Don't sell the skin till you have caught the bear:

Cost of capital for ESG and Non-ESG Stocks

This version: November 17, 2022

Ahmed Badreldin and Bernhard Nietert

Ahmed Badreldin: Philipps-University of Marburg, School of Business and Economics, Finance and Banking, Universitaetsstrasse 24, 35037 Marburg, Germany
ahmed.badreldin@wiwi.uni-marburg.de

Bernhard Nietert: Philipps-University of Marburg, School of Business and Economics, Finance and Banking, Universitaetsstrasse 24, 35037 Marburg, Germany
nietert@wiwi.uni-marburg.de

Abstract

Cost of capital is the most important aspect for investors when investing in ESG stocks. Given this background there are two puzzles in the ESG literature. When formulating hypotheses or interpreting empirical findings, empirical ESG cost of capital papers use economic interpretations developed in theoretical ESG cost of capital papers. Yet, to derive cost of capital, empirical ESG papers do not use the valuation formulas of theoretical ESG papers. Instead, empirical ESG papers rely on multi-factor regressions to estimate cost of capital. Second, an empirically implementable theoretical alternative to empirical cost of capital formulas is missing in ESG research, a fact that is in stark contrast to traditional stock valuation where it can be chosen between theoretical (e.g., "classical" CAPM) or empirical models (e.g., Fama/ French, 1993)

This paper bridges the gap in the literature and brings theory-based ESG pricing formulas into a form that consists of solely observable components and show that the cost of capital for ESG stocks is a linear function of the risk premium of the ESG sub-market portfolio whereas the cost of capital for non-ESG stocks is a linear combination of the risk premia of the market portfolio and the ESG sub-market portfolio. These explanatory factors are derived from an asset pricing model and are not empirical or "guessed" factors. Hence, they overcome the factor zoo problem raised in Fama/French (2018) and Harvey/Liu (2019). Moreover, this paper demonstrates that the cost of capital differences between empirical and theory-based cost of capital are both statistically and economically significant, where neither the sign nor the size of cost of capital differences can be forecasted with the help of different ESG rating methodologies or stock characteristics.

JEL Classification: G12, G19

Keywords: cost of capital, ESG and non-ESG stocks, empirical versus theory-based pricing

1 Introduction

Krüger/Sautner/Starks (2020) point out that cost of capital is the most important aspect for investors when investing in ESG (Environment/Social/Governance) stocks. It is therefore not surprising that the ESG pricing literature analyzes cost of capital heavily, from both a theoretical and an empirical perspective. From a theoretical pricing perspective, Heinkel/Kraus/Zechner (2001) and Luo/Balvers (2017) develop cost of capital models with segmentation between ESG and non-ESG investments, Pástor/ Stambaugh/Taylor (2020) and Pedersen/Fitzgibbons/Pomorski (2020) construct models with preferences for ESG, and Zerbib (2020) designs a model that integrates segmentation and preferences. From an empirical pricing perspective, the literature (see Coqueret, 2020 for an excellent survey) estimates cost of capital for stocks, mutual funds, and bonds.

However, when juxtaposing theoretical and empirical ESG cost of capital papers, two puzzling observations are witnessed. First, to formulate hypotheses or interpret empirical findings, empirical ESG cost of capital papers use economic interpretations regarding cost of capital differences between ESG and non-ESG stocks developed in Heinkel/Kraus/Zechner (2001) (primarily), Pástor/Stambaugh/Taylor (2020) (rarely), and Pedersen/Fitzgibbons/Pomorski (2020) (rarely) (see for stocks: Albuquerque/Koskinen/Zhang, 2019; Albuquerque/Koskinen/Yang/Zhang, 2020; Derrien/Krüger/Landier/Yao, 2021; Hong/Kacperczyk, 2009; Hsu/Li/Tsou, 2020; Lioui/Poncet/Sisto, 2018; Sautner/van Lent/ Vilkov/Zhang, 2021, or Wang/Kartika/Wang/Luo, 2021; for mutual funds: Berk/van Binsbergen, 2021; Ceccarelli/ Ramelli/Wagner, 2021; Gantchev/Giannetti/Li, 2020; Lopez de Silanes/McCahery/Pudschedl, 2022). Yet, to derive cost of capital, empirical ESG cost of capital papers do not use the cost of capital formulas of theoretical ESG papers. Instead, empirical ESG cost of capital papers rely on multi-factor regressions like Fama/French (1993), Carhart (1997), or Fama/French (2015). However, these multi-factor regressions do not bear any ESG reference in their formulas and, thus, are not ideal for determining cost of capital in an environment where ESG is explicitly stressed as distinguishing feature. Second, a theoretical alternative to empirical cost of capital formulas is still missing in ESG research, a fact that is in stark contrast to traditional stock valuation where decision makers/researchers can choose between theoretical (e.g., “classical” CAPM) and empirical models (e.g., Fama/French (1993)). For theoretical ESG cost of capital formulas are not presented in an empirically implementable form—they contain unobservable preference-dependent parameters.

Put differently, the empirical ESG literature seems to sell the skin before it caught the bear: cost of capital differences between ESG and non-ESG stocks, effects of ESG score changes, alternatives to Fama/French three factor models in an ESG environment, and the explanation of cost of capital with the help of, e.g., ESG scores and climate news, are all analyzed without having clarified sufficiently the

computation of ESG cost of capital. Therefore, a core (see Krüger/Sautner/Starks, 2020) and not just a marginal aspect of ESG analyses is shaky.

Against this background, our paper has two objectives: first, to develop a theoretical ESG cost of capital formula that is empirically implementable; second, to show that these empirically implementable theoretical ESG cost of capital formulas are a non-trivial extension to the literature in that they result in both statistically and economically significant cost of capital differences to existing empirical ESG cost of capital formulas. In this connection, we would like to stress that our motivation for the analysis of cost of capital is not a better empirical fit, but a better economic explanation/understanding of cost of capital, a dimension that is highly underappreciated nowadays.

To achieve the first objective, we focus on the theoretical ESG paper cited most by empirical ESG cost of capital papers: the segmented market model of Heinkel/Kraus/Zechner (2001). We express the preference-dependent parameters in Heinkel/Kraus/Zechner (2001) with the help of so-called sub-market portfolios. Sub-market portfolios are observable components of the market portfolio, e.g., the S&P 500 ESG index, which is a filtered subset of the S&P 500 index. We show that the cost of capital for ESG stocks is a linear function of the risk premium of the ESG sub-market portfolio whereas the cost of capital for non-ESG stocks is a linear combination of the risk premia of the market portfolio and the ESG sub-market portfolio.

To achieve the second objective, we compute cost of capital differences between our theoretical cost of capital formulas and: (i) a regression-based cost of capital formulas that uses the factors of the theoretical cost of capital formulas (but not its factor loadings); (ii) the Fama/French three factor model as the standard model of the ESG cost of capital literature (that uses different factors as well as factor loadings compared to the theoretical model). Regarding cost of capital differences between models with different factor loadings we elaborate, in a first step, theoretically when cost of capital differences equal zero. Only if these theoretical conditions are not met empirically, we will in a second step determine statistical and economic significance. Regarding cost of capital differences between models with different factors and factor loadings, we immediately rely on statistical and economic significance. Both statistical and economic significance are applied to 19 data sets that are characterized by19 different ESG score methodologies. We measure statistical significance with the help of the one-sample Cramér/von Mises test that allow us to determines whether the distribution of cost of capital differences diverges from the distribution of the Dirac function (= measure of identical cost of capital). We tackle economic significance by comparing cost of capital differences against a benchmark suggested by Fama/French (1997, p. 174): 1% and 2% (annualized).

We find with respect to cost of capital differences between models with different factor loadings: first, the theoretical conditions under which cost capital differences between empirical and theoretical models equal zero read: (i) the excess return of the ESG sub-market portfolio can be explained by the

excess return of the market portfolio using a linear model; (ii) there is just one ESG stock. Second, these conditions are not empirically given in reality. Third, cost of capital differences between empirical and theoretical models are both statistically and economically significant. However, fourth, over all of our 19 data sets we have a lower percentage of economic significances than Fama/French (1997). Nevertheless, for some data sets, e.g., "Sustainalytics Total ESG Score Negligible and Low", a percentage thrice as high as in Fama/French (1997) is economically significant. In particular, we discover that negative cost of capital differences exhibit a higher percentage of economic significance than positive cost of capital differences and, as a rule of thumb, RepRisk result in low levels of economically significant cost of capital differences, while Upright for ESG and Sustainalytics for non-ESG stocks deliver high levels.

With respect to cost of capital differences between models with different factors and factor loadings we observe both statistically and economically significant cost of capital differences. This time, economic significance reaches levels approximately identical in Fama/French (1997). This means that the cost of capital differences between the theoretical ESG model and the Fama/French three factor model are as pronounced as the differences between the CAPM and Fama/French three factor model.

In addition, neither the sign nor the size of cost of capital differences can be forecasted with the help of different ESG rating methodologies or stock characteristics (covariances with the market portfolios or industry classification). Combining this result with the statistical and economic significance of cost of capital differences indicates that a theoretical ESG cost of capital formula as an alternative to purely empirical cost of capital formulas is generally a non-trivial extension of the ESG literature. Specifically, our paper contributes to four strands of the ESG literature.

First, it adds to the theory of asset pricing for ESG and non-ESG stocks. The ESG asset pricing formulas of Heinkel/Kraus/Zechner (2001) contain unobservable preference-dependent parameters that prevent an immediate empirical implementation. Luo/Balvers (2017) develop an ESG asset pricing formula that is independent of investors' preferences and even possesses regression coefficients as factor loadings. However, the portfolio they use to eliminate investors' preference parameters does not coincide with observable ESG sub-market portfolios such as those offered by Thomson Reuters, Refinitiv/S-Network, MSCI, Sustainalytics, Upright Project, and RepRisk. Therefore, the model of Luo/Balvers (2017) does not use publicly available ESG information for the determination of cost of capital. If, however, these ESG sub-market portfolios are used, Luo/Balvers's (2017) approach can no longer be applied.— From that perspective, our paper is the only one that is able to devise a cost of capital formula for ESG and non-ESG stocks that is both independent of preferences and relies on publicly available ESG information.

Second, our paper contributes to the strand of the literature that analyzes the effects of ESG score changes. Berg/Fabisik/Sautner (2021) and Latino/Pelizzon/Rzeźnik (2021) examine abnormal return

caused by changes in the ESG score methodology, Avramov/Cheng/Lioui/Tarelli (2021) and Berg/ Kölbel/Pavlova/Rigobon (2021) develop a pricing model under ESG noise, Berg/Kölbel/Rigobon (2022), Billio/Costola/Hristova/Latino/Pelizzon (2021), Christensen/Serafeim/Sikochi (2022), Dyck/Lins/Roth/ Wagner (2019), Ehlers/Elsenhuber/Jegarasasingam/Jondeau (2022), and Gibson/Krüger/Schmidt (2021) offer explanations for diverging ESG scores, Sahin/Bax/Czado/Paterlini (2021) invent a procedure to deal with missing ESG data, and Dorfleitner/Kreuzer/Sparrer (2020) as well as Vu/Lehkonen/Junttila (2022) examine the performance consequences of different ESG ratings.—Our paper considers 19 different ESG score methodologies and shows that cost of capital differences between theoretical and empirical cost of capital vastly differ between different ESG score methodologies.

Third, our paper contributes to the strand of literature that questions the use of Fama/French (1993), Fama/French (2015), or Carhart (1997) in an ESG context since these multi-factor regressions do not bear any ESG reference in their formulas. This literature, thus, adds own factors (e.g., Dunn/Fitzgibbons/Pomorski, 2017; La Torre/Mango/Cafaro/Le, 2020; Matsumura/ Prakash/Vera-Muñoz, 2014), factors from energy economics (e.g., Oberndorfer, 2009), takes factor noise into consideration (Berg/Kölbel/Pavlova/Rigobon, 2021), determines factors endogenously (Lindsey/Pruitt/Schiller, 2021), or uses advanced statistical methods such as machine learning (e.g., Chen/Liu, 2020) or quantile regression (e.g., Santi,/Moretti, 2021 and Zhu/Tang/Peng/Yu, 2018). Moreover, Akey/Robertson/Simutin (2021) illustrate that using historical instead of current Fama/French factors changes the statistical significance of factors, conditional CAPM is employed by Areal/Cortez/Silva (2013), Bauer/Derwall/Otten (2007), or Cortez/Silva/Areal (2012), and fund in- and out-flows are taken into consideration when determining cost of capital (Berk/van Binsbergen, 2021 and van der Beck, 2021)—Our paper illustrates that theoretical ESG pricing models help to shift focus away from the (random) search for more factors ("factor zoo" problem described by Fama/French, 2018 and Harvey/Liu, 2019) to factors that are justified by asset pricing theory, in particular risk premium of the ESG sub-market portfolio, a factor that has not been discovered by the empirical literature so far. Moreover, our paper shows that both factors and factor loadings cause relevant cost of capital differences.

Fourth, our paper contributes to the stand of the literature that uses cost of capital as input for further analysis. Specifically, this literature asks how cost of capital can be explained with the help of, e.g., ESG scores and climate news (Baily/Gnabo, 2022), activists' activities (Barber/Morse/Yasuda, 2020), firm characteristics (Bolton/Kacperczyk, 2021; Karoui/Nguyen, 2022), emissions (Kazdin/Schwaiger/ Wendt/Ang, 2021), and carbon risk (Kuang/Liang, 2020).—Our paper illustrates that the statistical significance of factors changes when switching from empirical to theory-based cost of capital as dependent variable thus making it more difficult to understand the determinants of cost of capital.

The remainder of the paper is organized as follows: In Section 2 an empirically implementable form of Heinkel/Kraus/Zechner's (2001) segmented markets model is derived. Section 3 proves analytically

that cost of capital differences between theory-based models and models with different factor loadings arise and elaborates the exceptional conditions under which both cost of capital coincide. Research design and data set for the empirical analysis are described in Section 4. Section 5 empirically analyzes both statistical and economical significance of cost of capital differences between theoretical and empirical models. Section 6 concludes. Formal and empirical appendices end the paper.

2 Segmented markets' cost of capital formulas in empirically implementable form

Out of the group of theoretical ESG cost of capital models (Heinkel/Kraus/Zechner (2001), Luo/Balvers (2017), Pástor/Stambaugh/Taylor (2020), Pedersen/Fitzgibbons/Pomorski (2020), and Zerbib (2020)) empirical ESG cost of capital papers most often cite the segmented market model of Heinkel/ Kraus/Zechner (2001) when giving theoretical backing to their empirical findings. Specifically, they refer to Heinkel/Kraus/Zechner (2001) without the asset class "reformed asset". Therefore, we examine exactly this version of Heinkel/Kraus/Zechner (2001) in more detail regarding its empirical practicability.

2.1 Illustration that Heinkel/Kraus/Zechner (2001) is not in empirically implementable form

Appendix Online 1 illustrates that the segmented markets' cost of capital formulas of Heinkel/Kraus/Zechner (2001) without the asset class "reformed asset" read

Cost of capital for ESG stock G_i

(1)

$$E\{R_{G_i,t+1}\} = r + \frac{W_{M,t}}{\frac{1}{a_n} + \frac{1}{a_e}} \cdot \sigma_{R_{G_i},R_M}$$

Cost of capital for non-ESG stock H_i

(2)

$$E\{R_{H_i,t+1}\} = r + \frac{W_{M,t}}{\frac{1}{a_n}+\frac{1}{a_e}} \cdot \sigma_{R_{H_i},R_M} + \frac{a_n^2}{a_e+a_n} \cdot \left[\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}\right]$$

where $W_{M,t}$ denotes the wealth of the market portfolio at time t, R_M the return of the market portfolio, R_G the return (vector) of ESG stocks, $R_{G_i,t+1}$ ($R_{H_i,t+1}$) the return of ESG stock G_i (non-ESG stock H_i), a_j the risk preference parameter of the ESG ($j = e$) and non-ESG ($j = n$) investor group, r the riskless rate, ^{T} transposition of a vector or matrix, $\sigma_{x,y}$ the covariance between two random variables x and y, and $E\{.\}$ the expected value operator. Note that ESG investors invest in ESG stocks only, where non-ESG investors invest in both ESG and non-ESG stocks.

Since the risk premia formulas for both ESG stock G_i (1) and non-ESG stock H_i (2) contain unobservable risk preference parameters a_e and a_n, (1) and (2) are not in an empirically implementable form. Moreover, expected values, variances, and covariances are based on population values, which are unobservable as well.

2.2 Empirically implementable form of Heinkel/Kraus/Zechner (2001)

To eliminate the unobservable risk preference parameters from formulas (1) and (2), these parameters must be expressed with the help of observable portfolios.—This technique has been pioneered for two-factor models by Merton (1973) when he derived a special case of his intertemporal CAPM, namely the CAPM with stochastic interest rates.

Potential candidates for such observable portfolios are: the sub-market portfolio of ESG stocks, the sub-market portfolio of non-ESG stocks, and the market portfolio (of all stocks). Sub-market portfolios are observable components of the market portfolio. For example, the S&P 500 ESG index is a filtered subset of the S&P 500 index. Consequently, the market portfolio is the sum of ESG and non-ESG sub-market portfolios, i.e., $W_{M_G} + W_{M_H} = W_M$ meaning that all three portfolios are linearly dependent. Therefore, two arbitrary portfolios can be chosen to determine the unknown risk preference parameters a_n and a_e. However, ESG indices and market indices are published, but non-ESG indices (they would have to be computed[1]). As a result, the market portfolio M and the sub-market portfolio of ESG stocks M_G are the best candidate portfolios to determine the unobservable risk preference parameters.

