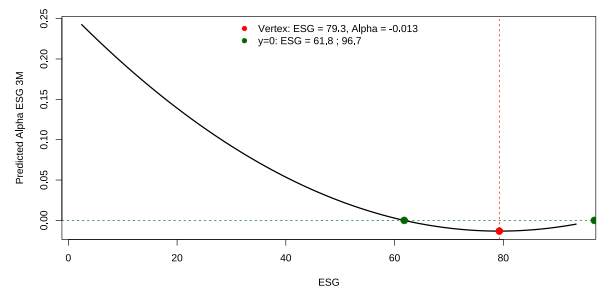
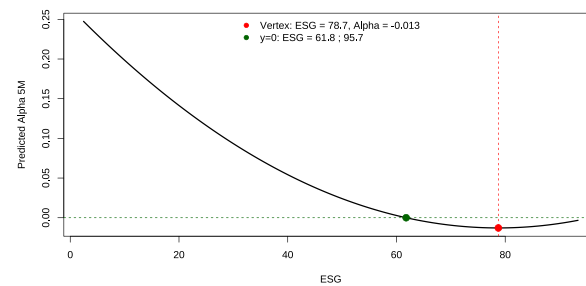


Fig. 6. Estimated relationship between ESG and predicted Alpha (3 years monthly).

This figure reports the predicted values of *Alpha*, estimated using monthly returns in a 3-year time window, for each ESG score from 1 to 100, under two specifications (ESG/non-ESG). The red vertical line represents the vertex; the green horizontal indicates a predicted level of *Alpha* equal to zero.

(a) Estimated Relationship: *ESG Score* and *Alpha 5M*



(b) Estimated Relationship: *ESG Score* and *Alpha ESG 5M*

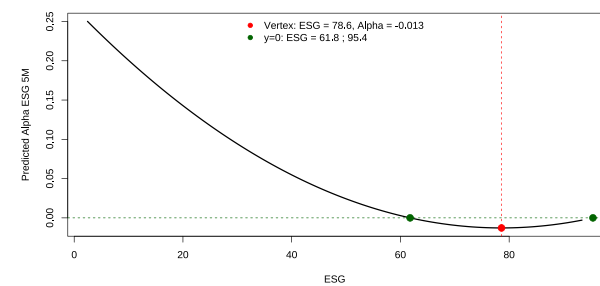


Fig. 7. Estimated relationship between ESG and predicted Alpha (5 years monthly).

This figure reports the predicted values of *Alpha*, estimated using monthly returns in a 5-year time window, for each ESG score from 1 to 100, under two specifications (ESG/non-ESG). The red vertical line represents the vertex; the green horizontal indicates a predicted level of *Alpha* equal to zero.

The fitted relationship also suggests two meaningful thresholds. The first, around $ESG \approx 61.5$, lies close to both the sample mean ($ESG = 61.8$) and median ($ESG = 65.0$). We interpret this value as the point at which the positive abnormal performance associated with relatively low-ESG firms largely disappears. As firms move toward an average ESG profile, the mechanisms supporting higher Alpha among brown firms become less pronounced, and predicted Alpha declines toward zero. The second threshold corresponds to the turning point of the quadratic curve, around $ESG \approx 80.0$, which lies in the upper tail of the ESG distribution and close to the boundary of the highest ESG quintile in our sample ($ESG = 76.6$). From an economic perspective, this pattern is consistent with a threshold mechanism: only firms in the top-ESG region appear sustainable enough for ESG-related benefits to become quantitatively material.

Table 9
VIF robustness test.

Variance inflation factors	
<i>ESG</i>	1.614851
<i>ESG</i> ²	1.293720
<i>SIZE</i>	1.316608
<i>LEV</i>	2.269579
<i>TAX</i>	1.071409
<i>ROA</i>	1.123490
<i>P/BV</i>	2.333760

Note: This table reports the results for the Variance Inflation Factor analysis (VIF); the VIF analysis is used to detect multicollinearity among the independent variables.

Table 10
Hausman robustness test.

