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The green premium in the European stock market

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# The green premium in the European stock market

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## Abstract

*This paper investigates the concept of greenium, the premium investors are willing to pay for sustainable assets relative to conventional investments, with a focus on the European stock market. As sustainable finance gains prominence, understanding greenium's implications is crucial for both investors and policymakers. The study addresses the challenges of defining and estimating greenium, including varying perceptions of climate risk and the lack of standardized criteria for green assets. Through comprehensive empirical analysis, we evaluate the presence of greenium and its effects on investment strategies, highlighting how sustainability considerations shape asset valuation and investor behavior. The findings contribute to a deeper understanding of the interplay between sustainability and financial performance in today's investment landscape.*

**Keywords:** Asset pricing, Climate risk, ESG, Greenium.

**JEL Codes:** C58, G11, G12, Q54

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## **1. Introduction**

Sustainable finance has gained significant importance in recent years, referring to financial processes and products that consider environmental, social, and governance (ESG) criteria to generate financial returns and positive impacts on society and the environment. The growing awareness of environmental challenges, such as climate change, biodiversity loss, and pollution, has prompted governments, companies, and investors to reconsider their strategies and adopt more sustainable practices. Green financial instruments, such as green bonds and green stocks, have become increasingly popular among investors seeking not only economic returns but also a positive contribution to global sustainability. In this context, the concept of "greenium" (or green premium) is particularly relevant and a topic of debate: greenium represents the premium that investors are willing to pay to invest in sustainable assets compared to conventional ones. This phenomenon reflects investors' preference for financial instruments that offer not only financial returns but also environmental benefits. Greenium manifests when green assets, such as bonds and stocks of sustainable companies, are traded at a higher price than their traditional counterparts, suggesting that investors accept a lower return in exchange for positive environmental impacts. The difficulties in accurately identifying and estimating greenium primarily stem from the lack of a unified definition of green assets, differing perceptions of climate risk among investors, adopted methodologies, and market circumstances. This uncertainty is reflected in the results of academic studies, which often reach conflicting conclusions. For instance, Meyer (2022), analyzing the European stock market, and Gimeno and González (2022), studying both the American and European stock markets, do not find evidence of a green premium. Other studies, such as those by Del Prado (2019) and Pastor et al. (2022), identify a positive greenium in the U.S. stock market, particularly noting that this premium exists during periods of heightened climate change concerns. Similarly, Moretti and Santi (2023) and Alessi et al. (2023) demonstrate that greenium can emerge in the European stock market when investors are concerned about climate change and perceive the transition to a sustainable economy as credible. In some cases, the existence of greenium seems to depend on the taxonomy adopted, as shown by De Angelis and Monasterolo (2024), who highlight how results can vary based on the "green" classification used. In summary, the heterogeneity of findings indicates that the presence of greenium is strongly

influenced by market context and investor perception, making it challenging to establish definitive and uniform conclusions.

The aim of this paper is to explore the concept of greenium, particularly assessing its presence in the European stock market. The structure of the paper is as follows. In Section 2 we provide a literature review. In Section 3 we illustrate the data used in the empirical analysis. In Section 4 we investigate the presence of the greenium and of a sustainability premium in the European stock market. The last section concludes.

## **2. Literature review**

In this section, we describe the literature regarding the greenium in the bond market and in the stock market, in the Subsections 2.1 and 2.2 respectively.

### *2.1. The Greenium in the bond market*

With reference to bonds, an important contribution is that of Zerbib (2019), who conducts an analysis from 2013 to 2017 examining a sample of 135 green bonds issued in the USA and their respective non-green bonds. The author finds a premium of -2 basis points for the entire sample analyzed, as well as for bonds in euros and USD separately, indicating that the returns on green bonds are lower than those of conventional bonds, consistent with the definition of greenium. The determinants of this premium are identified by the author as sector and rating. To obtain this result, Zerbib constructs a synthetic conventional equivalent for each green bond: he identified conventional bonds with the closest maturity from the same issuer and with the same characteristics (same currency, rating, bond structure, guarantee, type of coupon). However, since maturities cannot be identical, conventional bonds are identified with a term that is neither two years shorter nor two years longer than the maturity of the green bond. Another difference between the two categories of bonds is their liquidity: the eligible conventional bonds are restricted to those with an issuance amount of less than four times that of the green bond and more than a quarter of that amount, along with an issuance date that is at most six years before or six years after the issuance date of the green bond. In a second phase, the maturity bias is eliminated by constructing a panel consisting of pairs of bonds: to each green bond, a synthetic conventional equivalent bond with the same maturity is assigned; the yields of the two conventional bonds are then

linearly interpolated (or extrapolated) to the maturity date of the green bond to obtain a yield for the synthetic conventional bond that thus shows the same properties as the green bond, except for the difference in liquidity. To assess the relationship between yields and liquidity, Zerbib conducts a fixed effects regression analysis. In this model, the green bond premium is represented as a specific coefficient, while changes in liquidity are approximated through variations in the bid-ask spread. This approach allowed for a nuanced understanding of how liquidity affects the pricing of green bonds compared to their conventional counterparts.