With the help of these two observable portfolios, cost of capital formulas can be derived (please refer to Appendix 1) that are free of unobservable risk preference parameters. Moreover, using sample estimates for expected values, variances, and covariances gives the following empirically implementable form of Heinkel/Kraus/Zechner's (2001) cost of capital formulas:

---

[1] There is, however, an index for sin stocks (https://indexes.nasdaqomx.com/Index/Overview/SIN).

Cost of capital for ESG stock G_i

(3)

$$cost\ of\ capital_{G_i,theo} = r + \underbrace{\frac{\hat{s}_{R_{G_i},R_M}}{\hat{s}_{R_{M_G},R_M}}}_{b_{G_i,theo}} \cdot \left[\bar{R}_{M_G} - r\right]$$

where $\hat{s}_{x,x} \equiv \sum_{t=1}^{T}(x_t - \bar{x}) \cdot (y_t - \bar{y})$, $\bar{}$ denotes the sample arithmetic mean, R_{M_G} the return of the ESG sub-market portfolio, and $theo$ refers to the theory-based model.

Cost of capital for non-ESG stock H_i

(4)

$$cost\ of\ capital_{H_i,theo} = r +$$

$$\underbrace{\frac{\hat{s}_{R_M,R_M} \cdot \hat{s}^T_{R_G,R_{H_i}} \left(\hat{s}_{R_G,R_G}\right)^{-1} \hat{s}_{R_G,R_M} - \hat{s}_{R_{H_i},R_M} \cdot \hat{s}^T_{R_G,R_M} \left(\hat{s}_{R_G,R_G}\right)^{-1} \hat{s}_{R_G,R_M}}{\hat{s}_{R_{M_G},R_M} \cdot \left[\hat{s}_{R_M,R_M} - \hat{s}^T_{R_G,R_M} \left(\hat{s}_{R_G,R_G}\right)^{-1} \hat{s}_{R_G,R_M}\right]}}_{b_{H_i,M_G,theo}} \cdot \left[\bar{R}_{M_G} - r\right]$$

$$+ \underbrace{\frac{\hat{s}_{R_{H_i},R_M} - \hat{s}^T_{R_G,R_{H_i}} \left(\hat{s}_{R_G,R_G}\right)^{-1} \hat{s}_{R_G,R_M}}{\hat{s}_{R_M,R_M} - \hat{s}^T_{R_G,R_M} \left(\hat{s}_{R_G,R_G}\right)^{-1} \hat{s}_{R_G,R_M}}}_{b_{H_i,M,theo}} \cdot \left[\bar{R}_M - r\right]$$

According to (3) the cost of capital for ESG stocks is a linear function of the risk premium of the ESG sub-market portfolio whereas cost of capital for non-ESG stocks (4) is a linear combination of the risk premia of the market portfolio and the ESG sub-market portfolio.

The identification of this particular factor structure distinguishes (3) and (4) from the non-implementable pricing formulas (1) and (2) (besides the obvious fact that (3) and (4) no longer contain unobservable risk preference parameters). Therefore, (3) and (4) illustrate that theoretical ESG pricing models help to shift focus away from the (random) search for more factors ("factor zoo" problem described by Fama/French, 2018 and Harvey/Liu, 2019) to factors that are justified by asset pricing theory. In particular, risk premium of the ESG sub-market portfolio is a factor that has not been discovered by the empirical ESG literature so far.

3 Theoretical comparison of empirical and theory-based cost of capital

3.1 Identification of the models to be compared

Models can differ with respect to factor loadings (but use identical factors and, hence, is not subject to the factor zoo problem raised in Fama/French, 2018, pp. 239, 240 and Harvey/Liu, 2019) as well as both factors and factor loadings. As representative of the first class of models we consider cost of

capital formula that uses the factors of the theoretical ESG cost of capital formulas (3) and (4), i.e., return of the market portfolio minus riskless rate and return of the ESG sub-market portfolio minus riskless rate, but not its factor loadings. Instead, regression-based factor loadings are applied. Epitome for the second class of models—it is the standard model of the empirical ESG cost of capital literature—is the Fama/French three factor model since it uses different factors as well as factor loadings compared to the theoretical ESG cost of capital formulas.

We approach the comparison of empirical and theory-based cost of capital from two different angels. For cost of capital differences between models with different factor loadings (but identical factors) we elaborate, in a first step, theoretically when cost of capital differences equal zero. Only if these theoretical conditions are not met empirically, we will in a second step (Section 5) determine statistical and economic significance. For cost of capital differences between models with different factors and factor loadings, we immediately rely on statistical and economic significance (Section 5).

In other words, the rest of this section deals solely with models that only differ regarding factor loadings.

3.2 Derivation of regression-based cost of capital for models that differ with respect to factor loadings only

Cost of capital for ESG stock G_i

Using $R_{M_G,\tau} - r$ from the theory-based ESG models (3) as independent variable (factor), the time-series regression for ESG stock G_i reads

$$R_{G_i,\tau} - r = b_{G_i,regr} \cdot \left(R_{M_G,\tau} - r\right) + \varepsilon_{G_i,\tau}$$

Given this estimate of $b_{G_i,regr}$, cost of capital is calculated using the historical average for the factor, i.e., $\bar{R}_{M_G} - r$ (see, e.g., Campbell/Lo/MacKinlay, 1997, p. 184). Then it is obtained

(5)

$$cost\ of\ capital_{G_i,regr} = r + \underbrace{\frac{\hat{S}_{R_{G_i},R_{M_G}}}{\hat{S}_{R_{M_G},R_{M_G}}}}_{b_{G_i,regr}} \cdot \left[\bar{R}_{M_G} - r\right]$$

where the subscript $regr$ refers to the regression model.

Cost of capital for non-ESG stock H_i

Time-series regression with $R_{M_G,\tau} - r$ and $R_{M,\tau} - r$ from theory-based ESG models (4) as independent variables yields for non-ESG stock H_i

$$R_{H_i,\tau} - r = b_{H_i,M_G} \cdot \left[R_{M_G,\tau} - r\right] + b_{H_i,M} \cdot \left[R_{M,\tau} - r\right] + \varepsilon_{H_i,\tau}$$

and obtains (in a similar procedure to ESG stock G_i, this time, however, using two-factor OLS regression coefficients) cost of capital for non-ESG stock H_i

(6)

$$cost\ of\ capital_{H_i,regr} = r + \underbrace{\frac{\hat{s}_{R_M,R_M} \cdot \hat{s}_{R_{H_i},R_{M_G}} - \hat{s}_{R_{M_G},R_M} \cdot \hat{s}_{R_{H_i},R_M}}{\hat{s}_{R_{M_G},R_{M_G}} \cdot \hat{s}_{R_M,R_M} - \hat{s}^2_{R_{M_G},R_M}}}_{b_{H_i,M_G,regr}} \cdot \left[\bar{R}_{M_G} - r\right] + \underbrace{\frac{\hat{s}_{R_{M_G},R_{M_G}} \cdot \hat{s}_{R_{H_i},R_M} - \hat{s}_{R_{M_G},R_M} \cdot \hat{s}_{R_{H_i},R_{M_G}}}{\hat{s}_{R_{M_G},R_{M_G}} \cdot \hat{s}_{R_M,R_M} - \hat{s}^2_{R_{M_G},R_M}}}_{b_{H_i,M,regr}} \cdot \left[\bar{R}_M - r\right]$$

3.3 Comparison of empirical and theory-based cost of capital for models that differ with respect to factor loadings only

Comparing empirical (ESG stocks: (5); non-ESG stocks (6)) and theory-based (ESG stocks: (3); non-ESG stocks: (4)) cost of capital delivers:

For ESG stocks, the theoretical model (3) uses the covariance between the ESG sub-market portfolio and the market portfolio in the denominator, while the regression approach (5) uses the variance of the ESG sub-market portfolio. As a result, the factor loadings of both approaches differ.

Since the regression coefficients for non-ESG stocks do not contain the term $\hat{s}^T_{R_G,R_M}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$— just to mention the most notable difference—the factor loadings of the theoretical ESG Formula (4) differ from their (two-factor) regression counterparts (6).

3.4 Conditions under which empirical and theory-based cost of capital coincide (for models that differ with respect to factor loadings only)

Empirical and theory-based costs of capital (for models that differ with respect to factor loadings only) will coincide if either a special risk structure of stock returns is assumed or a specific sub-market portfolio is considered.

3.4.1 Special risk structure of stock returns

The two conditions regarding stock returns' risk structure are: Condition (i) the excess return of the sub-market portfolio of ESG stocks can be explained by the excess return of the market portfolio using a linear factor model; Condition (ii) there is just one ESG stock.

Condition (i)

Formally, Condition (i) reads

(7)

$$R_{M_G,t+1} - r = b \cdot \left(R_{M,t+1} - r\right) + \varepsilon_{M_G,t+1}$$

with

$$E\{\varepsilon_{M_G,t+1}\} = 0$$

$$cov\left(\varepsilon_{M_G,t+1}; R_{M,t+1}\right) = 0$$

Then it holds in sample form (for a formal proof, please refer to Appendix 2.1):

Cost of capital for ESG stock G_i

(8)

$$cost\ of\ capital_{G_i,Cond(i)} = r + \frac{\hat{s}_{R_{G_i},R_M}}{\hat{s}_{R_M,R_M}} \cdot [\bar{R}_M - r]$$

Cost of capital for non-ESG stock H_i

(9)

$$cost\ of\ capital_{H_i,Cond(i)} = r + \frac{\hat{s}_{R_{H_i},R_M}}{\hat{s}_{R_M,R_M}} \cdot [\bar{R}_M - r]$$

Both (8) and (9) are identical to the sample form of the classical CAPM. Hence their factor loadings coincide with one-factor regression coefficients and cost of capital differences will be zero.

The economic intuition behind Condition (i) is straightforward. The relation between $R_{M_G,t+1}$ and $R_{M,t+1}$ can be characterized by means of a linear factor model. This specific risk structure signifies that there is de facto one explanatory variable, namely $R_{M,t+1}$. Since the classical CAPM also relies exclusively on $R_{M,t+1}$, the parallel becomes apparent.

Condition (ii)

Formally, Condition (ii)—there is just one ESG stock—reads

(10)

$$R_{M_G,t+1} = R_{G_i,t+1}$$

Based on (10), the cost of capital formulas in sample form simplify to (for a formal proof, please refer to Appendix 2.2):

Cost of capital for ESG stock G_i

(11)

$$cost\ of\ capital_{G_i,Cond(ii)} = r + \left(\bar{R}_{G_i} - r\right)$$

Cost of capital for non-ESG stock H_i

(12)

$$cost\ of\ capital_{H_i,cond(ii)} = r + \frac{\hat{s}_{R_M,R_M} \cdot \hat{s}_{R_{G_i},R_{H_i}} - \hat{s}_{R_{H_i},R_M} \cdot \hat{s}_{R_{G_i},R_M}}{\hat{s}_{R_M,R_M} \cdot \hat{s}_{R_{G_i},R_{G_i}} - \hat{s}^2_{R_{G_i},R_{H_i}}} \cdot \left[\bar{R}_{M_G} - r\right] + \frac{\hat{s}_{R_{H_i},R_M} \cdot \hat{s}_{R_{G_i},R_{G_i}} - \hat{s}_{R_{G_i},R_{H_i}} \cdot \hat{s}_{R_{G_i},R_M}}{\hat{s}_{R_M,R_M} \cdot \hat{s}_{R_{G_i},R_{G_i}} - \hat{s}^2_{R_{G_i},R_{H_i}}} \cdot [\bar{R}_M - r]$$

Equation (11) is just a tautology. This result is not surprising since the ESG stock is used in a dual role: explanatory variable and asset whose cost of capital is to be determined.

Equation (12) on the other hand, is a two-factor model where the factor loadings are regression coefficients. Intuitively, this is due to the fact that with $R_{G_i} = R_{M_G}$ no other variables enter the picture beyond the market portfolio and the sub-market portfolio of ESG stocks (which is identical to the sole ESG stock). In particular, due to the simplified risk structure of Condition (ii) neither covariances between the different ESG stocks ($\hat{s}_{R_G,R_G}$) nor covariances between different ESG stocks and the market portfolio ($\hat{s}_{R_G,R_M}$) enter the cost of capital formula.

A funny aside: in their original paper Heinkel/Kraus/Zechner (2001) consider just one ESG stock for reason of simplicity. Thereby, they accidently end up with regression coefficients although their model in the multi-ESG stock case does not produce regression coefficients as factor loadings.

3.4.2 Specific sub-market portfolio: the approach of Luo/Balvers (2017)

Luo/Balvers (2017) derive an empirically implementable theoretical ESG cost of capital model and nevertheless obtain regression coefficients by using a specific sub-market portfolio. This can be seen as follows: their preference-dependent cost of capital equation (A-12)[2] is transformed into cost of capital equations that no longer depend on preferences (their Equations (A-14) or (A-15)). Moreover, their Equations (A-14) or (A-15) have factor loadings that are indeed regression coefficients.

To achieve these results, they choose a specific portfolio, the so-called “boycott portfolio”, together with the market portfolio to compute cost of capital for ESG and non-ESG stocks. This portfolio comprises all assets and possesses a specific structure shown in their Equation (A-11). Using our notations, this structure can be expressed as:

$$N_{M,B} \equiv \begin{pmatrix} -\sigma_{GG}^{-1}\, \Omega_{G,H}\, N_{M,H} \\ N_{M,H} \end{pmatrix}$$

[2] Referring to the original numbering of equations in the paper by Luo/Balvers (2017).

Given the specific structure of the portfolio holdings $N_{M,B}$ of the boycott portfolio, it is neither identical to the sub-market portfolio of ESG or non-ESG stocks nor does it use the pricing information of these sub-market portfolios. Instead it must be computed by hand. Therefore, the model of Luo/Balvers (2017) does not use publicly available ESG information like published ESG indices. If, as we suggest, publicly available ESG sub-market portfolios are used, Luo/Balvers's (2017) approach can no longer be applied.

3.4.3 Special risk preferences: do identical risk preference parameters for ESG and non-ESG investors make empirical and theory-based cost of capital coincide (for models that differ with respect to factor loadings only)?

Since unknown risk preference parameters a_n and a_e in (1) and (2) required two observable portfolios, the presence of two risk preference parameters might have been responsible for the fact that empirical and theory-based cost of capital diverge. Therefore, it should be analyzed whether identical risk preference parameters for ESG and non-ESG investors, i.e., $a_n = a_e = a$, make empirical and theory-based cost of capital coincide.

According to Appendix Online 2 the empirically implementable form of the theoretical ESG cost of capital in the case of identical risk preference parameters read (in sample form):

Cost of capital for ESG stock G_i

(13)

$$cost\ of\ capital_{G_i,identical\ risk\ pref} = r + \frac{\hat{s}_{R_{G_i},R_M}}{2 \cdot \hat{s}_{R_M,R_M} - \hat{s}^T_{R_G,R_M}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}} \cdot [\bar{R}_M - r]$$

Cost for capital of non-ESG stock H_i

(14)

$$cost\ of\ capital_{H_i,identical\ risk\ pref} = r + \frac{2 \cdot \hat{s}_{R_{H_i},R_M} - \hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}}{2 \cdot \hat{s}_{R_M,R_M} - \hat{s}^T_{R_G,R_M}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}} \cdot [\bar{R}_M - r]$$

In (13) and (14) cost of capital depends solely on one factor: the sample risk premium of the market portfolio. Hence, time series regressions employ $R_{M,\tau} - r$ as explanatory variable:

$$R_{G_i,\tau} - r = b_{G_i} \cdot \left[R_{M,\tau} - r\right] + \varepsilon_{G_i,\tau}$$

and

$$R_{H_i,\tau} - r = b_{H_i} \cdot \left[R_{M,\tau} - r\right] + \varepsilon_{H_i,\tau}$$

Such time series regressions deliver as regression coefficients $b_{G_i,regr} = \frac{\hat{s}_{R_{G_i},R_M}}{\hat{s}_{R_M,R_M}}$ and $b_{H_i,regr} = \frac{\hat{s}_{R_{H_i},R_M}}{\hat{s}_{R_M,R_M}}$.

This in turn means that even with identical risk preference parameters, cost of capital (13) and (14) do not equal regression-based cost of capital. Put differently, identical risk preference parameters are not

a third condition besides a special risk structure of stock returns or a specific sub-market portfolio that makes empirical and theory-based cost of capital coincide.

4 Empirical research design and data set

4.1 Empirical research design

Theoretically identified cost of capital differences between models with different factor loadings (but identical factors) do not necessarily mean that these differences will also be visible in practical application. Moreover, the theoretical analysis excluded completely cost of capital differences between models with different factors and factor loadings.

Against this background, we develop our empirical research design in four steps. In Step 1, we check whether the conditions that result in zero cost of capital differences between models with different factor loadings (but identical factors) hold in reality. If these conditions are violated, we will analyze in Step 2 whether the cost of capital differences for models with different factor loadings as well as different factors and loadings are statistically and economically significant. In Step 3 we try to explain differences in the level of economic significance to identify potential drivers of these cost of capital difference, i.e., differences in ESG rating methodologies or stock characteristics. In Step 4 we approach cost of capital differences from a different angle: explanatory power of cost of capital determinants instead of size differences. To that end, we lean on the strand of the literature that uses cost of capital as an input for further empirical analysis, for example by asking how cost of capital can be explained with the help of firm characteristics (e.g., market value, total assets, and operating income) or ESG variables. We then analyze whether the factors explaining regression-based cost of capital are different from those illuminating theory-based cost of capital.