Daily frequency (D) for 3- and 5-year timeframe				
	<i>Alpha 3D</i>	<i>AlphaESG 3D</i>	<i>Alpha 5D</i>	<i>AlphaESG 5D</i>
<i>Chi-squared</i>	54.546	58.800	56.326	60.861
<i>Degrees of freedom (df)</i>	7	7	7	7
<i>P-value</i>	$1.834 \times 10^{-9***}$	$2.619 \times 10^{-10***}$	$8.138 \times 10^{-10***}$	$1.016 \times 10^{-10***}$
Weekly frequency (W) for 3- and 5-year timeframe				
	<i>Alpha 3W</i>	<i>AlphaESG 3W</i>	<i>Alpha 5W</i>	<i>AlphaESG 5W</i>
<i>Chi-squared</i>	57.757	63.361	58.730	64.638
<i>Degrees of freedom (df)</i>	7	7	7	7
<i>P-value</i>	$4.226 \times 10^{-10***}$	$3.209 \times 10^{-11***}$	$2.705 \times 10^{-10***}$	$1.778 \times 10^{-11***}$
Monthly frequency (M) for 3- and 5-year timeframe				
	<i>Alpha 3M</i>	<i>AlphaESG 3M</i>	<i>Alpha 5M</i>	<i>AlphaESG 5M</i>
<i>Chi-squared</i>	59.670	65.022	55.533	60.525
<i>Degrees of freedom (df)</i>	7	7	7	7
<i>P-value</i>	$1.757 \times 10^{-10***}$	$1.489 \times 10^{-11***}$	$1.169 \times 10^{-9***}$	$1.186 \times 10^{-10***}$

Note: This table reports Hausman tests (fixed vs random effects), grouping by return frequency (daily/weekly/monthly) together. The test is significant for all models ($p < 0.001$), supporting the quality of the fixed-effects approach. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

The location of the turning point near the upper ESG quintile is also consistent with the empirical literature, which often defines top ESG firms using quintile-based portfolio sorts. In particular, Horn and Oehler (2024) analyze ESG-sorted quintile portfolios, while Giese et al. (2019) show that firms in the highest ESG quintile exhibit more favorable risk profile than those in the lowest quintile. This reinforces the interpretation that ESG-related benefits become quantitatively relevant only in the top segment of the ESG distribution.

This upper-tail behavior may reflect two complementary channels. First, exceptionally high ESG scores may contain information about managerial quality, governance, resilience, or long-term strategic positioning that is not fully incorporated into prices (Pedersen et al., 2021). Second, very high ESG performance may proxy for lower downside exposure or for hedging properties against sustainability-related shocks that are not fully captured by a one-factor benchmark (Hoepner et al., 2023; Luo and Balvers, 2017). In Pástor et al. (2021), this intuition is formalized through an ESG-related risk factor on which green and brown assets load with opposite signs, implying that green assets may provide hedging benefits even when their equilibrium expected returns are lower.

Importantly, according to the LSEG ESG Scores methodology, firms with $ESG > 75$ are classified as exhibiting excellent relative ESG performance and a high degree of transparency in publicly reporting material ESG data, whereas scores around $ESG \approx 60$ correspond to a grade B, indicating good relative ESG performance and above-average transparency (LSEG, 2024). Taken together, the estimated thresholds can define meaningful regions of the ESG distribution and are consistent with both the sustainable-investing literature and the qualitative interpretation provided by the score provider.

4.3. Robustness test

The first verification tool implemented is the Variance Inflation Factor (VIF) (Table 9).

In the defined specification, all VIF values are significantly below the threshold of 5, suggesting that there are no multicollinearity issues among the independent variables (Dutordoir et al., 2024; Meng et al., 2024).

To assess the quality of the fixed-effect approach we performed the test proposed by Hausman (1978). Table 10 reports the Hausman statistics comparing fixed-effects (FE) and random-effects (RE) estimators across all specifications (i.e., daily/weekly/monthly; 3/5 year and ESG/non-ESG). In every specification the null hypothesis is rejected ($p < 0.01$ in all models). Consequently, the fixed-effects estimator is preferred for the present analysis. Furthermore, the fixed-effects specification is the most appropriate for this analysis, as it mitigates endogeneity arising from the correlation between the regressors and the model's error term.

Table 11
2SLS models diagnostics for Jensen's Alpha.

3-year models			
	<i>Alpha 3D</i>	<i>Alpha 3W</i>	<i>Alpha 3M</i>
Instrument Strength: <i>ESG</i>	2127.695*** (0.000)	2127.695*** (0.000)	2127.695*** (0.000)
Instrument Strength: <i>ESG</i> ²	1232.859*** (0.000)	1232.859*** (0.000)	1232.859*** (0.000)
<i>Wu-Hausman</i>	0.375 (p = 0.687)	0.359 (p = 0.698)	0.319 (p = 0.726)
<i>Sargan</i>	0.037 (p = 0.981)	0.003 (p = 0.998)	0.316 (p = 0.853)
5-year models			
	<i>Alpha 5D</i>	<i>Alpha 5W</i>	<i>Alpha 5M</i>
Instrument Strength: <i>ESG</i>	2127.695*** (0.000)	2127.695*** (0.000)	2127.695*** (0.000)
Instrument Strength: <i>ESG</i> ²	1232.859*** (0.000)	1232.859*** (0.000)	1232.859*** (0.000)
<i>Wu-Hausman</i>	0.314 (p = 0.730)	0.289 (p = 0.749)	0.418 (p = 0.658)
<i>Sargan</i>	0.043 (p = 0.978)	0.011 (p = 0.994)	0.367 (p = 0.832)

Note: For each model we report: instrument strength, the Wu-Hausman test and the Sargan test. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 12
2SLS models diagnostics for ESG Jensen's Alpha.