Other authors also use liquidity as a regressor, such as Hinsche (2021): the author makes a prediction regarding a potential greenium for the Next Generation EU (NGEU) green bonds, conducting interviews with 15 experts in sustainable finance and analyzing the public market for green bonds from September 2014 to June 2021. The results of the analysis show a significant greenium of -0.7 basis points in the public market for green bonds, indicating that it increases for supranational issuers with AAA ratings, such as the European Union. Furthermore, the premium on green bonds is influenced by the issuer's sector and credit rating, while the size of the issuance and modified duration do not have significant effects. The rating and established reputation of issuers are also found to be important factors for other researchers, such as Bachelet et al. (2018), who, conducting a fixed effects OLS regression, conclude that green bonds may enjoy a negative premium: however, the premium requires both the established reputation of the (institutional) issuers and green certification in order to reduce information asymmetry and provide assurances to investors against the risk of greenwashing.

This result is consistent with the study by Kapraun et al. (2021). They employed a regression model where the dependent variable represents bond yields, and the main independent variable, a dummy variable labeled "Green," indicates whether a bond is classified as green (value of 1) or not (value of 0). Control variables include factors such as maturity, size, credit rating, and currency. To identify the greenium, the coefficient for the Green variable is analyzed, and it is found that investors are more willing to pay a premium for a green bond when it is certified as such by a third party, or when it is listed on a market with a dedicated segment for green bonds and strict listing requirements. Specifically, both in the primary and secondary markets, the greenium varies depending on the currency and the issuer, proving to be high and significant for bonds issued by official entities or for bonds in EUR.

For several researchers, therefore, the nature of the issuer and the certification of green bonds are key factors: it is beneficial for issuers to appoint one or more external reviewers to confirm the alignment of their bond or bond program with the fundamental components of the GBP; many external evaluations are possible, and in addition to ratings, issuers could, for example, seek a Second Party Opinion from an institution with expertise in environmental matters and independent of the issuer (generally concerning a compliance assessment with the Green Bond Principles), or obtain certification by verifying their green bonds against recognized external environmental assessment standards: the Climate Bonds Initiative (CBI), for example, provides requirements and certification standards, specifying sector-specific eligibility requirements, and assets that meet the CBI standard are eligible for Climate Bond Certification. The existence of a greenium is also highlighted by Löfer et al. (2021), who consider green and conventional bonds from 650 international issuers (from 2007 to 2019): regression estimates show that the yield for green bonds is on average 15-20 basis points lower than that of conventional bonds, both in primary and secondary markets.

Analyzing the European market, Sergei and Alesya (2022) highlight the existence of greenium across the European green bond market, which is approximately -4 basis points; however, a significant greenium is not observed in the green bond markets in the UK, France, the Netherlands, and Germany.

## *2.2. The Greenium in the stock market*

With reference to the stock market, an interesting contribution is that of Meyer (2022): analyzing the STOXX Europe total market index (2006-2020), he uses “carbon intensity” as a measure of “carbon risk,” which reflects how many tons of CO<sub>2</sub> a company requires to generate 1 million dollars in revenue. Meyer categorizes companies into quintiles based on their carbon intensity, with the first quintile (Clean) representing those with the lowest emissions, and the fifth quintile (Dirty) comprising the most polluting companies. The author develops a model to evaluate the relationship between stock returns and various risk factors. This model accounts for the difference between stock returns and the risk-free rate, incorporating several market factors, including the overall market performance, the Small Minus Big factor, the Momentum factor, and a specific carbon risk factor. To create the carbon

risk factor, Meyer constructs a hedge portfolio that takes long positions in stocks with low carbon intensity and short positions in stocks with high carbon intensity. The return of this carbon risk factor is calculated based on the performance of four distinct portfolios: small companies with high carbon intensity, small companies with low carbon intensity, large companies with high carbon intensity, and large companies with low carbon intensity. The findings of the analysis indicate that “less carbon intensive” portfolios provide higher returns compared to more polluting ones, as a monotonic reduction in excess return is observed when moving from the clean to the dirty portfolio.

Del Prado (2019) conducts an analysis using a methodology based on the CAPM with the addition of specific factors: the study was carried out on 120 US stocks (from 2005 to 2017), concluding that investing in carbon-intensive and non-sustainable companies leads to higher expected returns, consistent with the concept of greenium. The author divides the entire sample into three groups of 40 and creates three portfolios: cleanest, dirtiest, and medium, based on carbon emissions relative to revenue. In the analysis, the difference between stock returns and the risk-free rate is examined, incorporating various market factors. These includes the overall market return, the Small Minus Big (SMB) factor, the High Minus Low (HML) factor, and the Momentum factor. Additionally, two new factors are introduced: the Dirty Minus Clean (DMC) factor, which serves as a proxy for carbon risk by going long in the dirtiest portfolio and short in the cleanest, and the Climate Risk Factor (Worst Minus Best factor), representing the difference in returns between the 22 companies with the worst scores and the 18 with the best carbon scores. The analysis concludes that investing in carbon-intensive stocks is profitable.

Another interesting analysis is conducted by Oestreich and Tsiakas (2015) using stock returns from Germany, the largest economy in Europe, responsible for a significant portion of the EU's carbon emissions. They analyze the difference in performance between companies that received free carbon emission allowances and those that did not; the "carbon premium" exists if the companies that received these allowances outperformed the others. Specifically, three portfolios are created: "dirty" (for companies that received a high number of allowances), "medium" (for those that received a low number of allowances), and "clean" (for those that received no allowances). The Dirty Minus Clean portfolio is then defined: the

carbon premium is defined as the excess return of the dirty portfolio relative to the clean one (alpha). The authors conclude that the carbon premium exists and is high and statistically significant from 2003 to 2009 (the period when the market was certain that carbon-emitting companies would receive allowances for free), at approximately 17%. Thus, companies that received free emission allowances outperformed those that did not.