4.1.1 Models to compare

Both Step 1 and Step 2 involve cost of capital comparisons. Therefore, it must be clarified what cost of capital models are to be compared.

- Testing Condition (i): “excess return of the sub-market portfolio of ESG stocks can be explained by the excess return of the market portfolio using the linear factor model (7)”

Cost of capital for ESG stock G_i according to Equation (8) (Condition (i))	versus	Cost of capital for ESG stock G_i according to Equation (3) (theory-based)
Cost of capital for non-ESG stock H_i according to Equation (8) (Condition (i))	versus	Cost of capital for non-ESG stock H_i according to Equation(4) (theory-based)

- Testing Condition (ii): "there is just one ESG stock"

Cost of capital for ESG stock G_i according to Equation (11) (Condition (ii))	versus	Cost of capital for ESG stock G_i according to Equation (3) (theory-based)
Cost of capital for non-ESG stock H_i according to Equation (12) (Condition (ii))	versus	Cost of capital for non-ESG stock H_i according to Equation(4) (theory-based)

- Comparing cost of capital differences between models with different factor loadings (but identical factors)

Cost of capital for ESG stock G_i according to Equation (5) (one-factor OLS regression)	versus	Cost of capital for ESG stock G_i according to Equation (3) (theory-based)
Cost of capital for non-ESG stock H_i according to Equation (6) (two-factor OLS regression)	versus	Cost of capital for non-ESG stock H_i according to Equation(4) (theory-based)

- Comparing cost of capital differences between models with different factors and factor loadings

Cost of capital for ESG stock G_i (15) $cost\ of\ capital_{G_i,FF3} = r + b_{G_i} \cdot [\bar{R}_M - r] + s_{G_i} \cdot \bar{R}_{SMB} + h_{G_i} \cdot \bar{R}_{HML}$ (Fama/French three factor model)	versus	Cost of capital for ESG stock G_i according to Equation (3) (theory-based)
Cost of capital for non-ESG stock H_i (16) $cost\ of\ capital_{H_i,FF3} = r + b_{H_i} \cdot [\bar{R}_M - r] + s_{H_i} \cdot \bar{R}_{SMB} + h_{H_i} \cdot \bar{R}_{HML}$ (Fama/French three factor model)	versus	Cost of capital for non-ESG stock H_i according to Equation(4) (theory-based)

where $\bar{R}_{SMB}$ and $\bar{R}_{HML}$ are the average returns of the small minus big and high minus low portfolios from the Fama/French three factor model, b_{j_i}, s_{j_i}, and h_{j_i} $j \in \{G, H\}$ are the regression coefficients of the Fama/French regressions.

4.1.2 Assessing the relevance of cost of capital differences

The relevance of the differences in costs of capital is judged with the help of statistical and economic significance.

4.1.2.1 Measuring statistical significance

Differences in costs of capital can be (i) positive or negative and (ii) of varying sizes for different stocks. Therefore, a measure of statistical significance is needed that can deal with both features and does not produce a loss of information by aggregating both features.

Against this background, the Cramér/von Mises test for judging the goodness of fit of a distribution to a given empirical distribution seems to be an ideal choice since it deals with both positive and negative

deviations and explicitly considers variations beyond the mean. A t-test, on the other hand, nets positive and negative differences and disregards a lot of distributional information due to its sole focus on mean. The Kolmogorov/Smirnov-Test only considers the maximum difference and does not take all data points into consideration (see, e.g., Stephens (1991, 102)).

Specifically, we apply the following procedure to test for statistical significance:

(i) Differences in costs of capital are computed for each stock in each data set.

(ii) A cumulative relative frequency distribution of the cost of capital differences is determined based on the cost of capital differences for each stock in the respective data set. For example, for the particular data set "Thomson Reuters ESG Combined Score A- and better" the cumulative relative frequency distribution is based on cost of capital differences of 54 stocks, for "Refinitiv/S-Network ESG Best Practices Index" of 222 stocks etc.

(iii) The benchmark case of zero cost of capital differences is captured by means of the cumulative relative frequency distribution of the Dirac function. For the Dirac function possesses a probability of zero for differences unequal to zero and a probability of 1 for differences equal to zero.

(iv) The one-sample Cramér/von Mises is used for testing whether the distribution of cost of capital differences (= one sample) is different from the distribution of the Dirac function (= given empirical distribution).

4.1.2.2 Measuring economic significance

Statistical significance alone is not sufficient to prove that cost of capital differences are relevant. Instead, they should also matter regarding their effect size, i.e., be economically significant, in order to be deemed worthy of attention. Following Mitton (2020), we approach economic significance from two angles: first, contrasting our cost of capital differences with the size of cost of capital differences found in the literature, transaction costs because they might neutralize any potential trading gains arising from cost of capital differences.

Regarding the first angle, Fama/French (1997) is the key paper. They see differences in costs of capital between the CAPM and the Fama/French (1993) three-factor model of 1% and 2% (annualized) as relevant (see Fama/French, 1997, p. 174). From that perspective it could be argued that an annualized cost of capital difference less than 1% or 2% is less than the one found in the literature and, hence, is not economically significant.

With respect to the second angle, variable trading costs are a good proxy. Variable trading costs on the German Electronic Exchange (XETRA) equal 48 basis points. Put differently, costs of capital differences of more than 48 basis points would be regarded as economically significant since they cover the trading costs for a correcting transaction.

Since the Fama/French (1997) benchmarks (1% and 2%) and the variable transaction costs benchmark (48 basis points = 0.48%) are relatively far apart, we consider additional benchmarks (1.5%, 0.5% (approximately equals 48 basis points), 0.25%, and 0.1%). It is reasonable to consider further benchmarks beyond those used by Fama/French (1997) since considering a whole range of benchmarks allows us to obtain deeper insights into economic significance, i.e., whether cost of capital differences for subsets of assets (e.g., ESG versus non-ESG) exhibit a different level of economic significance.

4.1.2.3 Robustness analyses

Cost of capital differences should not be regarded as statistically and economically significant if the differences just hold in a narrow parameter setting. For that reason, cost of capital differences are computed along several dimensions:

(i) Investment horizons (return frequencies)

We consider daily, monthly, quarterly, and annual returns.

(ii) Different ESG ratings

Avramov/Cheng/Lioui/Tarelli (2020), Berg/Koelbel/Rigobon (2022), Billio/Costola/Hristova/Latino/Pelizzo (2021), Dorfleitner/Kreuzer/Sparrer (2020), and Gibson/Krüger/Schmidt (2021) demonstrate that different ESG rating methods result in different ESG scores for the same stock. Therefore, different ESG ratings might result in different cost of capital differences as well.—To capture these methodological rating differences, we consider 19 ESG ratings—our data sets—in our analysis.

(iii) Single stocks and portfolios

As opposed to single stocks, portfolios are assumed to exhibit lower unsystematic risk. Hence their cost of capital differences might behave differently than those of individual stocks. We therefore analyze Fama/French's (1997) industry portfolios in addition to single stocks.

It should also be noted that industry portfolios possess another advantage, namely, that they help mitigating a statistical problem present in longer investment horizons than daily: the number of stocks exceeds the number of observations meaning that the matrix $\hat{S}_{R_G,R_G}$ in the cost of capital formula for non-ESG stocks (4) cannot be inverted. Table 1 illustrates the number of observations in our sample using different investment horizons.

Investment Horizon	Number of Observations
Daily	2665
Monthly	145
Quarterly	46
Annual	11

Table 1: Number of observations in our data set using different investment horizons

For annual data, e.g., having 12 ESG stocks in the sample is enough to render $\hat{S}_{R_G,R_G}$ non-invertible.

4.2 Data set and data cleaning

In order to implement Steps 1 to 4 of our research design, we use the following cleaned data set.

4.2.1 Data set

We use U.S. stock price data for 505 individual stocks of the S&P 500 between January 2, 2009 to December 31, 2019 available from Thomson Reuters EIKON Datastream. Our sample period is chosen to avoid the effects of large financial crises on the stock market and therefore on parameter estimation: directly following the subprime mortgage crisis to right before the beginning of the COVID-19 pandemic. For Albuquerque/Koskinen/Yang/Zhang (2020), Demers/Joos/Hendrikse/Lev (2021) or Ding/Levine/Lin/Xie (2021) show that markets behave differently during the pandemic, thus creating an unwanted bias in the data set. Finally, following Fama/French's (1997) definition of industry portfolios, these stocks are allocated to 29 industry portfolios.

Based on stock price data, discrete daily, monthly, quarterly, and annual returns are computed. For monthly, quarterly, and annual returns the data frequency is set to 20, 60, and 250 (trading days) observations. In other words, starting from the end date December 31, 2019 the next monthly observation is December 04, 2019, the next quarterly observation is October 09, 2019, and the next annual observation January 16, 2019 etc.

Data is also collected for stocks' ESG ratings where ESG ratings can be divided into two groups. Index providers offer a list of stocks that fulfill their respective ESG criteria with no expressed rating preference among the stocks within the index. In such a case, all stocks in the index are treated equally and are included in the definition of ESG stocks. Rating providers communicate a rating system for a wide variety of stocks. Then cut-off points can be defined like "Ratings above level x" in order to determine which stocks should be included in the group of ESG stocks.

Out of the available ESG ratings, 19 different data sets are constructed that reflect different levels of ESG-strictness (please refer to Appendix Online 3 for details on data sets and selected cut-off points for each rating) that contain the following number of ESG stocks:

1 Thomson Reuters ESG Combined Score A and better (19 stocks) (rating provider)
2 Thomson Reuters ESG Combined Score A- and better (54 stocks) (rating provider)
3 Refinitiv/S-Network ESG Best Practices Index (222 stocks) (index provider)
4 MSCI KLD 400 Social Index (231 stocks) (index provider)
5 MSCI USA Select ESG & Trend Leaders Index (239 stocks) (index provider)
6 Sustainalytics Total ESG Score Negligible and Low (113 stocks) (rating provider)
7 Sustainalytics Total ESG Score Negligible, Low and Medium (274 stocks) (rating provider)
8 Sustainalytics Environment Score Negligible, Low and Medium (308 stocks) (rating provider)
9 Sustainalytics Social Score Negligible, Low and Medium (303 stocks) (rating provider)
10 Sustainalytics Governance Score Negligible, Low and Medium (340 stocks) (rating provider)
11 Sustainalytics Controversy Score No Controversy (23 stocks) (rating provider)
12 Sustainalytics Controversy Score No and Low Controversy (72 stocks) (rating provider)
13 Upright Absolute Net Impact Score Positive Only (157 stocks) (rating provider)
14 Upright Absolute Net Impact Score Above Average of Positive Only (38 stocks) (rating provider)
15 Upright Absolute Environment Impact Score Positive Only (3 stocks) (rating provider)
16 RepRisk RRI Below or Equal 10 (133 stocks) (rating provider)
17 RepRisk RRI Below or Equal 30 (354 stocks) (rating provider)
18 RepRisk Rating A and better (279 stocks) (rating provider)
19 RepRisk Rating BB and better (367 stocks) (rating provider)

Note in this connection that the number of ESG stocks differs in each of the 19 data sets meaning that each of the 19 data sets has an ESG sub-market portfolio of its own. Moreover, given that not all stocks in the S&P 500 are included in every rating method, the stocks used in the final sample are not identical to those in the S&P 500 index. Instead, the market portfolio's return must be constructed by multiplying the return of each stock by its portfolio weight in the market portfolio in order to achieve a market portfolio that is identical for each of the 19 data sets. At first glance, this procedure seems to contradict our claim made in Section 2.2 that we use publicly observable information. Note, however, that the need for manual computation arises from the fact that we consider 19 ESG portfolios simultaneously. If, for example, the data set Thomson Reuters ESG Combined Scores (A and better or A- and better) is taken, the ESG sub-market portfolio and the S&P 500 can be employed without any need for modification.

To avoid rebalancing problems and constituent changes across time, the constituents are used as at December 31, 2019. That way we can assure that the only source of variation is the stock return itself and not changes in portfolio weights or entry/exit into the ESG sub-market portfolio.

Fama/French factors are computed by hand and not taken from Kenneth French's webpage.—The factors must be fine-tuned to fit our specific choice of the market portfolios/subsample of the S&P 500.

Firm-specific data like market value, total assets, and operating income are obtained from Thomson Reuters EIKON Datastream.

The riskless rate is determined as follows (all data stem from the website of the St. Louis Federal Reserve as at December 31, 2019): daily investment horizon: federal funds rate; monthly investment horizon: 4-week Treasury Bills rate; quarterly investment horizon: 3-month Treasury Bills rate; annual investment horizon: 1-Year Treasury Bills rate.

4.2.2 Data cleaning

Of the collected 505 stocks, 58 were excluded due to missing daily price data for the given sample period. 7 stocks were excluded due to missing ESG ratings. Moreover, to ensure comparability across ratings—otherwise the market portfolio would not be the same across the 19 data sets—, only stocks for which data was available from each ESG rating provider were included in the final data.
In sum, the final data set for Steps 1 to 3 comprises 440 stocks. Since not all firm-specific data are available for these 440 stocks, the data set for Step 4 is further reduced to 245 stocks. This involves, in addition, a recalculation of the ESG sub-market portfolios as well as the market portfolio.

5 Empirical comparison of empirical and theory-based cost of capital

Section 5 analyzes cost of capital differences on a purely empirical. Specifically, Section 5.1 refers to models with different factor loadings (but identical factors), i.e., covers Step 1 of our research design (see, Section 4.1). The other subsections of Section 5—Steps 2 to 4 of our research—deal with models with different factor loadings (but identical factors) as well as models with different factors and factor loadings.

5.1 Realism of the conditions under which regression- and theory-based costs of capital coincide (Step 1)—daily data

5.1.1 Test of Condition (i): linear factor model

The test results regarding Condition (i) show (please refer to Appendix 3.1.1 and Appendix Online 4.1.1 for details) that daily cost of capital differences for single stocks as well as industry portfolios are statistically significant in all 19 data sets for both ESG and non-ESG stocks. Consequently, the empirical data does not support Condition (i)’s existence in any of our 19 data sets.

5.1.2 Test of Condition (ii): just one ESG stock

According to the description of the data set in Section 4.2.1 each data set consists of more than one stock with the exception of the industry portfolio for the data set "Upright Absolute Environment Impact Score Positive Only". From that perspective, it can be argued that Condition (ii) is not met by construction.

Nevertheless, several ESG stocks might behave in a way so that they become indistinguishable from the case of just one ESG stock. Hence, Condition (ii) is still worth testing. In this connection, the empirical specification of Formula (12) (non-ESG cost of capital in the case of just one ESG stock) needs some explanation. Since there are several ESG stocks, each ESG stock i assumes the role of "just one ESG stock". Then ESG stock i is used to compute cost of capital according to (12) for each non-ESG stock in the data set. The thusly obtained cost of capital are contrasted with the theory-based cost of capital (4) and the distribution of cost of capital differences is determined. In the next iteration step ESG stock $i + 1$ is regarded as "just one ESG stock". With the help of ESG stock $i + 1$ cost of capital differences for each non-ESG stock in the data set are computed once more etc.

Results (please refer to Appendix 3.1.2 and Appendix Online 4.1.2 for details) for ESG stocks (single stocks, daily data) indicate that for the data set "Upright Absolute Environment Impact Score Positive Only" the Cramér/von Mises one sample test assumes a value of 0.36, meaning the hypothesis of zero cost of capital differences and, hence, Condition (ii) can only be rejected at 90% level. For all other data sets (single stocks and industry portfolios, daily data) Condition (ii) can be rejected for ESG stocks at 99.5% or even 99.9% level for daily data. For non-ESG stocks (single stocks and industry portfolios, daily data) Condition (ii) can be rejected at 99.5% or even 99.9% level for all 19 data sets (the tables are too voluminous for an Appendix; but remain available from the authors; Appendix 3.1.2 just lists one typical case).

5.2 Cost of capital differences between empirical and theory-based approaches (Step 2)—daily data

5.2.1 Statistical significance

<u>Cost of capital differences between models with different factor loadings (but identical factors)</u>

The Cramér/von Mises test indicates (please refer to Appendix 3.2.1 and Appendix Online 4.2.1) that the cost of capital differences between models with different factor loadings and theory-based approaches are statistically significant at 99.5% or even 99.9% level. This holds for ESG and non-ESG stocks as well as for single stocks and industry portfolios. The only exception is the data set "Upright

Absolute Environment Impact Score Positive Only" for both single stocks and industry portfolios. For single stocks cost of capital differences are statistically significant (only) at 90% level, an observation that fits nicely to the fact that for this data set Condition (ii) "just one ESG-stock" can only be rejected at 90% level. For industry portfolios cost of capital differences are zero since there is just one industry portfolio, i.e., Condition (ii) is met by construction.

These results imply that even with identical explanatory factors in empirical and theory-based cost of capital formulas, the cost of capital differences caused by diverging factor loadings are critical. Specifically, it means: for the cost of capital for ESG stocks, using $\hat{s}_{R_{M_G},R_M}$ (theory-based cost of capital) instead of $\hat{s}_{R_{M_G},R_{M_G}}$ regression-based cost of capital) has non-trivial consequences; for the cost of capital for non-ESG stocks, the differences between regression- and theory-based factor loadings of both the market and the ESG sub-market portfolio do not neutralize each other.