3-year models			
	<i>Alpha ESG 3D</i>	<i>Alpha ESG 3W</i>	<i>Alpha ESG 3M</i>
Instrument Strength: <i>ESG</i>	2127.695*** (0.000)	2127.695*** (0.000)	2127.695*** (0.000)
Instrument Strength: <i>ESG</i> ²	1232.859*** (0.000)	1232.859*** (0.000)	1232.859*** (0.000)
<i>Wu-Hausman</i>	0.375 (p = 0.687)	0.343 (p = 0.709)	0.320 (p = 0.726)
<i>Sargan</i>	0.034 (p = 0.983)	0.003 (p = 0.998)	0.355 (p = 0.837)
5-year models			
	<i>Alpha ESG 5D</i>	<i>Alpha ESG 5W</i>	<i>Alpha ESG 5M</i>
Instrument Strength: <i>ESG</i>	2127.695*** (0.000)	2127.695*** (0.000)	2127.695*** (0.000)
Instrument Strength: <i>ESG</i> ²	1232.859*** (0.000)	1232.859*** (0.000)	1232.859*** (0.000)
<i>Wu-Hausman</i>	0.315 (p = 0.730)	0.279 (p = 0.757)	0.437 (p = 0.646)
<i>Sargan</i>	0.042 (p = 0.979)	0.012 (p = 0.994)	0.393 (p = 0.822)

Note: For each model we report: instrument strength, the Wu-Hausman test and the Sargan test. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

To test the possible presence of endogeneity in the model, we employ several complementary methodologies. First, we use both the Two-Stage Least Squares (2SLS) estimator and the Control Function Approach (CFA) to address potential sources of endogeneity such as reverse causality and simultaneity. The 2SLS model employs instrumental variables correlated with the endogenous variables but uncorrelated with the error term (Lochner and Moretti, 2015). The instruments used in this study are the first and second lags of both treatment variables (i.e., *ESG* and *ESG*²). Tables 11 and 12 report, respectively, the 2SLS model diagnostics for both conventional and ESG Alphas.

Table 13
CFA models diagnostics for Alpha.

3-year models						
	Alpha 3D	Alpha 3D (CFA)	Alpha 3W	Alpha 3W (CFA)	Alpha 3M	Alpha 3M (CFA)
ESG	-0.135*** (0.041)	-0.148*** (0.045)	-0.137*** (0.042)	-0.150*** (0.046)	-0.151*** (0.042)	-0.166*** (0.046)
ESG ²	0.004** (0.002)	0.003 (0.002)	0.004** (0.002)	0.003* (0.002)	0.004** (0.002)	0.004* (0.002)
v_{1it}		0.041 (0.090)		0.041 (0.090)		0.059 (0.091)
v_{2it}		0.001 (0.003)		0.001 (0.003)		0.001 (0.003)
5-year models						
	Alpha 5D	Alpha 5D (CFA)	Alpha 5W	Alpha 5W (CFA)	Alpha 5M	Alpha 5M (CFA)
ESG	-0.136*** (0.041)	-0.148*** (0.045)	-0.136*** (0.041)	-0.150*** (0.045)	-0.152*** (0.042)	-0.166*** (0.045)
ESG ²	0.004** (0.002)	0.003 (0.002)	0.004** (0.002)	0.003* (0.002)	0.004*** (0.002)	0.004** (0.002)
v_{1it}		0.043 (0.089)		0.039 (0.090)		0.065 (0.090)
v_{2it}		0.001 (0.003)		0.001 (0.003)		0.001 (0.003)

Note: This table reports the results of the CFA robustness test for Alpha under different specifications. For each model we report coefficients (top row) and standard errors (in parentheses). The coefficients for the control function regressors are shown where applicable. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