Boido et al. (2022) conducts an analysis on the Eurostoxx 600 Index to compare the performance of stock portfolios characterized by high ESG scores (first quartile) and those with low ESG scores (fourth quartile). The ESG scores considered include MSCI ESG Rating, Sustainalytics scores, and S&P DJI/Robeco ESG Scores. Both a five-year analysis (June 2016 - June 2021) and an annual analysis (June 2020 - June 2021) is developed, comparing the total return, standard deviation, and Sharpe ratio of the two portfolios. In both the five-year and annual analyses, based on Sustainalytics scores and S&P DJI/Robeco ESG Scores, the portfolio with high ESG scores outperformed the fourth quartile. A sectoral analysis is then conducted based on the GICS (Global Industry Classification Standard), which classifies each company into a sector according to its core business, measured by revenue accounting items. The goal is to identify whether certain sectors drive performance. Specifically, it appears that over a one-year horizon, the sector leading the outperformance of the first quartile is the "Telecommunication Services" sector in all three analyses. However, this same sector becomes the worst performer for the first quartile portfolio in the five-year analysis. In contrast, the best sector over a five-year horizon is the "Materials" sector according to the MSCI and S&P DJI Robeco studies, a finding not confirmed by Sustainalytics, where performance is attributed to the "Information Technology" sector. The worst sector over a one-year horizon, on the other hand, varies across all three cases.

Gimeno and González (2022) conduct an analysis on the Eurostoxx 600 and on the S&P 500, through the creation of the GMP (Green Minus Polluter) factor. They analyze the European market (Eurostoxx 600) and the US market (using companies from the S&P 500) over the period from 2002 to 2020. The analysis focused on the difference between the returns of individual stocks and the risk-free rate, as well as the expected market return. Various factors are included, such as the Momentum factor, which captures the premium for stocks that have performed well compared to those that have underperformed; the Small Minus Big (SMB) factor, reflecting

the return difference between small-cap and large-cap stocks; and the High Minus Low (HML) factor, which represents the return difference between value and growth stocks. Additionally, the analysis incorporated the RMW factor, which differentiates between highly profitable companies and less profitable ones, and the CMA factor, measuring the return difference between conservative and aggressive investment strategies. The authors introduce also the GMP factor ( $G_{CO_2,t} - P_{CO_2,t}$ ) based on the carbon footprints of companies (i.e., the parameter measuring the amount of greenhouse gases released), is introduced: for the US (Europe), the 50 (60) companies with the lowest scores and the 50 (60) with the highest scores in terms of carbon footprints are selected. To obtain this measure, the ratio of declared CO<sub>2</sub> emissions (Scope 1) to revenues in millions of US dollars is calculated: Scope 1 emissions are used because they are the most frequently reported, and they are then normalized based on revenues to control for company size. Thus, the GMP factor is constructed as a portfolio that is long on green stocks and short on polluting stocks. There is a growing importance of this factor for investors since the Paris Agreement, with a consistently positive performance of the GMP portfolio, both in the United States and in Europe. The presence of a green factor indicates that financial markets are seriously considering the relevance of climate change in their portfolio decisions, showing a preference for companies with a lower carbon footprint compared to those that are more polluting.

Some authors have also focused on the existence of a carbon premium associated with Scope 1 emissions (direct greenhouse gas emissions from facilities within the organization's boundaries) and Scope 2 emissions (indirect greenhouse gas emissions resulting from the generation of electricity, heat, and steam that are imported and consumed by the organization). Sankar et al. (2024) conduct an analysis between 2018 and 2019 on 141 companies listed on the S&P 500, using publicly available data on GHG emissions to investigate how stock prices respond to a 1% change in these emissions. In their analysis, they account for time-specific effects and examined the impact of Scope 1 and Scope 2 emissions on stock returns, while also considering various control variables. From the results obtained, it is concluded that there is a statistically significant and positive carbon premium associated with Scope 1 emissions (in particular, for every 1% increase in Scope 1 emissions, there is a 0.0761% increase in stock returns), while there is no significant premium associated with Scope 2 emissions: the risks connected to the companies' direct emissions are