Cost of capital differences between models with different factors and factor loadings

The results of the Cramér/von Mises test regarding cost of capital differences for models with different factors and factor loadings (please refer to Appendix 3.2.2 and Appendix Online 4.2.2) all are at the 99.9% level where the test statistics are generally greater than in Appendix 3.2.1 and Appendix Online 4.2.1. In particular, the data set "Upright Absolute Environment Impact Score Positive Only" now produces statistically significant cost of capital differences because Condition (ii) no longer matters when both factors and factor loadings are different.

5.2.2 Economic significance

Given that the differences between empirical and theory-based costs of capital were observed to be statistically significant, it becomes important to examine their economic significance.

Cost of capital differences between models with different factor loadings (but identical factors)

Insights into cost of capital differences will become accessible if Table 9 from Appendix 3.3.1 is clustered into different hierarchies, i.e., layers of aggregation. Aggregation is done by combining data sets using the number of stocks in the respective data set as weighting factor. Then the three hierarchies of Table 2 are obtained. The first hierarchy in Table 2 shows that aggregated over all data sets the following percentages of cost of capital differences greater than a certain benchmark hold: 32% for transaction costs (0.5%) as benchmark, 16.5% for a benchmark of 1% and 7.5% for a benchmark of 2%. These percentages are lower than those in Fama/French's (1997, p. 174): 56% for a benchmark of 1% and 27% for a benchmark of 2%. Note, however, that Fama/French (1997) vary both factors and factor loadings. In addition, for some data sets, e.g., "Sustainalytics Total ESG Score Negligible and Low" for negative differences and non-ESG stocks, remarkably 71% of cost of capital differences are greater than the benchmark of 2%; a result that lies thrice as high as Fama/French's (1997) findings. The second

hierarchy reveals that negative differences exhibit a higher percentage of economically significant differences than positive differences. Given that cost of capital differences are positive, according to the third hierarchy, ESG stocks have a higher percentage of economic significance.

In addition, and as a rule of thumb, RepRisk results in low levels of economic significance, while Upright for ESG and Sustainalytics for non-ESG exhibit high level of economically significant differences between regression- and theory-based cost of capital.

Cost of capital differences between models with different factors and factor loadings

Economic significance of cost of capital differences for models with different factors and factor loading exhibit a more extreme tendency than models where just different factor loadings are considered (please refer to Table 2 which aggregates Table 10 of Appendix 3.3.2): first hierarchy 71% for transaction costs (0.5%) as benchmark, 48% for a benchmark of 1% and 21% for a benchmark of 2%, percentages that are comparable to Fama/French's (1997) findings. Negative differences exhibit a slightly higher percentage of economically significant differences that positive differences and within the group of negative differences ESG stocks have higher differences than non-ESG stocks.

RepRisk and MSCI result in comparatively low cost of capital differences, Upright Absolute Environment Impact Score Positive Only produces 100% economically significant differences for ESG stocks for all benchmarks.

5.3 What explains differences in the level of economic significance (Step 3)—daily data

In the third step of our empirical analysis, we aim at explaining the differences in the level of economic significance. The hope is to identify potential drivers of the level of economic significance of cost of capital differences by controlling for different ESG rating methodologies and individual stock characteristics.

5.3.1 Different ESG rating methodologies

Since our 19 data sets are distinguished by different ESG rating methodologies, variables that capture different ESG rating methodologies are potentially a good starting point to explain differences in the level of economic significance across data sets.

Benchmark	0.1%		0.25%		0.5%		1%		1.5%		2%	
First hierarchy: Percentage of economically significant cost of capital differences												
Diff. factor loadings	77.3%		55.1%		32.2%		16.5%		10.8%		7.5%	
Diff. factors and factor loadings	94.2%		85.8%		71.5%		48.2%		33.9%		21.1%	
Second hierarchy: Pos. diff., i.e., $coc_{reg} > coc_{theo}$ or Neg. diff., i.e., $coc_{reg} < coc_{theo}$												
Diff. factor loadings	positive	negative	positive	negative	positive	negative	positive	negative	positive	negative	positive	negative
	70.4%	81.8%	51.3%	57.6%	29.7%	33.9%	13.3%	18.5%	7.7%	12.8%	4.2%	9.7%
Diff. factors and factor loadings	positive	negative	positive	negative	positive	negative	positive	negative	positive	negative	positive	negative
	93.7%	94.7%	84.7%	86.8%	69.5%	73.2%	46.6%	49.8%	30.3%	33.4%	18.3%	23.7%
Third hierarchy: ESG/non-ESG												
Diff. factor loadings	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG
	20.4%	33.6%	60.4%	41.1%	13.2%	25.7%	41.6%	29.6%	5.9%	16.2%	19.7%	20.8%	2.3%	7.5%	6.6%	14.4%	1.3%	4.4%	3.3%	10.8%	0.6%	2.5%	2.1%	8.5%
Diff. factors and factor loadings	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG	ESG	n-ESG
	30%	54.8%	63.5%	40%	25.8%	50.6%	58.3%	36.5%	18.69%	43.2%	49.3%	30.7%	11.3%	29.8%	32.6%	21.5%	7%	19.7%	20.8%	15.2%	4.1%	11.9%	14.4%	11.1%

Table 2: Hierarchy of differences between empirical and theory-based costs of capital (first hierarchy) split into positive and negative differences (second hierarchy); these are further split into ESG and non-ESG stocks (third hierarchy).
Note in this connection that the percentage found in the higher hierarchy is computed from the percentages of the lower hierarchy by weighting with the number of stocks in the respective hierarchy.
Example: 70.4% of the second hierarchy (for models with different factor loadings) equals

$$\frac{20.4\% \cdot number\ of\ ESG\ stocks\ in\ the\ third\ hierachy + 33.6\% \cdot number\ of\ non{-}ESG\ stocks\ in\ the\ third\ hierachy}{number\ of stocks\ with\ positive\ differences}$$

ESG rating methodologies can differ on the one hand (please refer to Appendix Online 3 for details) because some ratings consider controversial events, while others not. Therefore, a controversy dummy that assumes the value of 1 in the case the ESG rating comprises controversies and 0 otherwise is one explanatory variable. On the other hand, ratings can be based on only one dimension (Environment, or Social, or Governance) or all three dimensions simultaneously. Thus, an ESG dimension dummy that assumes a value of 0 if only one dimension is considered and 1 if all three dimensions are considered simultaneously can be defined.

With these two explanatory variables, the regression

$$perc_{data\ set_i} = a + b_{contr} \cdot dummy_{contr,data\ set_i} + b_{ESG\ dimension} \cdot dummy_{ESG\ dimension,data\ set_i} + \varepsilon_{data\ set_i}$$

where $perc_{data\ set_i}$ denotes the percentage of economically significant cost of capital differences in data set i.

is set up.

Cost of capital differences between models with different factor loadings (but identical factors)

Table 15 of Appendix 3.4.2.1 illustrates that regression results never deliver both statistically significant coefficients and a high Adjusted R^2. For ESG stocks, R^2 is always below 10%; for non-ESG stocks R^2 is higher and partially reaches 50%. However, then both coefficients are statistically insignificant.—These results do not change if an outlier analysis using the Cook distance is conducted.

Cost of capital differences between models with different factors and factor loadings

A similar picture is obtained for models that differ with both factors and factor loading as Table 16 of Appendix 3.4.2.2 illustrate including the slightly different results for ESG and non-ESG stocks.

5.3.2 Individual stock characteristics

Individual stock characteristics might possess some explanatory power regarding the level of economic significance of cost of capital differences since they enter the factor loadings of both empirical and theory-based costs of capital. Different factor loadings, in turn, might lead to different levels of economic significance.

Individual stock characteristics include on the one hand covariances and, on the other hand, industry classification.

Covariances are to be specified as:

ESG stocks	
term	relevant for
$\hat{s}_{R_{G_i},R_M}$	$cost\ of\ capital_{G_i,regr}$ (Equation (5)) $cost\ of\ capital_{G_i,theo}$(Equation (3))
non-ESG stocks	
$\hat{s}_{R_{H_i},R_M}$	$cost\ of\ capital_{G_i,regr}$(Equation (6)) $cost\ of\ capital_{G_i,theo}$(Equation (4))
$\hat{s}_{R_{H_i},R_{M_G}}$	$cost\ of\ capital_{G_i,regr}$(Equation (6))
$\hat{s}_{R_G,R_{H_i}}^T\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	$cost\ of\ capital_{G_i,theo}$(Equation (4))

As Appendix 3.5.1 demonstrates, the three covariance terms for non-ESG stocks are highly collinear. Therefore, we can utilize any of these covariances as an explanatory variable. We choose $\hat{s}_{R_{H_i},R_M}$ in the following logit regressions:

for ESG stocks

$$1_{\geq benchmark}(pos.difference_{G_i}) = a + b \cdot \hat{s}_{R_{G_i},R_M} + \varepsilon_{G_i} \qquad 1_{\geq benchmark}\left(\left|neg.difference_{G_i}\right|\right) = a + b \cdot \hat{s}_{R_{G_i},R_M} + \varepsilon_{G_i}$$

for non-ESG stocks

$$1_{\geq benchmark}(pos.difference_{H_i}) = a + b \cdot \hat{s}_{R_{H_i},R_M} + \varepsilon_{H_i} \qquad 1_{\geq benchmark}\left(\left|neg.difference_{H_i}\right|\right) = a + b \cdot \hat{s}_{R_{H_i},R_M} + \varepsilon_{H_i}$$

where 1(.) denotes the indicator function. The indicator function assumes a value of 1 if cost of capital differences of a specific stock lie above the benchmark and otherwise the value 0.

Cost of capital differences between models with different factor loadings (but identical factors)

All logit regressions of Table 15 (see Appendix 3.5.2.1) possess a low Adjusted R^2. Therefore, statistical significances (positive differences: for some benchmark; negative differences: for most benchmarks) do not matter. Put differently, stocks' covariances cannot help explaining the level of economically significant differences between empirical and theory-based cost of capital.

With respect to industry classifications, no explanatory power can be found as can be demonstrated with the help of counterexamples. ESG stock cost of capital differences for stocks belonging to Industry 4 for benchmarks 2%, 1.5%, and 1% are primarily economically significant for the data set "Refinitiv/S-Network ESG Best Practices Index", but primarily economically insignificant for the data set "Sustainalytics Total ESG Score Negligible, Low and Medium". Non-ESG stock cost of capital differences for stocks belonging to Industry 29 for benchmarks 2%, 1.5%, and 1% are never economically significant for the data set "Thomson Reuters ESG Combined Score A and better", but economically significant for the data set "Refinitiv/S-Network ESG Best Practices Index" (please refer to Appendix 3.6.1 for details). The reason behind both non-results can be illustrated best by the rather complex structure of cost of capital differences for non-ESG stocks: empirical cost of capital consists of two components (term in-

volving the market and other term involving the ESG sub-market portfolio), theory-based cost of capital of two components as well. Forming differences between both costs of capital means considering four terms simultaneously.

Cost of capital differences between models with different factors and factor loadings

Stocks' covariances cannot help explaining the level of economically significant differences between regression- and theory-based cost of capital (see Table 16, Appendix 3.5.2.2).

The same is true for industry classification (please refer to Appendix 3.6.2 for details).

5.4 Cost of capital as input for further empirical research (Step 4)—daily data

Cost of capital or ratios building upon them are often employed in the literature as input for further empirical research. The literature uses explanatory variables to shed further light on factors influencing cost of capital. In this connection, the literature typically combines an ESG variable with firm characteristics as the ensuing Table 3 demonstrates:

Paper	Dependent variable	Explained by
Stocks		
Barnett/Salomon (2006)	alpha	screening variable
Bolton/Kacperczyk (2021)	carbon premium	Fama/French factors and firm characteristics
Brouwers/Schoubben/Van Hulle/ Van Uytbergen (2016)	cumulative abnormal return	Fama/French factors and firm characteristics
Chava, Sudheer (2014)	implied cost of capital	environmental variables and firm characteristics
El Ghoul/Guedhami/Kwok/ Mishra (2011)	implied cost of capital	social responsibility variables and firm characteristics
Hartzmark and Sussman (2019)	cost of capital	environmental score
Karoui/Nguyen (2022)	alpha	ESG score and firm characteristics
Kazdin/Schwaiger/Wendt/Ang (2021)	implied cost of capital	emissions and firm characteristics
Latino/Pelizzon/Rzeźnik (2021)	cumulative abnormal return	changes in ESG ratings
Wang/Kartika/Wang/Luo (2021)	implied cost of capital	environmental variable, firm characteristics
Mutual funds		
Baily/Gnabo (2022)	alpha	ESG score, distinctiveness, and climate news
Barber/Morse/Yasuda (2020)	implied cost of capital	impact variable and mutual fund characteristics
Capelle-Blancard/Monjon (2014)	risk-adjusted returns	screening variable
Kuang/Liang (2020)	alpha	carbon risk, fund lows, and mutual fund characteristics
Lee/Humphrey/Benson/Ahn (2010)	risk-adjusted returns	screening intensity and mutual fund characteristics

Table 3: Exemplary overview of the literature that uses cost of capital/ratios as input for further empirical research

We mimic these studies by choosing ESG rating and, based on the availability in Thomson Reuters EIKON Datastream, market value, total assets, and operating income as firm characteristics. Since firm characteristics refer by definition to individual stocks and not industries, we do not consider industry

portfolios. Moreover, we conduct our analysis on one date only (December 31, 2019): one date suffices to detect potential biases caused by the use of empirical instead of theory-based cost of capital as dependent variable.

In one setting, we follow the literature and consider all stocks in one combined sample, i.e., do not distinguish between ESG and non-ESG stocks. In another setting, we conduct separate analyses for ESG and non-ESG stocks.

Our regression equations read

$$coc_{regr,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$

$$coc_{theo,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$

Note one thing in connection with these regressions. We solely use rating providers in the data set because index providers only publish a list of ESG stocks without giving an individual rating for each stock within the index. That way no ESG rating variation would exist within the group of ESG and non-ESG stocks.

Cost of capital differences between models with different factor loadings (but identical factors)

We obtain the results of Table 4 for the combined sample of ESG and non-ESG stocks (for the separate analysis of ESG and non-ESG stocks, please refer to Appendix 3.7.1):

Daily data – Significance Level No distinction between ESG and non-ESG stocks	**Differences in factor loadings**			**Differences in factors and factor loadings**		
	10%	**5%**	**1%**	**10%**	**5%**	**1%**
Thomson Reuters ESG Combined Score A and better	0%	25%	0%	25%	25%	25%
Thomson Reuters ESG Combined Score A- and better	0%	0%	0%	25%	25%	25%
Sustainalytics Total ESG Score Negligible and Low	50%	50%	25%	25%	25%	50%
Sustainalytics Total ESG Score Negligible, Low and Medium	0%	0%	0%	25%	25%	50%
Sustainalytics Environment Score Negligible, Low and Medium	0%	0%	0%	25%	25%	25%
Sustainalytics Social Score Negligible, Low and Medium	0%	0%	25%	50%	50%	25%
Sustainalytics Governance Score Negligible, Low and Medium	0%	0%	0%	25%	25%	25%
Sustainalytics Controversy Score No Controversy	0%	0%	25%	25%	50%	0%
Sustainalytics Controversy Score No and Low Controversy	25%	0%	25%	25%	25%	0%
Upright Absolute Net Impact Score Positive Only	0%	0%	0%	25%	25%	0%
Upright Absolute Net Impact Score Above Average of Positive Only	25%	0%	0%	25%	25%	0%
Upright Absolute Environment Impact Score Positive Only	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 10	0%	0%	0%	25%	25%	25%
RepRisk RRI Below or Equal 30	0%	0%	0%	25%	50%	25%
RepRisk Rating A and better	0%	0%	25%	25%	50%	50%
RepRisk Rating BB and better	0%	25%	25%	25%	50%	25%

Table 4: Percentage of explanatory variables whose significance level changes (increases or decreases) from an arbitrary value x to 10% (5%, 1%) when explaining regression- compared to theory-based cost of capital.

Table 4 is not easy to read. Therefore, some reading instructions might prove useful.

(i) We do not argue with the help of "significant"/"not significant" because such a classification crucially depends on the significance level applied. Therefore, we just report changes in the usual significance levels of 10%, 5%, and 1%.

Moreover, the direction of the change in significance levels (increase or decrease) is not important, only the fact that a change occurs matters.

(ii) We are only interested in significance changes of the explanatory variables, not the intercept. For that reason, we do not count changes in the significance of the intercept.

(iii) The columns 10%, 5%, and 1% are not to be understood cumulatively as the following example illustrates:

If one variable changes its significance from 15% to 1.5%, it appears in columns 10% and 5%.

If one variable changes its significance from 3% to 1.5%, it appears in no column.

If one variable changes its significance from 3% to 0.5%, it appears in columns 1%.

(iv) We count the number of explanatory variables whose significance changes. For example, if $b_{mv,regr}$ is insignificant at significance level *x* and $b_{mv,th}$ significant, we will count one change; if $b_{ta,regr}$ is significant at significance level *x* and $b_{ta,th}$ insignificant, we will count another change, i.e., altogether the significance of two explanatory variables changes.