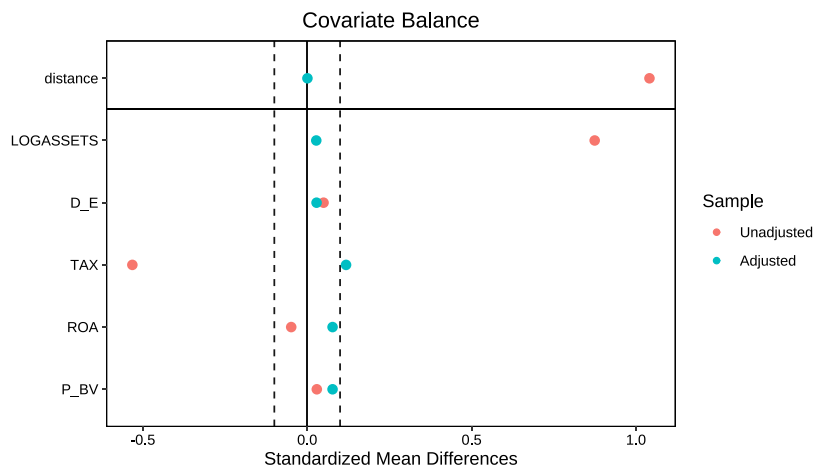


Fig. 8. Covariate balance before and after matching (Love plot).

The first-stage results from the 2SLS approach indicate that the instruments are relevant, exhibiting strong statistical significance ($p < 0.01$) for both treatment terms. The Wu-Hausman test yields non-significant p -values across all specifications ($p > 0.10$), suggesting that the IV and OLS estimates are statistically equivalent and therefore do not reject the null hypothesis of exogeneity. Consistently, the Sargan test also reports non-significant p -values for each model specification, supporting the joint exogeneity of the instruments employed, although these results should be interpreted with caution given the persistence of ESG scores over time.

With instrument relevance confirmed in the 2SLS results, we employed a second two-stage procedure to test for endogeneity, namely the Control Function Approach (CFA), which is particularly suitable for panel data applications (Wooldridge, 2015). The results of the CFA are presented in Tables 13 and 14, where v_{1it} and v_{2it} indicate the sets of residuals collected from the first-step regressions.

In none of the twelve tested specifications are the control function terms statistically significant. These results provide further evidence that the residuals obtained from the first-stage regression are not statistically significant, consistent with Petrin and Train (2010) and Wooldridge (2015). Nevertheless, given the persistent nature of ESG scores, lagged values may not be sufficient to fully rule out endogeneity, which may still arise from other sources of model misspecification. To address this concern, we further

Table 14
CFA models diagnostics for ESG Jensen's Alpha.

3-year models						
	<i>Alpha ESG</i> <i>3D</i>	<i>Alpha ESG</i> <i>3D (CFA)</i>	<i>Alpha ESG</i> <i>3W</i>	<i>Alpha ESG</i> <i>3 W (CFA)</i>	<i>Alpha ESG</i> <i>3M</i>	<i>Alpha ESG</i> <i>3M (CFA)</i>
<i>ESG</i>	−0.135*** (0.041)	−0.147*** (0.045)	−0.137*** (0.042)	−0.150*** (0.046)	−0.152*** (0.042)	−0.166*** (0.046)
<i>ESG</i> ²	0.004** (0.002)	0.003 (0.002)	0.004** (0.002)	0.003* (0.002)	0.004** (0.002)	0.004* (0.002)
<i>v</i> _{1<i>it</i>}		0.040 (0.089)		0.040 (0.090)		0.059 (0.091)
<i>v</i> _{2<i>it</i>}		0.001 (0.003)		0.001 (0.003)		0.001 (0.003)
5-year models						
	<i>Alpha ESG</i> <i>5D</i>	<i>Alpha ESG</i> <i>5D (CFA)</i>	<i>Alpha ESG</i> <i>5W</i>	<i>Alpha ESG</i> <i>5W (CFA)</i>	<i>Alpha ESG</i> <i>5M</i>	<i>Alpha ESG</i> <i>5M (CFA)</i>
<i>ESG</i>	−0.136*** (0.041)	−0.147*** (0.045)	−0.136*** (0.041)	−0.149*** (0.045)	−0.153*** (0.042)	−0.167*** (0.045)
<i>ESG</i> ²	0.004** (0.002)	0.003 (0.002)	0.004** (0.002)	0.003* (0.002)	0.005*** (0.002)	0.004** (0.002)
<i>v</i> _{1<i>it</i>}		0.042 (0.089)		0.039 (0.090)		0.065 (0.090)
<i>v</i> _{2<i>it</i>}		0.001 (0.003)		0.001 (0.003)		0.001 (0.003)

Note: This table reports the results of the CFA robustness test for *Alpha ESG* under different specifications. For each model we report coefficients (top row) and standard errors (in parentheses). The coefficients for the control function regressors are shown where applicable. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 15
Fixed-effects quadratic regression on matched sample (*Alpha*).