thus priced. Another aspect under study concerns the evolution of the greenium: Alessi et al. (2023) analyze 4,163 European stocks from 2006 to 2020 to examine this aspect and the greenium, estimated based on the CAPM, which is defined as the premium associated with the factors of transparency and sustainability. To assess this, the authors constructed three green portfolios: one for small companies, one for medium-sized companies, and one for large companies. They identified highly polluting companies as those that do not disclose environmental information and operate in carbon-intensive sectors. For these companies, three portfolios are also created based on size—small, medium, and large. Essentially, the study set up a hedge portfolio that takes a long position in green stocks and a short position in polluting stocks. It is concluded that investors in the European stock market tend to accept lower returns and hold more sustainable and transparent assets when economic shifts towards a low-carbon economy become more credible: the estimated greenium began to decrease in mid-2014, turning negative in early 2015 (in anticipation of the Paris Agreement); moreover, when President Donald Trump announced the withdrawal of the United States from the Paris Agreement, the European greenium started to rise. Other authors analyze how the past performance of green assets impacts future performance. Pastor's (2022) equilibrium model predicts that green assets have lower expected returns compared to brown assets for two reasons: investors have green preferences, and green assets provide better protection against climate risk. However, green assets may achieve higher realized returns when investor demand unexpectedly shifts towards green options. Investor demand for green assets can increase, directly boosting their prices; alternatively, consumer demand for sustainable products may strengthen—perhaps due to environmental regulations—leading to increased profits for green companies and thus higher stock prices. Similarly, investor demand for brown assets or consumer demand for such products may decline, again causing green stocks to outperform. Pastor et al. (2022) conclude that high realized returns do not always indicate high expected returns. The analysis is conducted on the US stock market from 2012 to 2020. To assign a measure of greenness to individual stocks, the authors used MSCI's "Environmental pillar score" and "Environmental pillar weight." The greenness score for company  $i$  at time  $t$  is determined by specific calculations reflecting environmental performance. It is shown that the high returns are unexpected, reflecting news about environmental concerns rather than high

expected returns. The authors, after constructing a Green Minus Brown (GMB) portfolio, demonstrate that the recent outperformance of the portfolio fades once the effects of unexpected increases in climate concerns are removed: indeed, the equity greenium is defined as the difference in expected returns between green and brown stocks, or the expected return of the GMB portfolio. To further analyze this, they develop a green factor that integrates greenness measures with stock performance metrics. The authors then develop a two-factor asset pricing model with the green factor: the recent outperformance of green stocks helps to explain the poor performance of value stocks from 2010 to 2020, the worst decade ever recorded for Fama and French's HML factor. The results show that the model explains much of the underperformance of the HML factor. In conclusion, the authors find that green stocks outperform brown ones when concerns about climate change increase. An additional analysis on the performance of green and brown stocks is conducted by Görden et al. (2020): the authors, using a sample of global stocks from January 2010 to December 2017, find no evidence of a risk premium associated with carbon risk; in particular, the analysis is conducted by creating a BMG (Brown Minus Green) factor to measure carbon risk. All companies are assigned to six portfolios based on their market capitalization and the Brown-Green Score (BGS), which is calculated by considering the value chain, public perception, and companies' adaptability to carbon-related issues and the transition, using the median and tertiles as breakpoints. The monthly average weighted returns for the four portfolios "small/high BGS" (SH), "big/high BGS" (BH), "small/low BGS" (SL), and "big/low BGS" (BL) are used to calculate the BMG factor according to the equation mentioned above. Thus,  $BMG_t$  is the return in month  $t$  of a zero-cost portfolio that is long on "brown" companies and short on "green" companies. The return of the BMG factor is slightly positive during the period from 2010 to the end of 2012, but the effect reverses from 2013 to the end of 2015, during which it drops from about +3% to about -23%, followed by an increase to around -11% in 2017. Therefore, during the sampling period, "brown" companies had, on average, worse performance than "green" companies. The companies are ranked based on their BGS into annually rebalanced quintiles, so that the first quintile contains the companies with the lowest BGS, meaning the most "green" companies, while the fifth quintile includes the companies with the highest BGS, meaning the most polluting ones. The authors performed time series regressions on the monthly

excess returns of the quintiles using both the global Carhart model and a model that included the BMG factor. Overall, the BMG factor provides expected results (i.e., the beta coefficients of BMG increase monotonically from the quintile with low BGS, showing a coefficient of -0.30, to the quintile with high BGS, with a coefficient of 0.98) and significantly improves the explanatory power of common factor models, especially for portfolios with high BSG. Conducting cross-sectional regressions, the authors find that the BMG factor is not statistically significant: there is no evidence of a risk premium associated with carbon risk. The authors argue that carbon risk may not be priced because investors are unable to adequately predict or quantify it. They demonstrate that "brown" stocks have higher expected returns, but unexpected shifts toward a green economy are favorable for the returns of "green" stocks: if companies generate a lower BGS, for example, by emitting less carbon or publicly announcing plans to reduce carbon emissions, they can still outperform "brown" stocks. Furthermore, green companies are becoming more sustainable more quickly than brown companies, leading the former to outperform the latter.

### **3. Data and methodology**

The analysis focused on the European stock market over the period from July 2018 to June 2023 (5 years). The data is downloaded from Refinitiv. The empirical analysis consists of two parts. In the first part we investigate the presence of a sustainability premium and a green premium by looking at annual returns, annualized Standard Deviation, and Sharpe Ratio of the constituents of the Eurostoxx 600. In particular, we evaluate the performance of sustainable portfolios versus non-sustainable portfolios by referring to the ESG score and the performance of green and brown portfolios, by referring to the E score. In the second part of the analysis, we robustly estimate the existence of the sustainability premium and of the greenium, by means of portfolio sorting techniques.