Table 4 reports that there is a change in significance of at least one explanatory variable in 8 out of 16 data sets. These changes are particularly severe in the data set "Sustainalytics Total ESG Score Negligible and Low" where the significance of 50% of the explanatory variables changes.

This means, using empirical instead of theory-based cost of capital creates potential biases when trying to understand the determinants of cost of capital.

Cost of capital differences between models with different factors and factor loadings

Table 4 and Table 20 show similar results for models with different factors and factor loadings. As usual, these results are more extreme in the sense that more changes in significance occur. This fact again stresses the danger of biases when trying to understand the determinants of cost of capital.

5.5 Robustness analyses: monthly, quarterly, and yearly data

As Appendix Online 4 shows, different investment horizons lead to identical results as daily data regarding: test of Condition (i): linear factor model, test of Condition (ii): just one ESG stock, cost of capital differences between empirical and theory-based approaches: statistical significance, and explanation of the differences in the level of economic significance.

Regarding economic significance, longer investment horizons deliver stronger results: the percentage of economically significant cost of capital differences increases. In particular, even for RepRisk high percentages of economically significant cost of capital differences arise.

6 Conclusion

We started out with the observation that there are two puzzles in the ESG cost of capital literature. When formulating hypotheses or interpreting empirical findings, empirical ESG cost of capital papers use economic interpretations regarding differences in cost of capital between ESG and non-ESG stocks developed in theoretical ESG cost of capital papers. Yet, to derive cost of capital, empirical ESG cost of capital papers do not use the valuation formulas of theoretical ESG cost of capital paper. Instead, empirical ESG cost of capital papers rely on multi-factor regressions. However, these multi-factor regressions do not bear any ESG reference in their formulas and, thus, are not ideal for determining cost of capital in an environment where ESG is explicitly stressed as distinguishing feature. Second, a theoretical alternative to empirical cost of capital formulas is still missing in ESG research, a fact that is in stark contrast to traditional stock valuation where decision makers/researchers can choose between theoretical (e.g., "classical" CAPM) and empirical models (e.g., Fama/French (1993)). For theoretical ESG cost of capital formulas are not presented in an empirically implementable form—they contain unobservable preference-dependent parameters.

Put differentially, the empirical ESG literature seems to sell the skin before it caught the bear: cost of capital differences between ESG and non-ESG stocks, effects of ESG score changes, alternatives to Fama/ French three factor models in an ESG environment, and the explanation of cost of capital with the help of, e.g., ESG scores and climate news are all analyzed without having clarified sufficiently the computation of ESG cost of capital. Therefore, a core (see Krüger/Sautner/Starks, 2020) and not just a marginal aspect of ESG analyses is shaky.

Our paper bridges this gap in the literature and brings theory-based ESG cost of capital formulas into a form that consists of solely observable components and shows that the cost of capital for ESG stocks is a linear function of the risk premium of the ESG sub-market portfolio whereas the cost of capital for non-ESG stocks is a linear combination of the risk premia of the market portfolio and the ESG sub-market portfolio. Moreover, it demonstrates that these empirically implementable theoretical ESG cost of capital formulas are a non-trivial extension to the literature in that they result in both statistically and economically significant cost of capital differences to existing empirical ESG cost of capital formulas.

These results have three practical implications. First, since for both models with different factor loadings and with different factors as well as factor loadings neither the sign nor the size of cost of capital

differences can be forecasted with the help of different ESG rating methodologies nor stock characteristics (covariances with the market portfolios or industry classification) and cost of capital differences are highly statistically and economically significant, having a theoretical model as an alternative to purely empirical cost of capital formulas proves helpful for researchers/decision makers. Recall cost of capital differences between the theoretical and the Fama/French three factor model are as pronounced as the differences between the CAPM and Fama/French three factor model. Therefore, theory-based cost of capital should always be considered even though they are more tedious to implement empirically—just remember the term $\hat{s}_{R_G,R_{H_i}}^{T}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$.

Second, if cost of capital serves as input for further empirical further empirical analysis, for example by asking how cost of capital can be explained with the help of firm characteristics or ESG variables, cautiousness is in order. We show that statistical significance of factors changes when switching from empirical to theory-based cost of capital as dependent variable. Using empirical cost of capital, thus, creates potential biases when trying to understand the determinants of cost of capital.

Third, the level of statistical and economical significance of differences between empirical and theory-based cost of capital differences for different ESG rating methodologies should not be confused with a statement on the quality of the ESG rating methodology. It merely states that for some rating methodologies differences in empirical and theory-based cost of capital are more pronounced than for others.

Appendix

Appendix 1 Derivation of an ESG pricing formula for stocks based on Heinkel/Kraus/Zechner (2001) without reformed assets

Appendix 1.1 Pricing formula: empirically implementable form

Appendix 1.1.1 Equation system to determine the unknown risk preference parameters

Multiplying the vector form of (1) by the portfolio holdings of the sub-market portfolio of ESG stocks $N_{M,G}^T$ gives for the risk premium $E\{W_{M_G,t+1}\} - (1+r) \cdot W_{M_G,t}$ of the ESG sub-market portfolio

(A1.1)

$$E\{W_{M_G,t+1}\} - (1+r) \cdot W_{M_G,t} = \frac{1}{\frac{1}{a_n} + \frac{1}{a_e}} \cdot \sigma_{M_G,M}$$

Multiplying the vector form of (2) by the portfolio holdings of the sub-market portfolio of non-ESG stocks $N_{M,H}^T$ and adding (A1.1) produces (after taking into account that $\sigma_{M_H,M} = \sigma_{M,M} - \sigma_{M_G,M}$ and $\sigma_{G,M_H}^T = \sigma_{G,M}^T - \sigma_{G,M_G}^T$)

(A1.2)

$$\begin{aligned} E\{W_{M,t+1}\} - (1+r) \cdot W_{M,t} \\ = \frac{1}{\frac{1}{a_n} + \frac{1}{a_e}} \cdot \sigma_{M,M} + \frac{a_n^2}{a_e + a_n} \\ \cdot \left[\sigma_{M,M} - \sigma_{M_G,M} - \sigma_{G,M}^T (\sigma_{G,G})^{-1} \sigma_{G,M} + \sigma_{G,M_G}^T (\sigma_{G,G})^{-1} \sigma_{G,M}\right] \end{aligned}$$

Appendix 1.1.2 Determination of the unknowns

It follows immediately from (A1.1)

(A1.3)

$$\frac{1}{\frac{1}{a_n} + \frac{1}{a_e}} = \frac{E\{W_{M_G,t+1}\} - (1+r) \cdot W_{M_G,t}}{\sigma_{M_G,M}}$$

Plugging this intermediate result into (A1.2) and taking $\sigma_{M_H,M} = \sigma_{M,M} - \sigma_{M_G,M}$ and $\sigma_{G,M_H}^T = \sigma_{G,M}^T - \sigma_{G,M_G}^T$ as well as $\sigma_{G,M_G}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M} = N_{G,t}^T \sigma_{G,G} \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M} = N_{G,t}^T \sigma_{G,M} = \sigma_{M_G,M}$ into consideration yields

(A1.4)

$$\frac{a_n^2}{a_e + a_n} = \frac{\left[E\{W_{M,t+1}\} - (1+r) \cdot W_{M,t}\right] \cdot \sigma_{M_G,M} - \left[E\{W_{G,t+1}\} - (1+r) \cdot W_{G,t}\right] \cdot \sigma_{M,M}}{\sigma_{M_G,M} \cdot \left[\sigma_{M,M} - \sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}\right]}$$

Appendix 1.1.3 Pricing model in empirically implementable form

(A1.3) and (A1.4) are now substituted into the risk premia equations (1) and (2) and the i^{th} row is cut out. Then it is obtained

For ESG stock G_i

(A1.5)

$$E\{P_{G_i,t+1}\} - (1+r) \cdot P_{G_i,t} = \left(E\{W_{M_G,t+1}\} - (1+r) \cdot W_{M_G,t}\right) \cdot \frac{\sigma_{G_i,M}}{\sigma_{M_G,M}}$$

For non-ESG stock H_i

(A1.6)

$$E\{P_{H_i,t+1}\} - (1+r) \cdot P_{H_i,t} =$$
$$\left[\frac{\sigma_{H_i,M}}{\sigma_{M_G,M}} - \frac{\sigma_{M,M} \cdot \left[\sigma_{H_i,M} - \sigma_{G,H_i}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}\right]}{\sigma_{M_G,M} \cdot \left[\sigma_{M,M} - \sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}\right]}\right] \cdot \left[E\{W_{G,t+1}\} - (1+r) \cdot W_{G,t}\right]$$
$$+ \frac{\sigma_{H_i,M} - \sigma_{G,H_i}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}}{\sigma_{M,M} - \sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}} \cdot \left[E\{W_{M,t+1}\} - (1+r) \cdot W_{M,t}\right]$$

or rather

(A1.7)

$$E\{P_{H_i,t+1}\} - (1+r) \cdot P_{H_i,t} =$$
$$\frac{\sigma_{M,M} \cdot \sigma_{G,H_i}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M} - \sigma_{H_i,M} \cdot \sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}}{\sigma_{M_G,M} \cdot \left[\sigma_{M,M} - \sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}\right]} \cdot \left[E\{W_{G,t+1}\} - (1+r) \cdot W_{G,t}\right]$$
$$+ \frac{\sigma_{H_i,M} - \sigma_{G,H_i}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}}{\sigma_{M,M} - \sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}} \cdot \left[E\{W_{M,t+1}\} - (1+r) \cdot W_{M,t}\right]$$

Appendix 1.2 Pricing formula: returns form

Prices/portfolio holdings are good for the derivation of pricing equations because they can explicitly address market equilibrium and directly use the relationship $W_{M_G} + W_{M_H} = W_M$. Returns are, however, better suited for implementing models empirically due to their superior statistical features. It is therefore important for the purposes of empirical implementation to derive the pricing model in returns form.

Appendix 1.2.1 Pricing formula: form that contains risk preference parameters

Multiplying the vector form of (1) by the diagonal matrix of prices $P_{G,t}$ and the vector form of (2) by the diagonal matrix of prices $P_{H,t}$, and expanding by $\frac{W_M}{W_M}$ delivers

For ESG stocks

(A1.8)

$$E\{R_{G,t+1}\} - r \cdot \mathbf{1} = \frac{W_M}{\frac{1}{a_n} + \frac{1}{a_e}} \cdot \sigma_{R_G,R_M}$$

For non-ESG stocks

(A1.9)

$$E\{R_{H,t+1}\} - r \cdot \mathbf{1} = \frac{W_M}{\frac{1}{a_n} + \frac{1}{a_e}} \cdot \sigma_{R_H,R_M} + \frac{a_n^2}{a_e + a_n} \cdot \left[\sigma_{R_H,M} - \sigma_{G,R_H}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}\right]$$

To transform (A1.9) into an equation that contains only references to returns, further restructuring is required: expanding the second term by $\frac{W_{M,t}}{W_{M,t}}$ and noticing that $\sigma_{G,R_{H_i}}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}$ and $\sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}$ can be multiplied by $diag(P_G)\ diag(P_G)^{-1}$, where $diag(P_G)$ denotes the diagonal matrix of prices of ESG assets, it is obtained

(A1.10)

$$E\{R_{H,t+1}\} - r \cdot \mathbf{1} = \frac{W_M}{\frac{1}{a_n} + \frac{1}{a_e}} \cdot \sigma_{R_H,R_M} + \frac{a_n^2 \cdot W_M}{a_e + a_n} \cdot \left[\sigma_{R_H,R_M} - \sigma_{R_G,R_H}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}\right]$$

Appendix 1.2.2 Pricing formula: empirically implementable form

For ESG stock G_i

Dividing (A1.5) by $P_{G_i,t}$ and multiplying the right-hand side by $\frac{W_{M_G,t}}{W_{M_G,t}}$ and $\frac{W_{M,t}}{W_{M,t}}$ gains

(A1.11)

$$E\{R_{G_i,t+1}\} - r = \left(E\{R_{M_G,t+1}\} - r\right) \cdot \frac{\sigma_{R_{G_i},R_M}}{\sigma_{R_{M_G},R_M}}$$

For non-ESG stock H_i

Dividing (A1.6) by $P_{H_i,t}$ and expanding the first term on the right-hand side repeatedly by $\frac{W_{M,t}}{W_{M,t}}$ and $\frac{W_{M_G,t}}{W_{M_G,t}}$, the second term on the right-hand side repeatedly by $\frac{W_{M,t}}{W_{M,t}}$, and noticing that $\sigma_{G,R_{H_i}}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}$ and $\sigma_{G,M}^T \left(\sigma_{G,G}\right)^{-1} \sigma_{G,M}$ can be multiplied by $diag(P_G)\ diag(P_G)^{-1}$, where $diag(P_G)$ denotes the diagonal matrix of prices of ESG assets, it is obtained

(A1.12)

$$E\{R_{H_i,t+1}\} - r =$$

$$\left[\frac{\sigma_{R_{H_i},R_M}}{\sigma_{R_{M_G},R_M}} - \frac{\sigma_{R_M,R_M} \cdot \left[\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}\right]}{\sigma_{R_{M_G},R_M} \cdot \left[\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}\right]}\right] \cdot \left[E\{R_{M_G,t+1}\} - r\right]$$

$$+ \frac{\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}}{\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}} \cdot \left[E\{R_{M,t+1}\} - r\right]$$

or rather

(A1.13)

$$E\{R_{H_i,t+1}\} - r =$$

$$\frac{\sigma_{R_M,R_M} \cdot \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M} - \sigma_{R_{H_i},R_M} \cdot \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}}{\sigma_{R_{M_G},R_M} \cdot \left[\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}\right]} \cdot \left[E\{R_{M_G,t+1}\} - r\right]$$

$$+ \frac{\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}}{\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}} \cdot \left[E\{R_{M,t+1}\} - r\right]$$

Appendix 2 Relation of segmented markets' pricing formulas to regression-based factor models

Appendix 2.1 Linear dependence of the excess return of the sub-market portfolio of ESG stocks and the market portfolio

Using the return connection (7) between the ESG sub-market and the market portfolio in (A1.11) and (A1.13) delivers

For ESG stock G_i

(A2.1)

$$E\{R_{G_i,t+1}\} - r = \left(E\{R_{M,t+1}\} - r\right) \cdot \frac{\sigma_{R_{G_i},R_M}}{\sigma_{R_M,R_M}}$$

For non-ESG stock H_i

(A2.2)

$$E\{R_{H_i,t+1}\} - r =$$

$$\frac{\sigma_{R_M,R_M} \cdot \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M} - \sigma_{R_{H_i},R_M} \cdot \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}}{\sigma_{r+b\cdot(R_M-r),R_M} \cdot \left[\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}\right]} \cdot b \cdot \left[E\{R_{M,t+1}\} - r\right]$$

$$+ \frac{\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}}{\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^T \left(\sigma_{R_G,R_G}\right)^{-1} \sigma_{R_G,R_M}} \cdot \left[E\{R_{M,t+1}\} - r\right]$$

and, finally,

(A2.3)

$$E\{R_{H_i,t+1}\} - r = \frac{\sigma_{R_{H_i},R_M}}{\sigma_{R_M,R_M}} \cdot \left[E\{R_{M,t+1}\} - r\right]$$

Appendix 2.2 Just one ESG stock

Using the fact that the return of only one ESG stock equals the return of the ESG sub-market portfolio in (A1.11) and (A1.13) delivers

For ESG stock G_i

(A2.4)

$$E\{R_{G_i,t+1}\} - r = E\{R_{G_i,t+1}\} - r$$

For non-ESG stock H_i

(A2.5)

$$E\{R_{H_i,t+1}\} - r =$$

$$\left[\frac{\sigma_{R_{H_i},R_M}}{\sigma_{R_{G_i},R_M}} - \frac{\sigma_{R_M,R_M}\cdot\left[\sigma_{R_{H_i},R_M} - \sigma_{R_{G_i},R_{H_i}}\cdot\frac{\sigma_{R_{G_i},R_M}}{\sigma_{R_{G_i},R_{G_i}}}\right]}{\sigma_{R_{G_i},R_M}\cdot\left[\sigma_{R_M,R_M} - \frac{\sigma^2_{R_{G_i},R_M}}{\sigma_{R_{G_i},R_{G_i}}}\right]}\right]\cdot\left[E\{R_{G_i,t+1}\} - r\right]$$

$$+\frac{\sigma_{R_{H_i},R_M} - \sigma_{R_{G_i},R_{H_i}}\frac{\sigma_{R_{G_i},R_M}}{\sigma_{R_{G_i},R_{G_i}}}}{\sigma_{R_M,R_M} - \frac{\sigma^2_{R_{G_i},R_M}}{\sigma_{R_{G_i},R_{G_i}}}}\cdot\left[E\{R_{M,t+1}\} - r\right]$$

and, finally,

(A2.6)

$$E\{R_{H_i,t+1}\} - r =$$

$$\frac{\sigma_{R_M,R_M}\cdot\sigma_{R_{G_i},R_{H_i}} - \sigma_{R_{H_i},R_M}\cdot\sigma_{R_{G_i},R_M}}{\sigma_{R_M,R_M}\cdot\sigma_{R_{G_i},R_{G_i}} - \sigma^2_{R_{G_i},R_{H_i}}}\cdot E\{R_{G_i,t+1} - r\}$$

$$+\frac{\sigma_{R_{H_i},R_M}\cdot\sigma_{R_{G_i},R_{G_i}} - \sigma_{R_{G_i},R_{H_i}}\cdot\sigma_{R_{G_i},R_M}}{\sigma_{R_M,R_M}\cdot\sigma_{R_{G_i},R_{G_i}} - \sigma^2_{R_{G_i},R_{H_i}}}\cdot E\{R_{M,t+1} - r\}$$