	<i>Alpha 3D</i>	<i>Alpha 3W</i>	<i>Alpha 3M</i>	<i>Alpha 5D</i>	<i>Alpha 5W</i>	<i>Alpha 5M</i>
<i>ESG</i>	−0.122** (0.050)	−0.122** (0.050)	−0.135*** (0.051)	−0.121** (0.050)	−0.121** (0.050)	−0.135*** (0.050)
<i>ESG</i> ²	0.005** (0.002)	0.005*** (0.002)	0.006*** (0.002)	0.005** (0.002)	0.005*** (0.002)	0.006*** (0.002)
<i>SIZE</i>	−0.010 (0.008)	−0.009 (0.008)	−0.007 (0.008)	−0.010 (0.008)	−0.008 (0.008)	−0.008 (0.008)
<i>LEV</i>	−0.007 (0.004)	−0.007* (0.004)	−0.007* (0.004)	−0.007 (0.004)	−0.007* (0.004)	−0.007* (0.004)
<i>TAX</i>	0.046 (0.084)	0.031 (0.084)	0.003 (0.085)	0.051 (0.084)	0.034 (0.083)	0.018 (0.084)
<i>ROA</i>	0.619*** (0.094)	0.635*** (0.094)	0.672*** (0.099)	0.619*** (0.093)	0.633*** (0.093)	0.657*** (0.097)
<i>P/BV</i>	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Observations	2547	2547	2547	2547	2547	2547
<i>R</i> ²	0.172	0.186	0.182	0.179	0.192	0.186
Adj. <i>R</i> ²	0.137	0.151	0.147	0.144	0.158	0.152

Note: This table reports fixed-effects regressions estimated on the matched sample obtained from the propensity score matching procedure. The dependent variable is Jensen's Alpha under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared ESG score (constructed as in the baseline specification). Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

implement a propensity score matching (PSM) approach to construct comparable portfolios conditional on the set of control variables employed in the analysis (Rosenbaum and Rubin, 1983; Caliendo and Kopeinig, 2008). Specifically, we define high-ESG and low-ESG portfolios based on the LSEG ESG methodology, which classifies firms with an ESG score above 50 as exhibiting good ESG performance and an above-average degree of transparency (LSEG, 2024).

We then match observations across the two groups using the full set of observable firm-level control variables. This procedure yields two portfolios that are comparable in terms of the control variables, while at the same time displaying different ESG performance. The resulting matched sample exhibits substantially improved covariate balance, as shown in Fig. 8, thereby enabling a cleaner comparison between firms with contrasting ESG profiles (Billio et al., 2021; Wang et al., 2023).

Table 16
Fixed-effects quadratic regression on matched sample (*Alpha ESG*).

	<i>Alpha ESG 3D</i>	<i>Alpha ESG 3W</i>	<i>Alpha ESG 3M</i>	<i>Alpha ESG 5D</i>	<i>Alpha ESG 5W</i>	<i>Alpha ESG 5M</i>
<i>ESG</i>	−0.122** (0.050)	−0.122** (0.050)	−0.135*** (0.051)	−0.122** (0.049)	−0.121** (0.050)	−0.136*** (0.050)
<i>ESG</i> ²	0.005** (0.002)	0.005*** (0.002)	0.006*** (0.002)	0.005** (0.002)	0.005*** (0.002)	0.006*** (0.002)
<i>SIZE</i>	−0.010 (0.008)	−0.009 (0.008)	−0.008 (0.008)	−0.010 (0.008)	−0.008 (0.008)	−0.008 (0.008)
<i>LEV</i>	−0.007 (0.004)	−0.007* (0.004)	−0.007* (0.004)	−0.007 (0.004)	−0.007* (0.004)	−0.007* (0.004)
<i>TAX</i>	0.048 (0.084)	0.030 (0.084)	−0.001 (0.085)	0.052 (0.083)	0.032 (0.083)	0.015 (0.084)
<i>ROA</i>	0.615*** (0.094)	0.633*** (0.094)	0.674*** (0.099)	0.617*** (0.093)	0.633*** (0.092)	0.659*** (0.097)
<i>P/BV</i>	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Observations	2547	2547	2547	2547	2547	2547
<i>R</i> ²	0.169	0.187	0.181	0.176	0.192	0.186
Adj. <i>R</i> ²	0.134	0.152	0.146	0.141	0.158	0.151

Note: This table reports fixed-effects regressions estimated on the matched sample obtained from the propensity score matching procedure. The dependent variable is ESG-adjusted Jensen's Alpha under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared ESG score (constructed as in the baseline specification). Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 17
Fixed-effects quadratic regression without ROA (*Alpha*).