#### *3.1. Methodology*

Each stock in the Eurostoxx600 is assigned its corresponding ESG score (E-score) using June 27, 2022, as the reference date, which represents the most recent availability of data. After obtaining the ESG score (E-score) for each stock, the

sample is divided into quartiles based initially on the ESG score and then based on the Environmental dimension: the stocks are ranked in descending order based on their ESG score (E-score); the first quartile contains the stocks with the highest scores, thus forming the sustainable (green) portfolio, while the last quartile, the fourth, contains the stocks of less sustainable (more polluting) companies, forming the brown portfolio. In the first part of the analysis, the annual return, annualized Standard Deviation, and Sharpe Ratio of the first and fourth quartiles are compared for each considered year. The second part of the analysis is conducted as follows. The analysis is first conducted for the portfolios created based on the E-score, and then for those created based on the ESG-score. Initially, a regression is performed for each quartile ( $i=1,2,3,4$ ):

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i^{mkt}(R_{m,t} - R_{f,t}) + \beta_i^{BMG} BMG_t + \varepsilon_{i,t} \quad (1)$$

In particular:  $R_{i,t}$  are the monthly returns weighted by the market cap of the quartiles Q1, Q2, Q3, Q4, which are calculated in the previous analysis based on the returns of the Eurostoxx 600;  $R_{f,t}$  is the risk-free rate, considered equivalent to the 1-month Euribor;  $R_{m,t}$  is the monthly return of the Eurostoxx 600 index; BMG is the Brown Minus Green factor, meaning a hedge portfolio created by subtracting the monthly returns of the fourth quartile (brown/non sustainable portfolio) from those of the first quartile (green/sustainable portfolio): the BMG portfolio created is equivalent to going long on the polluting portfolio and short on the green portfolio. This initial analysis allowed for an investigation into the sensitivity of the quartiles to the BMG factor. Following Elyasiani et al. (2020), monthly data over a one-year time window are used to estimate the model described by Equation (1) using Ordinary Least Squares (OLS) procedure. This step uses the excess returns over the risk-free rate and produces estimates of the beta coefficients for the considered risk factors for each stock. Secondly, a cross-sectional analysis is performed by creating four portfolios based on the sensitivity to the  $\beta_i^{BMG}$  factor: the first (fifth) portfolio contains stocks with the lowest (highest) value of  $\beta_i^{BMG}$ . At the end of the sorting procedure, the time series of monthly post-ranking returns for each portfolio are obtained. The return of each portfolio is then calculated for the following year as a proxy for its expected return. The following regression is conducted for the created quartiles Q1, Q2, Q3, Q4, controlling for the five Fama-French factors (downloaded from Ken French's online data library):

$$R_{j,t} = \alpha_j + \beta_j^{MKT} MKT_t + \beta_j^{SMB} SMB_t + \beta_j^{HML} HML + \beta_j^{RMW} RMW_t + \beta_j^{CMA} CMA_t + \varepsilon_{j,t} \quad (2)$$

The aim is to analyze the intercept  $\alpha_j$ , which is the amount of return unexplained by the considered factors, and thus attributable to the premium under analysis.

## 4. Results

In this section, the results obtained from the two analyses are presented: in subsection 4.1, the results of the first analysis are shown, while section 4.2 presents the results of the second analysis (econometric analysis).

### *4.1. The performance of sustainable/green portfolios versus non-sustainable/brown portfolios*

The analysis of portfolios based on the Environmental Pillar Score (E-score) reveals that while the brown portfolio generally outperformed the green portfolio in terms of annualized returns, the latter displayed better risk management and stability. Table 1 shows that in the first year (July 2018- June 2019), the brown portfolio achieved an annualized return of 4.30%, while the green portfolio lagged behind at 0.63%. The Standard Deviation for the brown portfolio is higher at 23.77 compared to 18.73 for the green portfolio, indicating greater volatility. The Sharpe Ratio for the brown portfolio is 0.180, suggesting that it provides better risk-adjusted returns, despite being more volatile. In the following year (July 2019- June 2020), the trend continued, with the brown portfolio yielding 21.54% against a negative return of -2.65% for the green portfolio. The Sharpe Ratio for the brown portfolio surges to 1.059, while the green portfolio remained negative at -0.135, highlighting the stark difference in performance during that turbulent period. During the July 2020- June 2021 period, both portfolios experienced strong annualized returns, with the brown portfolio yielding 35.79% and the green portfolio achieving 31.70%. Despite the brown portfolio's higher return, it exhibited greater volatility, with a Standard Deviation of 26.09 compared to 20.32 for the green portfolio. Interestingly, the Sharpe Ratio for the green portfolio is higher at 1.560, indicating it provided better risk-adjusted returns. This suggests that, although the brown portfolio has a higher raw return, the green portfolio is more effective in balancing risk and return during the recovery from the pandemic. In the subsequent year, the green portfolio

outperformed the brown one, achieving an annualized return of 3.77% compared to the brown portfolio's -8.50%. This shift is reflected in the Sharpe Ratios, with the green portfolio at 0.206 and the brown at -0.385, indicating a significant advantage for the green portfolio in terms of risk-adjusted returns during this challenging period. In the subsequent period of July 2022- June 2023, the trend shifted again. The brown portfolio outperformed the green one with an annualized return of 13.11% versus 9.68%. However, the brown portfolio's volatility is higher, with a Standard Deviation of 23.80, compared to 17.76 for the green portfolio. The Sharpe Ratios are similar, with the brown portfolio slightly ahead at 0.550 compared to 0.545 for the green portfolio. This indicates that while the brown portfolio is able to achieve higher returns, it still carried more risk.