Appendix 3 Empirical results

Appendix 3.1 Statistical significance of the special cases

Appendix 3.1.1 Special case "excess return of the sub-market portfolio of ESG stocks can be explained by the excess return of the market portfolio using the linear factor model (7)"

Table 5: Cramér/von Mises test statistics for cost of capital differences Equation (8) – (3) for ESG stocks and (9) – (4) for non-ESG stocks.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	Rep Risk RRI Below or Equal 10	Rep Risk RRI Below or Equal 30	Rep Risk Rating A and better	Rep Risk Rating BB and better
ESG stocks																			
daily	6.65 ***	17.33 ***	74.33 ***	80.00 ***	77.33 ***	38.00 ***	91.67 ***	103.00 ***	101.33 ***	113.67 ***	7.98 ***	24.33 ***	52.66 ***	12.99 ***	1.24 ***	44.66 ***	118.33 ***	93.33 ***	122.67 ***
Non-ESG stocks																			
daily	89.09 ***	81.23 ***	24.90 ***	40.98 ***	39.40 ***	28.89 ***	20.51 ***	20.97 ***	12.65 ***	17.50 ***	43.34 ***	75.39 ***	36.64 ***	99.84 ***	81.13 ***	63.43 ***	13.47 ***	33.45 ***	9.94 ***

Appendix 3.1.2 Special case “there is just one ESG stock”

Table 6: Cramér/von Mises test statistics for cost of capital differences Equation (11) – (3) for ESG stocks and (12) – (4) for non-ESG stocks.
Equation (12) is only illustrated for the case that United Rentals is the “only” ESG stock; United Rentals is contained in a maximum number of data sets.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
† Special case of only one ESG stock leading to identical cost of capital.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	Rep Risk RRI Below or Equal 10	Rep Risk RRI Below or Equal 30	Rep Risk Rating A and better	Rep Risk Rating BB and better
ESG stocks																			
daily	2.32 ***	6.13 ***	20.39 ***	22.52 ***	22.86 ***	12.23 ***	26.21 ***	28.30 ***	28.83 ***	30.73 ***	1.99 ***	6.43 ***	15.60 ***	4.56 ***	0.36 (sig. at 10%)	12.35 ***	32.67 ***	25.86 ***	33.55 ***
Non-ESG stocks																			
daily	United Rentals not contained in data set	United Rentals not contained in data set	25.25 ***	25.86 ***	28.80 ***	28.16 ***	25.11 ***	27.23 ***	31.76 ***	25.39 ***	United Rentals not contained in data set	34.28 ***	56.00 ***	United Rentals not contained in data set	47.26 ***	29.33 ***	7.82 ***	17.56 ***	6.58 ***

Appendix 3.2 Statistical significance of empirical and theory-based capital cost

Appendix 3.2.1 Models with different factor loadings (but identical factors)

Table 7: Cramér/von Mises test statistics for cost of capital differences Equation (5) – (3) for ESG stocks and (6) – (4) for non-ESG stocks.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	Rep Risk RRI Below or Equal 30	Rep Risk Rating A and better	Rep Risk Rating BB and better
ESG stocks																			
daily	1.99 ***	5.17 ***	34.87 ***	38.58 ***	52.62 ***	28.80 ***	58.09 ***	50.97 ***	63.60 ***	60.32 ***	2.54 ***	9.68 ***	44.13 ***	9.32 ***	0.36 (sig. at 10%)	16.09 ***	29.61 ***	23.35 ***	34.93 ***
Non-ESG stocks																			
daily	44.47 ***	53.61 ***	48.48 ***	27.18 ***	44.18 ***	48.21 ***	18.67 ***	14.13 ***	14.59 ***	9.63 ***	72.09 ***	74.70 ***	41.29 ***	33.60 ***	39.90 ***	46.32 ***	9.55 ***	16.39 ***	9.94 ***

Appendix 3.2.2 Models with different factors and factor loadings

Table 8: Cramér/von Mises test statistics for cost of capital differences Equation (15) – (3) for ESG stocks and (16) – (4) for non-ESG stocks.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	Rep Risk RRI Below or Equal 10	Rep Risk RRI Below or Equal 30	Rep Risk Rating A and better	Rep Risk Rating BB and better
ESG stocks																			
daily	6.65 ***	16.33 ***	44.72 ***	20.38 ***	26.12 ***	36.01 ***	71.36 ***	65.88 ***	30.24 ***	36.09 ***	6.99 ***	22.36 ***	22.18 ***	9.32 ***	1.24 ***	12.17 ***	63.24 ***	27.61 ***	62.83 ***
monthly	5.65 ***	7.97 ***	22.13 ***	31.58 ***	23.38 ***	32.27 ***	51.93 ***	53.32 ***	44.21 ***	50.74 ***	6.96 ***	22.36 ***	25.86 ***	6.51 ***	1.24 ***	26.85 ***	78.20 ***	50.87 ***	75.78 ***
quarterly	5.65 ***	8.53 ***	40.12 ***	20.05 ***	25.12 ***	29.64 ***	44.63 ***	42.17 ***	37.86 ***	38.34 ***	6.98 ***	16.34 ***	19.93 ***	5.43 ***	1.24 ***	20.71 ***	53.56 ***	43.30 ***	65.86 ***
annual	2.77 ***	5.77 ***	27.74 ***	39.14 ***	36.86 ***	23.43 ***	48.76 ***	52.72 ***	54.90 ***	52.31 ***	2.09 ***	7.22 ***	30.17 ***	7.13 ***	1.24 ***	17.76 ***	49.10 ***	39.24 ***	53.04 ***
Non-ESG stocks																			
daily	89.10 ***	72.45 ***	21.86 ***	16.98 ***	19.93 ***	29.17 ***	18.67 ***	19.90 ***	14.01 ***	13.76 ***	38.58 ***	40.56 ***	28.92 ***	61.60 ***	51.00 ***	25.96 ***	7.29 ***	13.95 ***	6.33 ***
monthly	41.24 ***	38.31 ***				34.25 ***					48.17 ***	44.10 ***		34.00 ***	53.27 ***	31.29 ***			
quarterly	49.47 ***										43.06 ***			33.83 ***	45.75 ***				
annual															65.53 ***				

Appendix 3.3 Economic significance of differences between empirical and theory-based cost of capital

Appendix 3.3.1 Models with different factor loadings (but identical factors)

Table 9: Percentage of stocks in a data set where the (positive or negative) cost of capital difference Equation (5) – (3) for ESG stocks and (6) – (4) for non-ESG stocks is greater than the benchmark fitted to the respective investment horizon. Formally,

$$|(5) - (3)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

and

$$|(6) - (4)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Single stock: daily investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	100 %	86%	100 %	43%	75%	14%	42%	14%	17%	14%	17%	86%	76%	67%	55%	42%	28%	10%	1%	4%	0%	1%	0%
Thomson Reuters ESG Combined Score A- and better	95%	100 %	89%	94%	79%	88%	53%	44%	16%	16%	11%	0%	88%	74%	64%	44%	27%	20%	0%	3%	0%	0%	0%	0%
Refinitiv/S-Network ESG Best Practices Index	80%	88%	39%	56%	6%	11%	0%	0%	0%	0%	0%	0%	99%	93%	96%	68%	87%	50%	54%	25%	28%	11%	10%	11%
MSCI KLD 400 Social Index	75%	91%	46%	64%	14%	23%	4%	3%	0%	0%	0%	0%	91%	77%	74%	47%	41%	20%	7%	10%	1%	3%	0%	0%
MSCI USA Select ESG & Trend Leaders index	40%	82%	8%	54%	4%	24%	2%	3%	0%	0%	0%	0%	66%	13%	25%	4%	1%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Total ESG Score Negligible and Low	80%	99%	70%	95%	60%	90%	40%	71%	30%	55%	10%	44%	86%	99%	73%	96%	56%	96%	33%	86%	16%	77%	10%	71%
Sustainalytics Total ESG Score Negligible, Low and Medium	49%	92%	31%	75%	18%	36%	5%	4%	0%	0%	0%	0%	98%	98%	95%	95%	87%	94%	76%	90%	69%	86%	51%	80%
Sustainalytics Environment Score Negligible, Low and Medium	36%	76%	11%	45%	5%	15%	0%	2%	0%	0%	0%	0%	96%	100 %	96%	98%	89%	94%	83%	90%	76%	83%	70%	71%
Sustainalytics Social Score Negligible, Low and Medium	84%	94%	45%	71%	18%	19%	5%	1%	0%	0%	0%	0%	98%	99%	81%	91%	58%	74%	23%	46%	8%	16%	4%	7%
Sustainalytics Governance Score Negligible, Low and Medium	33%	67%	8%	22%	2%	4%	0%	0%	0%	0%	0%	0%	97%	100 %	85%	97%	74%	97%	62%	85%	44%	66%	21%	51%
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	100 %	100 %	93%	100 %	87%	100 %	67%	88%	60%	27%	70%	13%	24%	4%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	100 %	94%	90%	87%	80%	73%	70%	38%	45%	15%	15%	8%	72%	86%	40%	51%	19%	20%	0%	0%	0%	0%	0%	0%
Upright Absolute Net Impact Score Positive Only	89%	98%	44%	90%	44%	70%	22%	25%	22%	7%	0%	1%	89%	99%	77%	94%	62%	86%	42%	63%	28%	41%	23%	20%
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	100 %	100 %	100 %	100 %	100 %	75%	94%	75%	68%	50%	29%	92%	93%	81%	77%	55%	59%	25%	33%	9%	11%	2%	3%
Upright Absolute Environment Impact Score Positive Only	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	50%	62%	77%	32%	39%	1%	5%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 10	80%	91%	73%	80%	63%	43%	56%	9%	41%	1%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 30	76%	71%	53%	37%	19%	13%	1%	0%	0%	0%	0%	0%	24%	33%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk Rating A and better	82%	79%	60%	35%	28%	9%	4%	1%	0%	0%	0%	0%	5%	14%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk Rating BB and better	76%	74%	45%	38%	9%	6%	0%	0%	0%	0%	0%	0%	40%	34%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Appendix 3.3.2 Models with different factors and factor loadings

Table 10: Percentage of stocks in a data set where the (positive or negative) cost of capital difference Equation (15) – (3) for ESG stocks and (16) – (4) for non-ESG stocks is greater than the benchmark fitted to the respective investment horizon. Formally,

$$|(15) - (3)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

and

$$|(16) - (4)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

† Special case of only one ESG stock leading to identical capital costs.

Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.
#DIV/0! Either means no positive (solely negative) or no negative (solely positive) cost of capital differences.

Single stock: daily investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	#DIV/0!	100 %	#DIV/0!	95%	#DIV/0!	95%	#DIV/0!	95%	#DIV/0!	89%	#DIV/0!	98%	92%	92%	83%	80%	72%	59%	33%	39%	18%	16%	7%
Thomson Reuters ESG Combined Score A- and better	100 %	100 %	98%	0%	92%	0%	86%	0%	74%	0%	56%	0%	98%	89%	93%	77%	85%	47%	65%	17%	42%	6%	20%	3%
Refinitiv/S-Network ESG Best Practices Index	98%	77%	94%	66%	89%	60%	82%	29%	61%	6%	37%	0%	97%	90%	89%	88%	78%	74%	52%	53%	23%	28%	9%	16%
MSCI KLD 400 Social Index	97%	91%	89%	76%	80%	57%	43%	39%	20%	24%	8%	12%	94%	93%	88%	73%	66%	45%	35%	29%	10%	17%	2%	11%
MSCI USA Select ESG & Trend Leaders index	96%	92%	84%	81%	61%	64%	25%	39%	10%	25%	5%	16%	91%	93%	77%	81%	64%	60%	19%	35%	8%	22%	5%	18%
Sustainalytics Total ESG Score Negligible and Low	50%	98%	50%	97%	50%	96%	50%	94%	0%	85%	0%	71%	99%	100 %	96%	98%	91%	93%	85%	82%	70%	68%	55%	53%
Sustainalytics Total ESG Score Negligible, Low and Medium	73%	98%	55%	92%	45%	83%	18%	64%	9%	40%	9%	29%	95%	96%	91%	93%	86%	85%	74%	65%	66%	44%	63%	29%
Sustainalytics Environment Score Negligible, Low and Medium	77%	95%	60%	89%	35%	76%	19%	49%	7%	34%	5%	22%	97%	94%	95%	88%	84%	72%	75%	41%	70%	38%	63%	34%
Sustainalytics Social Score Negligible, Low and Medium	90%	94%	76%	87%	42%	73%	19%	44%	9%	31%	3%	22%	97%	96%	89%	92%	82%	72%	64%	48%	53%	34%	29%	22%
Sustainalytics Governance Score Negligible, Low and Medium	86%	94%	67%	85%	34%	69%	14%	43%	8%	28%	3%	20%	97%	93%	95%	85%	89%	67%	79%	41%	68%	26%	60%	19%
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	95%	100 %	68%	100 %	23%	0%	9%	0%	5%	86%	91%	73%	81%	54%	69%	21%	40%	8%	25%	4%	17%
Sustainalytics Controversy Score No and Low Controversy	100 %	100 %	100 %	94%	100 %	84%	50%	51%	0%	34%	0%	20%	90%	97%	82%	92%	61%	82%	28%	62%	14%	40%	7%	27%
Upright Absolute Net Impact Score Positive Only	85%	91%	63%	81%	29%	66%	20%	38%	7%	25%	5%	19%	96%	88%	86%	76%	73%	50%	51%	25%	32%	17%	18%	14%
Upright Absolute Net Impact Score Above Average of Positive Only	75%	100 %	75%	100 %	50%	91%	50%	59%	25%	21%	0%	6%	97%	94%	92%	76%	82%	55%	68%	38%	44%	25%	22%	19%
Upright Absolute Environment Impact Score Positive Only	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	95%	98%	86%	94%	65%	87%	40%	72%	21%	56%	10%	42%
RepRisk RRI Below or Equal 10	91%	96%	76%	85%	47%	65%	9%	35%	2%	15%	0%	9%	90%	93%	80%	84%	64%	69%	22%	39%	10%	29%	6%	21%
RepRisk RRI Below or Equal 30	75%	97%	49%	89%	24%	75%	10%	51%	1%	29%	0%	19%	93%	93%	80%	82%	63%	73%	32%	56%	20%	42%	15%	31%
RepRisk Rating A and better	90%	95%	78%	87%	50%	71%	12%	36%	5%	22%	1%	15%	92%	90%	79%	81%	60%	68%	24%	43%	10%	32%	9%	29%
RepRisk Rating BB and better	80%	95%	57%	87%	27%	73%	15%	49%	5%	27%	1%	18%	94%	93%	79%	85%	61%	75%	27%	60%	15%	45%	12%	35%

Appendix 3.4 Explaining economic significance: ESG score methodology

Appendix 3.4.1 Data set characteristics encoded in the form of dummy variables

Table 11: Data set characteristics encoded in the form of dummy variables

Data set Dummy Variables	Controversy dummy - without (0) and with controversy scores (1)	ESG dimensions dummy - only one dimension (Environment, or Social, or Governance) considered (0) and all three dimensions simultaneously considered (1)
Thomson Reuters ESG Combined Score A and better	1	1
Thomson Reuters ESG Combined Score A- and better	1	1
Refinitiv/S-Network ESG Best Practices Index	0	1
MSCI KLD 400 Social Index	0	1
MSCI USA Select ESG & Trend Leaders index	0	1
Sustainalytics Total ESG Score Negligible and Low	0	1
Sustainalytics Total ESG Score Negligible, Low and Medium	0	1
Sustainalytics Environment Score Negligible, Low and Medium	0	0
Sustainalytics Social Score Negligible, Low and Medium	0	0
Sustainalytics Governance Score Negligible, Low and Medium	0	0
Sustainalytics Controversy Score No Controversy	1	1
Sustainalytics Controversy Score No and Low Controversy	1	1
Upright Absolute Net Impact Score Positive Only	0	1
Upright Absolute Net Impact Score Above Average of Positive Only	0	1
Upright Absolute Environment Impact Score Positive Only	0	0
RepRisk RRI Below or Equal 10	1	1
RepRisk RRI Below or Equal 30	1	1
RepRisk Rating A and better	1	1
RepRisk Rating BB and better	1	1

Appendix 3.4.2 Regression outputs for explaining different percentages of economically significant cost of capital differences

Appendix 3.4.2.1 Models with different factor loadings (but identical factors)

Table 12: Regression results for the controversy dummy (results for the constant are not depicted) of a regression that explains the percentage of economically significant cost of capital differences per data set with the help of the controversy dummy and the ESG dimension of the data set:

$$proc_{data\ set_i} = a + b_{contr} \cdot dummy_{contr,data\ set_i} + b_{ESG\ dimension} \cdot dummy_{ESG\ dimension,data\ set_i} + \varepsilon_{data\ set_i}$$

For industry portfolios the data set Upright Absolute Environment Impact Score Positive Only is omitted because it consists of just one industry and, hence, belongs to the special case of "just one ESG stock".
Therefore, there are 19 data sets for single stocks and 18 for industry portfolios.
There is no dummy trap.