	<i>Alpha 3D</i>	<i>Alpha 3W</i>	<i>Alpha 3M</i>	<i>Alpha 5D</i>	<i>Alpha 5W</i>	<i>Alpha 5M</i>
<i>ESG</i>	−0.090** (0.041)	−0.091** (0.042)	−0.105** (0.042)	−0.091** (0.041)	−0.091** (0.041)	−0.106** (0.041)
<i>ESG</i> ²	0.003** (0.002)	0.004** (0.002)	0.004** (0.002)	0.003** (0.002)	0.004** (0.002)	0.004** (0.002)
<i>SIZE</i>	−0.020*** (0.006)	−0.019*** (0.006)	−0.018*** (0.006)	−0.020*** (0.006)	−0.018*** (0.006)	−0.018*** (0.006)
<i>LEV</i>	−0.002** (0.001)	−0.002** (0.001)	−0.003** (0.001)	−0.002** (0.001)	−0.003** (0.001)	−0.003** (0.001)
<i>TAX</i>	0.046 (0.079)	0.030 (0.079)	0.003 (0.081)	0.045 (0.079)	0.032 (0.079)	0.015 (0.080)
<i>P/BV</i>	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)
Observations	3397	3397	3397	3397	3397	3397
<i>R</i> ²	0.146	0.156	0.153	0.153	0.163	0.160
Adj. <i>R</i> ²	0.119	0.129	0.126	0.126	0.136	0.133

Note: This table reports fixed-effects regressions where the dependent variable is Jensen's Alpha under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared ESG score (constructed as in the baseline specification). The control set excludes contemporaneous profitability (ROA). Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Re-estimating our baseline quadratic specification on the matched sample leaves the main conclusions unchanged: the relationship between ESG and Alpha retains its quadratic shape, and the key coefficients remain statistically significant (Tables 15 and 16). We therefore interpret the PSM evidence as a robustness check that strengthens the credibility of our findings under selection on observables. At the same time, we acknowledge that research designs exploiting plausibly exogenous shocks, such as regulatory changes, are beyond the scope of the present study, and therefore represent a possible development for future research.

Finally, as an additional robustness test, we re-estimate the main quadratic specifications excluding ROA. The results, reported in Tables 17 and 18, remain fully consistent with the baseline evidence: for both conventional Alpha and ESG-adjusted Alpha, the ESG-Alpha relationship retains its U-shaped form, with both the linear ESG term and the squared ESG term remaining statistically significant across the alternative specifications. These findings further support the robustness of the baseline specification, suggesting that the main results are not driven by the inclusion of ROA as a contemporaneous control.

Table 18
Fixed-effects quadratic regression without ROA (Alpha ESG).

	<i>Alpha ESG 3D</i>	<i>Alpha ESG 3W</i>	<i>Alpha ESG 3M</i>	<i>Alpha ESG 5D</i>	<i>Alpha ESG 5W</i>	<i>Alpha ESG 5M</i>
<i>ESG</i>	−0.090** (0.041)	−0.092** (0.041)	−0.106** (0.042)	−0.091** (0.041)	−0.091** (0.041)	−0.107*** (0.041)
<i>ESG</i> ²	0.003** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)
<i>SIZE</i>	−0.020*** (0.006)	−0.019*** (0.006)	−0.018*** (0.006)	−0.020*** (0.006)	−0.018*** (0.006)	−0.018*** (0.006)
<i>LEV</i>	−0.002** (0.001)	−0.002** (0.001)	−0.003** (0.001)	−0.002** (0.001)	−0.003** (0.001)	−0.003** (0.001)
<i>TAX</i>	0.047 (0.079)	0.030 (0.079)	0.000 (0.081)	0.047 (0.079)	0.032 (0.079)	0.013 (0.080)
<i>P/BV</i>	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)
Observations	3397	3397	3397	3397	3397	3397
<i>R</i> ²	0.146	0.158	0.154	0.152	0.164	0.161
Adj. <i>R</i> ²	0.119	0.132	0.127	0.125	0.137	0.134

Note: This table reports fixed-effects regressions where the dependent variable is ESG-adjusted Jensen's Alpha under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared ESG score (constructed as in the baseline specification). The control set excludes contemporaneous profitability (ROA). Coefficients are reported with standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5. Conclusions

This study examines whether a firm's ESG performance influences the Alpha of its stock based on the CAPM framework. In order to address this research question, we estimated the CAPM's Beta coefficients under twelve different specifications, taking into consideration the three most common sampling frequencies (i.e., daily, weekly and monthly) and the two most relevant medium-term estimation windows (i.e., 3 and 5 years) (Bazhutov et al., 2023). These six sampling specifications were used with two alternative market benchmarks (i.e., the S&P 500 ESG index and the S&P 500 index), in order to capture the potential effect of including ESG factors in the estimation of systematic risk exposure.