**Table 1.** The results for the analysis based on the Environmental Pillar Score

Period	Return (1q)	Return (4q)	SD (1q)	SD (4q)	SR (1q)	SR (4q)
July 2018- June 2019	0,63%	4,30%	18,732	23,769	0,033	0,18
July 2019- June 2020	-2,65%	21,54%	19,56	20,335	-0,135	1,059
July 2020- June 2021	31,70%	35,79%	20,321	26,087	1,56	1,372
July 2021- June 2022	3,77%	-8,50%	18,305	22,018	0,206	-0,385
July 2022- June 2023	9,68%	13,11%	17,764	23,803	0,544	0,55

Note: This table shows the annual return, the annualized Standard Deviation (SD), the Sharpe Ratio (SR), for the first (1q) and for the fourth (4q) quartile, based on portfolios created using the E-Score. Therefore, the 1q represents the green portfolio, while the 4q represents the brown portfolio.

In the analysis of portfolios based on the ESG score, the performance revealed distinct patterns across different time periods. The results are shown in Table 2.

In the initial year analyzed (July 2018- June 2019), the sustainable portfolio (first quartile) achieved an annualized return of 0.24%, while the unsustainable portfolio (fourth quartile) posted a loss of -5.66%. This indicates that the sustainable portfolio not only outperformed the unsustainable one in terms of returns but also exhibited a lower standard deviation, suggesting a more stable performance. The Sharpe Ratio for the sustainable portfolio is slightly positive at 0.011, while the unsustainable portfolio had a negative Sharpe Ratio of -0.271, indicating that the sustainable portfolio provided better risk-adjusted returns. In the following year (July 2019- June 2020), the trend reversed, with the unsustainable portfolio delivering an annualized return of 5.68% compared to -2.25% for the sustainable portfolio.

Despite the sustainable portfolio showing lower volatility (15.27 vs. 16.58), its negative Sharpe Ratio (-0.147) highlighted its inadequate compensation for risk during this period. The year July 2020- June 2021 saw both portfolios achieve impressive returns, with the unsustainable portfolio leading at 47.75% against 27.49% for the sustainable portfolio. Although the unsustainable portfolio has a higher return, it also exhibited significantly higher volatility (26.53 vs. 18.33). Both portfolios have high Sharpe Ratios (1.800 for unsustainable and 1.499 for sustainable), indicating strong risk-adjusted performance, but the unsustainable portfolio still maintained an edge in raw returns. In the year July 2021- June2022, the sustainable portfolio returned 6.20%, outperforming the unsustainable portfolio, which posted a loss of -11.22%. The sustainable portfolio's lower standard deviation (14.61) and positive Sharpe Ratio (0.424) contrasted sharply with the unsustainable portfolio's negative Sharpe Ratio (-0.528), illustrating the sustainable portfolio's superior risk management during a challenging market environment. In the final year analyzed, the unsustainable portfolio again outperformed with an annualized return of 10.93%, compared to 6.32% for the sustainable portfolio. However, the unsustainable portfolio exhibited higher volatility (24.81 vs. 17.00), while both portfolios have similar Sharpe Ratios, indicating that, once again, the unsustainable portfolio achieves higher raw returns but at a greater risk.

**Table 2.** The results for the analysis based on the ESG-Score

Period	Return (1q)	Return (4q)	SD (1q)	SD (4q)	SR (1q)	SR (4q)
July 2018- June 2019	0,24%	-5,66%	20,666	20,835	0,011	-0,271
July 2019- June 2020	-2,25%	5,68%	15,269	16,576	-0,147	0,342
July 2020- June 2021	27,49%	47,75%	18,327	26,525	1,499	1,8
July 2021- June 2022	6,20%	-11,22%	14,614	21,207	0,424	-0,528
July 2022- June 2023	6,32%	10,93%	17,003	24,81	0,371	0,44

Note: This table shows the annual return, the annualized Standard Deviation (SD), the Sharpe Ratio (SR), for the first (1q) and for the fourth (4q) quartile, based on portfolios created using the ESG-Score. Therefore, the 1q represents the sustainable portfolio, while the 4q represents the unsustainable portfolio.

A focus is then made on the returns. From Table 3, it is evident that in 3 years of the 5 analyzed years, the fourth quartile (i.e., the least sustainable portfolio) outperforms the sustainable portfolio in terms of higher returns, both regarding the

ESG-score and the E-score. The only year in which it outperforms the first quartile is from July 2021 to June 2022, likely due to macroeconomic and geopolitical factors. Additionally, in the first year of analysis (July 2018 - June 2019), the first quartile outperforms in terms of the ESG score but underperforms in terms of the E-score; thus, considering only environmental aspects, excluding social and governance factors, the brown portfolio performs better. During this period, awareness and preference for sustainable investments may not have been fully developed, leading investors to favor traditional companies. Furthermore, companies that began adopting more sustainable practices may have incurred significant initial costs for the energy transition, reducing their short-term returns.

**Table 3.** The outperformance in returns

	Outperformance of returns	ESG-Score	E-Score
July 2018- June 2019	first quartile	x	
	fourth quartile		x
July 2019- June 2020	first quartile		
	fourth quartile	x	x
July 2020- June 2021	first quartile		
	fourth quartile	x	x
July 2021- June 2022	first quartile	x	x
	fourth quartile		
July 2022- June 2023	first quartile		
	fourth quartile	x	x

Note: The table highlights which quartile, between the first and the fourth, has performed better in terms of higher annualized returns, referring to both the portfolios created based on the ESG-Score (column 3) and those created based on the E-Score (column 4).