Single stocks	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	-0.1643	-0.0683	-0.0502	0.0413	0.0743	0.0978	-0.0988	-0.1034	-0.0771	0.0000	0.0123	0.0054
Standard Errors	0.0826	0.0889	0.1604	0.1763	0.2626	0.1543	-0.1354	-0.2116	-0.3278	-0.4405	-0.4985	-0.4613
P-Value	6.40%	45.39%	75.83%	81.77%	78.07%	53.50%	47.63%	63.19%	81.71%	99.99%	98.06%	99.08%
ESG dimension Dummy	0.1955	0.2246	0.2320	0.2294	0.1821	0.1315	0.1114	0.1320	0.1442	0.1683	0.1668	0.1582
Standard Errors	0.1614	0.1854	0.1916	0.1894	0.1504	0.1086	0.0920	0.1090	0.1191	0.1390	0.1377	0.1306
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%
Adj R^2	0.0437	0.0148	0.0436	0.0750	0.2296	0.2137	0.2416	0.3072	0.4153	0.4379	0.4994	0.4894
Adj R^2	0.1119	0.0627	0.1798	0.2746	0.2987	0.3594						

Single stocks	ESG stocks – negative differences						Non-ESG stocks– negative differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	-0.0196	-0.0631	0.0293	0.1597	0.1669	0.0864	-0.0572	-0.0832	-0.1137	-0.0970	-0.1235	-0.1228
Standard Errors	0.0001	-0.0426	-0.0114	-0.0049	-0.0483	-0.0404	-0.2641	-0.3265	-0.4340	-0.4918	-0.4684	-0.3327
P-Value	0.00%	15.84%	2.05%	0.00%	0.33%	4.82%	83.13%	80.22%	79.67%	84.61%	79.55%	71.70%
ESG dimension Dummy	0.1303	0.2000	0.2368	0.2378	0.1689	0.0701	0.1619	0.1743	0.1789	0.1914	0.1825	0.1827
Standard Errors	0.1076	0.1651	0.1955	0.1964	0.1394	0.0579	0.1337	0.1439	0.1477	0.1580	0.1507	0.1508
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%
Adj R^2	0.0017	0.0181	0.0010	0.0328	0.0581	0.0881	0.2647	0.3291	0.4530	0.4677	0.4813	0.3393

Appendix 3.4.2.2 Models with different factors and factor loadings

Table 13: Regression results for the controversy dummy (results for the constant are not depicted) of a regression that explains the percentage of economically significant cost of capital differences per data set with the help of the controversy dummy and the ESG dimension of the data set:

$$proc_{data\ set_i} = a + b_{contr} \cdot dummy_{contr,data\ set_i} + b_{ESG\ dimension} \cdot dummy_{ESG\ dimension,data\ set_i} + \varepsilon_{data\ set_i}$$

For industry portfolios the data set Upright Absolute Environment Impact Score Positive Only is omitted because it consists of just one industry and, hence, belongs to the special case of "just one ESG stock".
Therefore, there are 19 data sets for single stocks and 18 for industry portfolios.
There is no dummy trap.

Single stocks	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	0.0582	0.1111	0.2363	0.2058	0.0481	-0.0214	-0.1569	-0.1701	-0.0977	-0.0278	-0.0248	-0.0075
Standard Errors	0.0937	0.0386	0.0607	0.0899	0.0955	0.0982	-0.1364	-0.1647	-0.2013	-0.1115	-0.0641	-0.0313
P-Value	54.37%	1.14%	0.14%	3.70%	62.15%	83.08%	26.71%	31.69%	63.38%	80.65%	70.45%	81.36%
ESG dimension Dummy	0.1730	0.2019	0.2161	0.1815	0.1245	0.0918	0.1188	0.1269	0.1231	0.0652	0.0383	0.0197
Standard Errors	0.1297	0.1514	0.1621	0.1361	0.0934	0.0689	0.0981	0.1048	0.1016	0.0538	0.0316	0.0163
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%
Adj R^2	0.0618	0.0367	0.1165	0.1555	0.1070	0.1264	0.2911	0.3220	0.3152	0.2896	0.3059	0.2581

Single stocks	ESG stocks – negative differences						Non-ESG stocks– negative differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	-0.1893	-0.1591	-0.0743	-0.0577	-0.0550	-0.0328	-0.0631	-0.0695	-0.0349	-0.0823	-0.0624	-0.0159
Standard Errors	0.0121	-0.0239	-0.0845	-0.0671	-0.0493	0.0538	-0.0159	-0.0183	-0.0298	0.0334	-0.0031	-0.0127
P-Value	0.00%	0.00%	39.21%	40.28%	28.12%	55.11%	0.11%	0.16%	25.81%	2.56%	0.00%	22.91%
ESG dimension Dummy	0.1928	0.1853	0.1650	0.1411	0.1444	0.0321	0.0795	0.0958	0.1091	0.0851	0.0427	0.0190
Standard Errors	0.1592	0.1530	0.1362	0.1165	0.1192	0.0265	0.0657	0.0791	0.0901	0.0703	0.0353	0.0157
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%
Adj R^2	0.0655	0.0638	0.0608	0.0519	0.0341	0.2062	0.0623	0.0533	0.0231	0.0553	0.1488	0.1318

Appendix 3.5 Explaining economic significance: covariances of single stocks

Appendix 3.5.1 Collinearity

Table 14: Variance Inflation Factors (VIF) for the three covariance variables $\hat{s}_{R_{H_i},R_M}$, $\hat{s}_{R_{H_i},R_{M_G}}$, and $\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$

Variance Inflation Factor (VIF) Single Stocks	$\hat{s}_{R_{H_i},R_M}$		$\hat{s}_{R_{H_i},R_{M_G}}$		$\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$		$\hat{s}_{R_{H_i},R_M}+\hat{s}_{R_{H_i},R_{M_G}}$		$\hat{s}_{R_{H_i},R_M}+\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$		$\hat{s}_{R_{H_i},R_{M_G}}+\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Daily investment horizon												
$\hat{s}_{R_{H_i},R_M}$			16.05	7.54	18.45	11.81					33.39	16.63
$\hat{s}_{R_{H_i},R_{M_G}}$	16.05	7.54			9.52	5.42			16.13	11.36		
$\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	18.45	11.81	9.52	5.42			18.54	7.64				

Appendix 3.5.2 Logit regression results

Appendix 3.5.2.1 Models with different factor loadings (but identical factors)

Table 15: Logit regression results for the covariance terms that explain cost of capital differences of single stocks:

ESG stocks	
$1_{\geq benchmark}(pos.difference_{G_i}) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$	$1_{\geq benchmark}\left(\left\|neg.difference_{G_i}\right\|\right) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$
non-ESG stocks	
$1_{\geq benchmark}(pos.difference_{H_i}) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$	$1_{\geq benchmark}\left(\left\|neg.difference_{H_i}\right\|\right) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$

where cov_{G_i} and cov_{H_i} are specified in the most left column of the ensuing table.

Single stocks	**ESG stocks – positive differences**						**Non-ESG stocks– positive differences**					
	2%	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**	**2%**	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	20886.17660	11622.34580	8928.42784	5611.71346	9255.07800	12830.92292	0.90713	6.44346	1.52893	5.58181	3.10750	4.07121
Standard Errors	8828.90344	4502.36587	5746.79497	3524.10757	4545.94062	2613.98987	1.37715	0.80601	1.06272	0.72803	0.84397	0.64729
P-Value	1.80%	0.98%	12.03%	11.13%	4.18%	0.00%	51.01%	0.00%	15.02%	0.00%	0.02%	0.00%
Adj R^2	0.0054	0.0024	0.0017	0.0007	0.0026	0.0110	-0.0001	0.0251	0.0008	0.0238	0.0068	0.0161
	ESG stocks – negative differences						**Non-ESG stocks– negative differences**					
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	3833.73788	14495.96127	5339.21851	14777.71023	8708.86840	10496.79349	6.31768	1.93425	4.48834	3.16817	3.55435	5.25290
Standard Errors	2983.81725	1747.08891	2426.26953	1605.16810	2665.08412	2130.29725	0.68087	0.57828	0.63495	0.57525	0.68454	0.69975
P-Value	19.88%	0.00%	2.78%	0.00%	0.11%	0.00%	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%
Adj R^2	0.0007	0.0311	0.0040	0.0327	0.0077	0.0072	0.0394	0.0041	0.0213	0.0117	0.0109	0.0231

Appendix 3.5.2.2 Models with different factors and factor loadings

Table 16: Logit regression results for the covariance terms that explain cost of capital differences of single stocks:

ESG stocks	
$1_{\geq benchmark}(pos.difference_{G_i}) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$	$1_{\geq benchmark}\left(\left\|neg.difference_{G_i}\right\|\right) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$
non-ESG stocks	
$1_{\geq benchmark}(pos.difference_{H_i}) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$	$1_{\geq benchmark}\left(\left\|neg.difference_{H_i}\right\|\right) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$

where cov_{G_i} and cov_{H_i} are specified in the most left column of the ensuing tables.

Single stocks	**ESG stocks – positive differences**						**Non-ESG stocks– positive differences**					
	2%	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**	**2%**	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	30023.3897	21098.9945	15360.1795	13500.8109	7871.6185	5872.5496	5.0877	5.7412	5.4686	4.1886	3.7262	3.388
Standard Errors	3957.258	3111.3474	2628.7928	2519.3095	2922.4742	4111.7429	0.7174	0.6274	0.5988	0.6834	0.8969	1.3607
P-Value	0.00%	0.00%	0.00%	0.00%	0.71%	15.32%	0.00%	0.00%	0.00%	0.00%	0.00%	1.28%
Adj R^2	0.0539	0.0394	0.0291	0.0244	0.0053	0.0005	0.0195	0.0308	0.0309	0.0133	0.0054	0.0017
	ESG stocks – negative differences						**Non-ESG stocks– negative differences**					
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	47922.8123	41839.1442	33228.4203	18242.6993	13113.5825	10246.5996	18.2928	15.7487	11.8994	8.3349	6.9078	5.0018
Standard Errors	2660.0626	2255.7505	1904.7433	1834.5715	2328.0092	3513.9234	1.0761	0.9136	0.761	0.7397	0.9072	1.2833
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Adj R^2	0.1893	0.1881	0.1543	0.0385	0.0109	0.0022	0.1922	0.1838	0.1388	0.0657	0.0248	0.0057

Appendix 3.6 Explaining economic significance: industry classification

Appendix 3.6.1 Models with different factor loadings (but identical factors)

Tables 17a and b: Industry classification and cost of capital differences greater than benchmark 2% (1.5%, 1%) for selected stocks and data sets

ESG stocks							
Stock name	Industry classification	Refinitiv/S-Network ESG Best Practices Index			Sustainalytics Total ESG Score Negligible, Low and Medium		
		Benchmark			Benchmark		
		2%	1.5%	1%	2%	1.5%	1%
BANKOFAMERICA	4	false	false	false	false	false	false
BANKOFNEWYORKMELLON	4	false	false	false	false	false	false
CITIGROUP	4	false	false	false	false	false	false
COMERICA	4	false	false	false	false	false	false
FIFTHTHIRDBANCORP	4	false	false	false	false	false	false
HUNTINGTONBCSH	4	false	false	false	false	false	false
JPMORGANCHASECO	4	false	false	false	false	false	false
KEYCORP	4	false	false	false	false	false	false
REGIONSFINLNEW	4	false	false	false	false	false	true
WELLSFARGOCO	4	false	false	false	false	false	false

Non-ESG stocks							
Stock name	Industry classification	Refinitiv/S-Network ESG Best Practices Index			Thomson Reuters ESG Combined Score A and better		
		Benchmark			Benchmark		
		2%	1.5%	1%	2%	1.5%	1%
AMEREN	29	true	true	true	false	false	false
ATMOSENERGY	29	true	true	true	false	false	false
CENTERPOINTEN	29	false	true	true	false	false	false
CMSENERGY	29	true	true	true	false	false	false
DTEENERGY	29	true	true	true	false	false	false
DUKEENERGY	29	false	true	true	false	false	false
EVERGY	29	true	true	true	false	false	false
EVERSOURCEENERGY	29	true	true	true	false	false	false
PINNACLEWESTCAP	29	true	true	true	false	false	false
PUBSERENTERGP	29	true	true	true	false	false	false
SEMPRAEN	29	true	true	true	false	false	false
WECENERGYGROUP	29	true	true	true	false	false	false
		Upright Absolute Net Impact Score Positive Only			Sustainalytics Controversy Score No and Low Controversy		
DEERE	13	false	false	false	false	false	false
FLOWSERVE	13	true	true	true	false	false	false
IDEX	13	true	true	true	false	false	false
ILLINOISTOOLWORKS	13	true	true	true	false	false	false
PACCAR	13	true	true	true	false	false	false
PARKERHANNIFIN	13	true	true	true	false	false	false
WABTEC	13	true	true	true	false	false	false

Appendix 3.6.2 Models with different factors and factor loadings

Tables 18a and b: Industry classification and cost of capital differences greater than benchmark 2% (1.5%, 1%) for selected stocks and data sets

ESG stocks							
Stock name	Industry classification	Refinitiv/S-Network ESG Best Practices Index			Sustainalytics Total ESG Score Negligible, Low and Medium		
		Benchmark			Benchmark		
		2%	1.5%	1%	2%	1.5%	1%
BANKOFAMERICA	4	false	true	true	true	true	true
BANKOFNEWYORKMELLON	4	false	false	false	true	true	true
CITIGROUP	4	false	false	false	true	true	true
COMERICA	4	false	false	true	true	true	true
FIFTHTHIRDBANCORP	4	false	false	false	true	true	true
HUNTINGTONBCSH	4	false	false	true	true	true	true
JPMORGANCHASECO	4	false	false	true	true	true	true
KEYCORP	4	false	false	true	true	true	true
REGIONSFINLNEW	4	false	true	true	true	true	true
WELLSFARGOCO	4	false	false	false	true	true	true

Non-ESG stocks							
Stock name	Industry classification	Refinitiv/S-Network ESG Best Practices Index			Thomson Reuters ESG Combined Score A and better		
		Benchmark			Benchmark		
		2%	1.5%	1%	2%	1.5%	1%
AMEREN	29	false	false	false	false	false	false
ATMOSENERGY	29	false	false	false	false	false	false
CENTERPOINTEN	29	false	false	false	false	false	false
CMSENERGY	29	false	false	false	false	false	false
DTEENERGY	29	false	false	false	false	false	false
DUKEENERGY	29	false	false	false	false	false	false
EVERGY	29	false	false	false	false	false	false
EVERSOURCEENERGY	29	false	false	false	false	false	false
PINNACLEWESTCAP	29	false	false	false	false	false	false
PUBSERENTERGP	29	false	false	false	false	false	false
SEMPRAEN	29	false	false	false	false	false	false
WECENERGYGROUP	29	false	false	false	false	false	false
		Upright Absolute Net Impact Score Positive Only			Sustainalytics Controversy Score No and Low Controversy		
DEERE	13	false	false	false	false	false	false
FLOWSERVE	13	false	true	true	false	false	false
IDEX	13	false	false	true	false	false	false
ILLINOISTOOLWORKS	13	false	false	false	false	false	false
PACCAR	13	false	false	true	false	false	false
PARKERHANNIFIN	13	false	false	true	false	false	false
WABTEC	13	false	false	true	false	false	false

Appendix 3.7 Cost of capital empirical versus theory-based: different statistical significance of explanatory variables

Appendix 3.7.1 Models with different factor loadings (but identical factors)

Table 19: Percentage of explanatory variables whose significance level changes (increase or decrease) from an arbitrary value x to 10% (5%, 1%) when explaining empirical compared to theory-based cost of capital:

$$coc_{regr,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$
$$coc_{theo,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$

Three data sets were excluded because no differentiation in ESG rating was possible (index provider instead of rating provider): MSCI USA Select ESG & Trend Leaders index, MSCI KLD 400 Social Index, and Refinitiv/S-Network ESG Best Practices Index.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Significance Level	**10%**	**5%**	**1%**
No distinction between ESG and non-ESG stocks	**Daily**	**Daily**	**Daily**
Thomson Reuters ESG Combined Score A and better	0%	25%	0%
Thomson Reuters ESG Combined Score A- and better	0%	0%	0%
Sustainalytics Total ESG Score Negligible and Low	50%	50%	25%
Sustainalytics Total ESG Score Negligible, Low and Medium	0%	0%	0%
Sustainalytics Environment Score Negligible, Low and Medium	0%	0%	0%
Sustainalytics Social Score Negligible, Low and Medium	0%	0%	25%
Sustainalytics Governance Score Negligible, Low and Medium	0%	0%	0%
Sustainalytics Controversy Score No Controversy	0%	0%	25%
Sustainalytics Controversy Score No and Low Controversy	25%	0%	25%
Upright Absolute Net Impact Score Positive Only	0%	0%	0%
Upright Absolute Net Impact Score Above Average of Positive Only	25%	0%	0%
Upright Absolute Environment Impact Score Positive Only	0%	0%	0%
RepRisk RRI Below or Equal 10	0%	0%	0%
RepRisk RRI Below or Equal 30	0%	0%	0%
RepRisk Rating A and better	0%	0%	25%
RepRisk Rating BB and better	0%	25%	25%

Appendix 3.7.2 Models with different factor loadings (but identical factors)