Drawing on these twelve Beta estimates and using two definitions of the equity risk premium, one based on the conventional S&P 500 and the other on the ESG-adjusted S&P 500 ESG, we derived twelve Alpha specifications, computed following Jensen (1968) and subsequently used as dependent variables in the regression analysis. The results obtained from the initial linear specification indicate a negative and statistically significant relationship between ESG scores and Alpha, thereby supporting our first hypothesis (H_1). Importantly, this pattern is consistent with the view that investors may derive a non-pecuniary utility from sustainable assets and are therefore willing to accept lower returns on greener stocks (Pástor et al., 2021; Cohen, 2023). Under this interpretation, the negative ESG-Alpha relationship may therefore reflect preference-related pricing channels, and more broadly ESG-related return differentials, that are not fully captured by the traditional one-factor CAPM framework (Priem and Gabbellone, 2024; Chava et al., 2025).

This relationship remains statistically significant across all twelve specifications, indicating that the result holds consistently across sampling frequencies and time horizons, even when employing a market benchmark constructed using ESG criteria.

While the baseline model identifies a negative and statistically significant association between ESG scores and Alpha, our second hypothesis (H_2) suggests that such a relationship may be non-linear. Rather, we suggest a U-shaped ESG-Alpha relation, whereby Alpha decreases over a broad range of ESG scores but becomes positively associated with ESG performance beyond a sufficiently high threshold. To examine this possibility, we include the squared ESG term (*ESG*²) as an additional regressor. The quadratic specification offers a parsimonious way to capture a non-monotonic pattern in the data, allowing the initially negative association to weaken and eventually reverse among firms in the upper tail of the ESG distribution.

The results of the second analysis provide support for a U-shaped relationship between ESG scores and Alpha. Across all twelve specifications, the estimated relation starts to flatten at an ESG score of approximately 61.5. Beyond this threshold, the association remains slightly negative over an intermediate range, reaching its minimum predicted Alpha at an ESG score of around 80. Thereafter, the relationship turns positive, and predicted Alpha increases as ESG performance approaches its maximum. This pattern suggests that the ESG-Alpha relation is more complex than implied by a linear specification: while higher ESG scores are generally associated with lower Alpha over most of the distribution, firms in the upper tail of ESG performance appear to experience a partial reversal of this effect. Such evidence is consistent with the possibility that, at very high levels of ESG performance, ESG scores may proxy for firm characteristics such as resilience, managerial quality, or governance quality that are not fully reflected in a traditional one-factor CAPM benchmark. At the same time, this reversal is also consistent with the sustainable-investing literature, which suggests that highly sustainable firms may temporarily exhibit stronger realized abnormal returns when unexpected positive shocks increase investor demand for green assets, even if such assets command lower expected returns in equilibrium.

Furthermore, these findings suggest that adopting a market benchmark constructed according to ESG criteria is not, in itself, sufficient to fully absorb ESG-related return differentials for firms listed in the S&P 500. In particular, for firms with ESG scores below

the identified threshold, the evidence remains consistent with the presence of return differentials associated with sustainability-related characteristics that are not fully captured by the standard CAPM framework. By contrast, above the threshold, the estimated relationship becomes less negative and eventually turns positive, suggesting that the role of ESG characteristics in shaping abnormal returns may differ across the distribution of ESG performance. This pattern potentially reflects the joint influence of investor preferences, hedging properties, and other firm-specific attributes that a one-factor asset-pricing model is not able to fully capture.

The findings of this study have significant operational relevance. Given the widespread use of the CAPM in professional applications (Graham, 2022; Pinto et al., 2019), market participants who rely on this framework to estimate a firm's cost of equity and conduct equity valuations should be aware that sustainability-related characteristics may be associated with return differentials that are not fully captured by the traditional one-factor model. This issue is particularly relevant because the cost of equity serves both as the discount rate in equity-side valuation models and as a core component of the WACC, so any systematic divergence in its estimation may translate into valuation distortions and affect capital allocation. More specifically, our evidence suggests that these return differentials are not eliminated by adopting ESG-adjusted Betas or by using ESG-screened market benchmarks (e.g., the S&P 500 ESG), independently of the return frequency (i.e., daily, weekly, or monthly) and the estimation window (i.e., 3 or 5 years).

In conclusion, although this study provides evidence on the link between ESG performance and stock abnormal returns, some limitations must be recognized. The present analysis focuses exclusively on firms included in the S&P 500 index; this choice may limit the generalizability of the results to other markets. Moreover, although the CAPM framework is still widely used in practice, it only considers exposure to systematic risk in the estimation of expected returns and does not incorporate multifactor dynamics such as size, value, or profitability (Fama and French, 1993; Carhart, 1997). In addition, Beta estimates may be affected by potential non-stationarity within the estimation window, especially for firms undergoing major regulatory, or ESG-related transitions.