In summary, particularly based on the E-score, in 4 years of 5 analyzed years, the brown portfolio achieves higher returns than the green one. This result may suggest the presence of a greenium, indicating that investors might be willing to sacrifice some financial returns in exchange for intangible or long-term benefits associated with sustainable investments.

#### 4.2. Econometric analysis

Starting from Equation (1), we analyze the coefficients of the BMG factor. For the portfolios created using the E-score, the results are presented in the first row of the Table 4: the increase in significance and magnitude of the BMG coefficient from the first to the fourth quartile suggests a growing sensitivity to the BMG factor as one moves toward quartiles with lower environmental scores. An increase in this factor—meaning a superior performance of the brown portfolio (which achieves higher returns) compared to the green portfolio—generates a significant increase in the returns of the third and fourth quartiles. For the first two quartiles, however, the BMG factor has no relevant effect on returns: these portfolios seem to be less sensitive to variations in the factor. In conclusion, brown portfolios benefit from higher returns when the BMG factor increases. Regarding the portfolios created using the ESG score, the results are presented in the second row of the Table 4: the first quartile (sustainable portfolio) has a  $\beta_i^{BMG}$  of 0.62, which is positive and significant but of lower intensity compared to the other quartiles; this portfolio thus has a relatively low exposure to the returns of the BMG factor. The second and third quartiles show a  $\beta_i^{BMG}$  close to 1, suggesting that these portfolios have a greater exposure to the BMG factor compared to the sustainable portfolio. The fourth quartile displays a very high  $\beta_i^{BMG}$  of 1.62, indicating that these stocks are strongly influenced by movements in the BMG factor. This means that the non-sustainable portfolio benefits more when the returns of the non-sustainable portfolio exceed those of the sustainable portfolio. In conclusion, in this analysis, as in the previous one, the results indicate that non-sustainable portfolios are more sensitive to the BMG return difference; at the same time, sustainable portfolios are less exposed to this factor.

**Table 4.** BMG coefficient of the portfolios

	1Q	2Q	3Q	4Q
(E-score) $\beta_i^{BMG}$	-0,1117	0,2221	0,6021*	0,8495***
(ESG-score) $\beta_i^{BMG}$	0,6203**	1,0976***	1,0307***	1,6203***

Note: The table shows the value of the BMG coefficient  $\beta_i^{BMG}$  assumed by the first (1Q), second (2Q), third (3Q), and fourth (4Q) quartile obtained using the E-Score (first row) and using the ESG-Score (second row). \*\*\*, \*\*, \* indicate significance at the 1%, 5%, and 10% levels, respectively.

The regression (2) was then conducted: Table 5 contains results for portfolio created based on the E-score. It is noted that the first quartile contains stocks with the lowest  $\beta_i^{BMG}$  (negative at -0.8003), while the fourth quartile contains those with the highest  $\beta_i^{BMG}$  values (1.9838). The difference in average  $\beta_i^{BMG}$  between Q4 and Q1 indicates a significant gap of 2.7841. Regarding average returns, the lowest average return is associated with the second quartile, which then increases progressively up to Q4. Concerning the intercept, it is noted that for all quartiles, it is highly significant, as shown by the low p-values: this suggests that expected returns are not fully explained by known risk factors and that there are other sources of return or risk that the model does not capture. The highest level of alpha is assumed by the fourth quartile, while the lowest is from the second. Analyzing the significant difference in alpha between Q4 and Q1, which is 0.0117, it is found that stocks with higher beta have a higher unexplained expected return (alpha) compared to those with lower beta (Q1). This difference could indicate a form of greenium, suggesting that investors might be willing to accept a lower return of 1.17% for holding more sustainable stocks compared to less sustainable ones.

**Table 4.** The results for the portfolios created using the E-score

	Q1	Q2	Q3	Q4	Q4-Q1
$\beta_i^{BMG}$	-0,8003	0,0290	0,2583	1,9838	2,7841
Avg. return	0,0059	0,001	0,0028	0,0231	0,0152
Alpha	0,0103***	0,0018***	0,0037***	0,0251***	0,0117***

Note: This table shows the results for the portfolios created using the E-score. Quintile 1 (4) collects stocks with the lowest (highest) values of  $\beta_i^{BMG}$ , Q4-Q1 portfolios are obtained combining a long position in Q4 and a short position in Q1. For each quartile portfolio plus the Q4-Q1 portfolio, we report the average  $\beta_i^{BMG}$ , the average return, and the alpha computed as the intercept obtained by estimating the Equation (2). \*\*\*, \* \*, \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 5 summarizes the results obtained for the portfolios created using the ESG score. From the summary table, it is noted that Q1 contains stocks with the lowest  $\beta_i^{BMG}$  (0.0219), while Q4 contains those with the highest  $\beta_i^{BMG}$  values (2.8807). The difference in average  $\beta_i^{BMG}$  between Q4 and Q1 indicates a gap of 2.6660. Regarding average return, the lowest average return is associated with the second quartile, which then increases progressively up to the fourth quartile, similar to the previous analysis related to the E-score. Furthermore, concerning the intercept, it is noted that in all quartiles it is positive and highly significant, indicating that in all cases there is an excess return. This suggests that expected returns are not fully explained by known risk factors, making the presence of a sustainability premium possible. Specifically, analyzing the significant difference between the intercepts of Q4 and Q1, it appears that investors might be willing to accept a lower return of 2.20% for holding more sustainable stocks.