Despite these limitations, our findings contribute to the literature by documenting a robust and non-linear association between ESG performance and Alpha. While the underlying mechanism cannot be identified conclusively within our empirical setting, the evidence is consistent with the view that ESG characteristics may affect stock returns through channels not fully captured by a standard one-factor model, thus motivating further research on the incorporation of sustainability-related considerations into return-pricing frameworks.

CRedit authorship contribution statement

Massimo Postiglione: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alberto Falini:** Supervision, Conceptualization. **Paolo Zaninelli:** Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis.

Ethics approval

All ethical guidelines were followed in the conduct of this research, including adherence to the appropriate ethical standards.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Model specification with firm-clustered standard errors

This appendix reports an additional robustness test based on firm-clustered standard errors. In particular, the baseline model specifications are re-estimated by clustering standard errors at the firm level (*RIC*), rather than relying on *HCI* heteroskedasticity-robust standard errors. The results confirm the statistical significance and overall pattern of the baseline findings for both conventional Alpha and ESG-adjusted Alpha (Tables A.19 and A.20).

Data availability

Data will be made available on request.

Table A.19
Fixed-effects quadratic regression firm-clustered standard errors (Alpha).

	<i>Alpha 3D</i>	<i>Alpha 3W</i>	<i>Alpha 3M</i>	<i>Alpha 5D</i>	<i>Alpha 5W</i>	<i>Alpha 5M</i>
<i>ESG</i>	−0.135*** (0.040)	−0.137*** (0.041)	−0.151*** (0.041)	−0.136*** (0.040)	−0.136*** (0.041)	−0.152*** (0.041)
<i>ESG</i> ²	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004*** (0.002)
<i>SIZE</i>	−0.007 (0.005)	−0.006 (0.005)	−0.005 (0.006)	−0.007 (0.005)	−0.006 (0.005)	−0.005 (0.006)
<i>LEV</i>	−0.002 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.002* (0.001)
<i>TAX</i>	0.041 (0.076)	0.025 (0.076)	−0.002 (0.078)	0.040 (0.076)	0.027 (0.076)	0.010 (0.077)
<i>ROA</i>	0.632*** (0.090)	0.650*** (0.090)	0.661*** (0.094)	0.636*** (0.089)	0.650*** (0.089)	0.652*** (0.094)
<i>P/BV</i>	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001* (0.000)
Observations	3385	3385	3385	3385	3385	3385
<i>R</i> ²	0.168	0.178	0.175	0.175	0.185	0.182
Adj. <i>R</i> ²	0.141	0.152	0.149	0.149	0.159	0.156

Note: This table reports fixed-effects regressions where the dependent variable is Jensen's Alpha under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared ESG score (constructed as in the baseline specification). Standard errors are clustered at the firm level (RIC), allowing for arbitrary heteroskedasticity and serial correlation within firms over time. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table A.20
Fixed-effects quadratic regression firm-clustered standard errors (Alpha ESG).

	<i>Alpha ESG 3D</i>	<i>Alpha ESG 3W</i>	<i>Alpha ESG 3M</i>	<i>Alpha ESG 5D</i>	<i>Alpha ESG 5W</i>	<i>Alpha ESG 5M</i>
<i>ESG</i>	−0.135*** (0.040)	−0.137*** (0.041)	−0.152*** (0.042)	−0.136*** (0.040)	−0.136*** (0.041)	−0.153*** (0.041)
<i>ESG</i> ²	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)	0.005*** (0.002)
<i>SIZE</i>	−0.008 (0.005)	−0.007 (0.005)	−0.005 (0.006)	−0.008 (0.005)	−0.006 (0.005)	−0.005 (0.006)
<i>LEV</i>	−0.002 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.002* (0.001)
<i>TAX</i>	0.042 (0.076)	0.025 (0.076)	−0.005 (0.078)	0.041 (0.076)	0.027 (0.076)	0.008 (0.077)
<i>ROA</i>	0.628*** (0.089)	0.648*** (0.090)	0.660*** (0.095)	0.633*** (0.088)	0.649*** (0.089)	0.652*** (0.094)
<i>P/BV</i>	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001* (0.000)
Observations	3385	3385	3385	3385	3385	3385
<i>R</i> ²	0.167	0.180	0.176	0.174	0.186	0.183
Adj. <i>R</i> ²	0.140	0.154	0.150	0.147	0.160	0.157

Note: This table reports fixed-effects regressions where the dependent variable is ESG-adjusted Jensen's Alpha under six specifications (3y/5y; daily/weekly/monthly). *ESG*² denotes the squared ESG score (constructed as in the baseline specification). Standard errors are clustered at the firm level (RIC), allowing for arbitrary heteroskedasticity and serial correlation within firms over time. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

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