**Table 5.** The results for the portfolios created using the ESG-score

	Q1	Q2	Q3	Q4	Q4-Q1
$\beta_i^{BMG}$	0,0219	0,2888	0,6324	2,8807	2,666
Avg. return	0,0024	0,002	0,0046	0,0212	0,0187
Alpha	0,0029***	0,0024***	0,0062***	0,0300***	0,0220***

Note: This table shows the results for the portfolios created using the ESG-score. Quintile 1 (4) collects stocks with the lowest (highest) values of  $\beta_i^{BMG}$ , Q4-Q1 portfolios are obtained combining a long position in Q4 and a short position in Q1. For each quartile portfolio plus the Q4-Q1 portfolio, we report the average  $\beta_i^{BMG}$ , the average return, and the alpha computed as the intercept obtained by estimating the Equation (2). \*\*\*, \* \*, \* indicate significance at the 1%, 5%, and 10% levels, respectively.

## 5. Conclusions

This paper analyzes the existence of the greenium in the European stock market over a period of five years, from July 2018 to June 2023. By calculating total Return, Standard Deviation, and Sharpe Ratio for sustainable and non-sustainable portfolios (created based on both ESG scores and E-scores) from the EuroSTOXX 600, it was particularly observed that, in most cases, the returns of the less sustainable portfolio are higher than those of the more sustainable portfolio. This result suggests the possible existence of a green premium and, more generally, a sustainability premium. For a more accurate verification and estimation of this premium, a detailed analysis of the existence of the green and sustainability risk premium is conducted through cross-sectional analysis. Furthermore, by constructing an adequate dataset, it is possible to analyze the excess return (alpha) of the created portfolios while controlling for the five Fama-French factors.

Regarding the results obtained from the analysis based on the E-score, a statistically significant green premium of 1.17% is found in the European stock market: specifically, the excess return for Q4 (brown portfolio) is 0.0251, while for Q1 (green portfolio) it is lower at 0.0103. The analysis is repeated using portfolios based on the ESG score, and the results are consistent with the previous analysis: a statistically significant sustainability premium of 2.20% is demonstrated, with the excess return for Q4 at 0.0300, greater than that of Q1 at 0.0029. The results obtained with both the E-score and ESG score confirm the hypothesis that less sustainable portfolios tend to generate higher returns than more sustainable ones: the presence of a green premium suggests that sustainability significantly affects

expected returns for investors. These results align with the studies of De Angelis and Monasterolo (2024), who conducted an empirical analysis of the EuroSTOXX 600 Index from January 2010 to February 2020: using the ESG score and E-score provided by Refinitiv, the authors found evidence of a green premium, as portfolios with lower ESG or E scores achieved statistically significant excess returns greater than those of more sustainable portfolios. Specifically, the brown portfolio (low E-score) showed a positive excess return after the Paris Agreement (0.8847 and significant at 5%); also, regarding the ESG analysis, portfolios with low ESG scores, according to the authors' analyses, had positive abnormal returns ( $\alpha = 0.5793$ , significant at 5%) even before the Paris Agreement. The authors noted that for portfolios with higher E and ESG scores, the intercept is not significant, concluding that there are no abnormal returns for more sustainable companies. Similarly, Alessi et al. (2023) analyzed European stocks from 2006 to 2020, using the E-score and emissions intensity data obtained from Bloomberg: consistent with the findings of this paper, the authors found that green portfolios have lower average annualized returns than brown portfolios, suggesting that green portfolios tend to generate lower returns compared to those with high emissions companies. Specifically, the positive and significant alpha of brown portfolios relative to the CAPM, 3F-Fama French, and Carhart models suggests that non-sustainable portfolios tend to generate additional returns not explained by traditional risk factors. In contrast, green portfolios exhibit a positive alpha value but generally lower. Moreover, the authors calculated the “greenness and transparency factor” as the difference between the returns of the green portfolio and those of the brown portfolio: the excess return associated with this factor (referring to the CAPM, 3F-Fama French, and Carhart models) is negative at 0.5%, indicating that less sustainable companies offer a return that is 0.5% higher than green companies. Future studies could conduct similar analyses using different time frames to evaluate the evolution of the greenium in periods characterized by various market, political, and climate conditions: a broader analysis period could allow for an examination of how key events, such as the implementation of stricter environmental regulations, influence the greenium; a shorter time frame, on the other hand, would capture short-term dynamics by analyzing the impact of sudden shocks to the markets, such as economic crises. Other interesting aspects for future studies could involve using different ESG scores from those utilized in this analysis,

as well as considering geographical areas other than the European market (e.g., emerging markets), where the perception and impact of sustainability may significantly differ from developed markets. Furthermore, additional studies could also examine specific sectors, as delving into the effect of the greenium at the sector level could reveal variations in the impact of sustainability across different industries, such as the energy sector compared to the technology sector.

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## **Conflict of interest**

The authors declare that they have no conflict of interest.

## **Availability of data and materials**

Not applicable.

## **Code availability**

Not applicable.

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