Table 20: Percentage of explanatory variables whose significance level changes (increase or decrease) from an arbitrary value x to 10% (5%, 1%) when explaining empirical compared to theory-based cost of capital:

$$coc_{regr,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$
$$coc_{theo,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$

Three data sets were excluded because no differentiation in ESG rating was possible (index provider instead of rating provider): MSCI USA Select ESG & Trend Leaders index, MSCI KLD 400 Social Index, and Refinitiv/S-Network ESG Best Practices Index.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Significance Level	**10%**	**5%**	**1%**
No distinction between ESG and non-ESG stocks	**Daily**	**Daily**	**Daily**
Thomson Reuters ESG Combined Score A and better	25%	25%	25%
Thomson Reuters ESG Combined Score A- and better	25%	25%	25%
Sustainalytics Total ESG Score Negligible and Low	25%	25%	50%
Sustainalytics Total ESG Score Negligible, Low and Medium	25%	25%	50%
Sustainalytics Environment Score Negligible, Low and Medium	25%	25%	25%
Sustainalytics Social Score Negligible, Low and Medium	50%	50%	25%
Sustainalytics Governance Score Negligible, Low and Medium	25%	25%	25%
Sustainalytics Controversy Score No Controversy	25%	50%	0%
Sustainalytics Controversy Score No and Low Controversy	25%	25%	0%
Upright Absolute Net Impact Score Positive Only	25%	25%	0%
Upright Absolute Net Impact Score Above Average of Positive Only	25%	25%	0%
Upright Absolute Environment Impact Score Positive Only	0%	0%	0%
RepRisk RRI Below or Equal 10	25%	25%	25%
RepRisk RRI Below or Equal 30	25%	50%	25%
RepRisk Rating A and better	25%	50%	50%
RepRisk Rating BB and better	25%	50%	25%

References

Akey, Pat; Robertson, Adriana; and Simutin, Mikhail (2021): "Noisy Factors". Working paper, available at: https://ssrn.com/abstract=3930228

Albuquerque, Rui; Koskinen, Yrjo; Yang, Shuai and Zhang, Chendi (2020): "Resiliency of Environmental and Social Stocks: An Analysis of the Exogenous COVID-19 Market Crash". The Review of Corporate Finance Studies, Vol. 9, No. 3, pp. 593–621, https://doi.org/10.1093/rcfs/cfaa011

Albuquerque, Rui; Koskinen, Yrjo and Zhang, Chendi (2019): "Corporate Social Responsibility and Firm Risk: Theory and Empirical Evidence". Management Science, Vol. 65, No. 10, pp. 4451–4469, https://doi.org/10.1287/mnsc.2018.3043

Areal, Nelson; Cortez, Maria Céu and Silva, Florinda (2013): "The conditional performance of US mutual funds over different market regimes: do different types of ethical screens matter?". Financial Markets and Portfolio Management 27 (2013): 397–429. https://doi.org/10.1007/s11408-013-0218-5

Avramov, Doron; Cheng, Si; Lioui, Abraham and Tarelli, Andrea (2021): "Investment and Asset Pricing with ESG Disagreement". Working Paper, available at: https://ssrn.com/abstract=3711218

Baily, Camille and Gnabo, J. Y. (2022): "How Different Are ESG Mutual Funds? Evidence and Implications". Working paper, available at: https://ssrn.com/abstract=4048577

Barber, Brad M.; Morse, Adair and Yasuda, Ayako (2020): "Impact Investing". Journal of Financial Economics, Vol. 139, Issue 1, pp. 162-185. https://doi.org/10.1016/j.jfineco.2020.07.008

Barnett, Michael L. and Salomon, Robert M. (2006): "Beyond Dichotomy: The Curvilinear Relationship Between Social Responsibility and Financial Performance". Strategic Management Journal, Vol. 27, No. 11, pp. 1101–1122, https://doi.org/10.1002/smj.557

Bauer, Rob; Derwall, Jeroen and Otten, Rogér (2007): "The Ethical Mutual Fund Performance Debate: New Evidence from Canada". Journal of Business Ethics, Vol. 70, No. 2 (Jan., 2007), pp. 111-124. https://doi.org/10.1007/s10551-006-9099-0

Berg, Florian, Fabisik, Kornelia and Sautner, Zacharias (2021): "Rewriting History II: The (Un)Predictable Past of ESG Ratings". Ecgi Finance Working Paper N° 708/2020, available at: https://ssrn.com/abstract=3722087

Berg, Florian; Kölbel, Julian; Pavlova, Anna and Rigobon, Roberto (2021): "ESG Confusion and Stock Returns: Tackling the Problem of Noise". Working paper, available at: https://ssrn.com/abstract=3941514

Berg, Florian, Kölbel, Julian F. and Rigobon, Roberto (2022): "Aggregate Confusion: The Divergence of ESG Ratings". Review of Finance, available at: https://doi.org/10.1093/rof/rfac033

Berk, Jonathan B. and van Binsbergen, Jules H. (2021): "The Impact of Impact Investing". Stanford University Graduate School of Business Research Paper, Law & Economics Center at George Mason University Scalia Law School Research Paper Series No. 22-008, available at: https://ssrn.com/abstract=3909166

Billio, Monica; Costola, Michele; Hristova, Iva; Latino, Carmelo and Pelizzon, Loriana (2021): "Inside the ESG Ratings: (Dis)agreement and performance". Corporate Social Responsibility Environmental Management, Vol 28, pp. 1426–1445. https://doi.org/10.1002/csr.2177

Bolton, Patrick and Kacperczyk, Marcin (2021): "Do Investors Care about Carbon Risk?". Journal of Financial Economics, Vol. 142, No. 2, pp. 517-549 https://doi.org/10.1016/j.jfineco.2021.05.008

Borgers, Arian; Derwall, Jeroen; Koedijk, Kees and Ter Horst, Jenke (2015): "Do social factors influence investment behavior and performance? Evidence from mutual fund holdings". Journal of Banking & Finance, Vol. 60, pp. 112–126, https://doi.org/10.1016/j.jbankfin.2015.07.001

Brouwers, Roel; Schoubben, Frederiek; Van Hulle, Cynthia and Van Uytbergen, Steve (2016): "The initial impact of EU ETS verification events on stock prices". Energy Policy, Vol. 94, pp. 138–149. https://doi.org/10.1016/j.enpol.2016.04.006

Campbell, John Y.; Lo, Andrew W. and MacKinlay, A. Craig (1997): "The Econometrics of Financial Markets", Princeton University Press, Princeton, New Jersey.

Capelle-Blancard, Gunther and Monjon, Stéphanie (2014): "The Performance of Socially Responsible Funds: Does the Screening Process Matter?". European Financial Management, Vol. 20, pp. 494–520. https://doi.org/10.1111/j.1468-036X.2012.00643.x

Carhart, Mark M. (1997): "On Persistence in Mutual Fund Performance". The Journal of Finance, Vol. 52, No. 1, pp. 57-82, https://doi.org/10.2307/2329556

Ceccarelli, Marco; Ramelli, Stefano and Wagner, Alexander F. (2021): “Low-carbon Mutual Funds”. Working paper, available at: https://ssrn.com/abstract=3353239

Chava, Sudheer (2014): “Environmental Externalities and Cost of Capital”. Management Science, Vol. 60, No. 9, pp. 2223-2247. https://www.jstor.org/stable/24550583

Chen, Qian and Liu, Xiao-Yang (2020): “Quantifying ESG Alpha Using Scholar Big Data: An Automated Machine Learning Approach”. Working paper, available at: https://ssrn.com/abstract=3806840

Coqueret, Guillaume (2020): “ESG equity investing: a short survey”. Working paper, available at: https://ssrn.com/abstract=3715753

Cortez, Maria Ceu; Silva, Florinda and Areal, Nelson (2012): “Socially Responsible Investing in the Global Market: The Performance of US and European Funds”. International Journal of Finance & Economics 17 (2012): 254–271. https://doi.org/10.1002/ijfe.454

Christensen, Dane; Serafeim, George and Sikochi, Anywhere (2022): “Why is Corporate Virtue in the Eye of The Beholder? The Case of ESG Ratings”. The Accounting Review, Vol 97, No. 1, pp. 147–175. https://doi.org/10.2308/TAR-2019-0506

Demers, Elizabeth; Joos, Philip; Hendrikse, Jurian and Lev, Baruch (2020): “ESG did not immunize stocks during the COVID-19 crisis, but investments in intangible assets did”. Journal of Business Finance & Accounting, Vol. 48, pp. 433–462. https://doi.org/10.1111/jbfa.12523

Derrien, François; Krüger, Philipp; Landier, Augustin and Yao, Tianhao (2021): “ESG news, future cash flows, and firm value”. Swiss Finance Institute Research Paper No. 21-84, available at: https://ssrn.com/abstract=3903274

Ding, Wenzhi; Levine, Ross; Lin, Chen and Xie, Wensi (2021): “Corporate immunity to the COVID-19 pandemic”. Journal of Financial Economics, Vol. 141, No. 2, pp. 802-830, https://doi.org/10.1016/j.jfineco.2021.03.005

Dorfleitner, Gregor; Kreuzer, Christian and Sparrer, Christian (2020): ”ESG controversies and controversial ESG: about silent saints and small sinners“. Journal of Asset Management 21 (2020), 393–412. https://doi.org/10.1057/s41260-020-00178-x

Dunn, Jeff; Fitzgibbons, Shaun and Pomorski, Lukasz (2017): “Assessing Risk Through Environmental, Social and Governance Exposures“. Journal of Investment Management, Vol. 16, No. 1, pp. 4-17.

Dyck, Alexander, Lins, Karl V., Roth, Lukas, and Wagner, Hannes F. (2019): "Do institutional investors drive corporate social responsibility? International evidence". Journal of Financial Economics 131 (2019): 693–714. https://doi.org/10.1016/j.jfineco.2018.08.013

Ehlers, Torsten; Elsenhuber, Ulrike; Jegarasasingam, Anandakumar and Jondeau, Eric (2022): "Deconstructing ESG scores: How to invest with your own criteria". BIS Working Papers No 1008, available at: https://ssrn.com/abstract=4055418

El Ghoul, Sadok; Guedhami, Omrane; Kwok, Chuck C. Y. and Mishra, Dev R. (2011): "Does corporate social responsibility affect the cost of capital?". Journal of Banking & Finance, Vol. 35, pp. 2388–2406. https://doi.org/10.1016/j.jbankfin.2011.02.007

Errunza, Vihang and Losq, Etienne (1985): "International Asset Pricing under Mild Segmentation: Theory and Test". The Journal of Finance, Vol. 40, No. 1, pp. 105-124, https://doi.org/10.2307/2328050

Fama, Eugene F. and French, Kenneth F. (1993): "Common risk factors in the returns on stocks and bonds". Journal of Financial Economics, Vol. 33, No. 1, pp. 3-56, https://doi.org/10.1016/0304-405X(93)90023-5

Fama, Eugene F. and French, Kenneth F. (1997): "Industry costs of equity". Journal of Financial Economics, Vol., 43, No. 2, pp. 153-193, https://doi.org/10.1016/S0304-405X(96)00896-3

Fama, Eugene F. and French, Kenneth F. (2015): "A five-factor asset pricing model". Journal of Financial Economics, Vol. 116, No. 1, pp. 1-22, https://doi.org/10.1016/j.jfineco.2014.10.010

Fama, Eugene F. and French, Kenneth F. (2018): "Choosing factors". Journal of Financial Economics, Vol. 128, No. 2, pp. 234-252, https://doi.org/10.1016/j.jfineco.2018.02.012

Gantchev, Nickolay; Giannetti, Mariassunta and Li, Rachel (2020): "Sustainability or Performance? Ratings and Fund Managers' Incentives". Working paper, available at: https://ssrn.com/abstract=3731006

Gibson Rajna; Krüger, Philipp and Schmidt, Peter S. (2021): "ESG Rating Disagreement and Stock Returns". Financial analysts Journal, Vol. 77, No. 4, pp. 104-127, https://doi.org/10.1080/0015198X.2021.1963186

Hartzmark, Samuel M. and Sussman, Abigail B. (2019): "Do Investors Value Sustainability? A Natural Experiment Examining Ranking and Fund Flows". The Journal of Finance, Vol. 74, No. 6, pp. 2789–2837, https://doi.org/10.1111/jofi.12841

Harvey, Campbell R. and Liu, Yan (2019): "A Census of the Factor Zoo". Working paper, available at: https://ssrn.com/abstract=3341728

Heinkel, Robert; Kraus, Alan and Zechner, Josef (2001): "The Effect of Green Investment on Corporate Behavior". Journal of Financial and Quantitative Analysis, Vol. 36, No. 4, pp. 431-449, https://doi.org/10.2307/2676219

Hong, Harrison and Kacperczyk, Marcin (2009): "The price of sin: The effects of social norms on markets". Journal of Financial Economics, Vol. 93, No. 1, pp. 15–36, https://doi.org/10.1016/j.jfineco.2008.09.001

Hsu, Po-Hsuan; Li, Kai and Tsou Chi-Yang (2020): "The Pollution Premium". Working Paper, available at: https://ssrn.com/abstract=3578215

Karoui, Aymen and Nguyen, Duc Khuong (2022): "Systematic ESG Exposure and Stock Returns: Evidence from the United States during the 1991-2019 Period". Business Ethics, the Environment & Responsibility, pp. 1-16 https://doi.org/10.1111/beer.12429

Kazdin, Joshua; Schwaiger, Katharina; Wendt, Viktoria-Sophie and Ang, Andrew, (2021): "Climate Alpha with Predictors Also Improving Company Efficiency". The Journal of Impact and ESG Investing Nov 2021, 2 (2) 35-56 https://doi.org/10.3905/jesg.2021.1.030

Krüger, Philipp; Sautner, Zacharias and Starks, Laura T. (2020): "The Importance of Climate Risks for Institutional Investors". The Review of Financial Studies, Vol. 33, No. 3, pp. 1067-1111, https://doi.org/10.1093/rfs/hhz137

Kuang, Huan and Liang, Bing (2020): "Carbon Risk Exposure in the Mutual Fund Industry". Working paper, available at: https://ssrn.com/abstract=3750244

La Torre, Mario; Mango, Fabio Massimo; Cafaro Arturo and Leo, Sabrina (2020): "Does the ESG Index Affect Stock Return? Evidence from the Eurostoxx50". Sustainability, Vol. 12, No. 16, https://doi.org/10.3390/su12166387

Latino, Carmelo; Pelizzon, Loriana and Rzeźnik, Aleksandra (2021): "The Power of ESG Ratings on Stock Markets". SAFE Working Paper No. 310, available at: https://ssrn.com/abstract=3801703

Lee, Darren D.; Humphrey, Jacquelyn E.; Benson, Karen L., and Ahn, Jason Y. K. (2010): "Socially responsible investment fund performance: the impact of screening intensity". Accounting and Finance, Vol. 50, pp. 351–370. https://doi.org/10.1111/j.1467-629X.2009.00336.x

Lindsey, Laura Anne; Pruitt, Seth and Schiller, Christoph (2021): "The Cost of ESG Investing". Working paper, available at: https://ssrn.com/abstract=3975077

Lioui, Abraham; Poncet, Patrice and Sisto, Michelle (2018): "Corporate Social Responsibility and the Cross Section of Stock Returns". Working Paper, available at: https://ssrn.com/abstract=2730722

Luo, H. Arthur and Balvers, Ronald J. (2017): "Social Screens and Systematic Investor Boycott Risk". Journal of Financial and Quantitative Analysis, Vol. 52, No. 1, pp. 365-399, https://doi.org/10.1017/S0022109016000910

Matsumura, Ella Mae; Prakash, Rachna and Vera-Muñoz, Sandra C. (2014): "Firm-Value Effects of Carbon Emissions and Carbon Disclosures". The Accounting Review, Vol. 89, No. 2, pp. 695–724, https://doi.org/10.2308/accr-50629

Merton, Robert C. (1973): "An Intertemporal Capital Asset Pricing Model". Econometrica, Vol. 41, No. 5, pp. 867-887, https://doi.org/10.2307/1913811

Mitton, Todd (2020): "Economic Significance in Corporate Finance". Working paper, available at: https://ssrn.com/abstract=3667830

Oberndorfer, Ulrich (2009): "EU Emission Allowances and the stock market: Evidence from the electricity industry". Ecological Economics, Vol. 68, No. 4, pp. 1116-1126, https://doi.org/10.1016/j.ecolecon.2008.07.026

Pástor, Luboš; Stambaugh, Robert F. and Taylor, Lucian A. (2020): "Sustainable Investing in Equilibrium". Journal of Financial Economics, Vol. 142, No. 2, pp. 550-571, https://doi.org/10.1016/j.jfineco.2020.12.011

Pedersen, Lasse Heje; Fitzgibbons, Shaun and Pomorski Lukasz (2020): "Responsible investing: The ESG-efficient frontier". Journal of Financial Economics, Vol. 142, No. 2, pp. 572-597, https://doi.org/10.1016/j.jfineco.2020.11.001

Sahin, Özge; Bax, Karoline; Czado, Claudia and Paterlini, Sandra (2021): "ESGM: ESG scores and the Missing Pillar". Working paper, available at: https://ssrn.com/abstract=3890696

Santi, Caterina and Moretti, Angelo (2021): “Carbon Risk Premium and Worries about Climate Change and Energy Disruption”. Working paper, available at: https://ssrn.com/abstract=3942738

Sautner, Zacharias; van Lent, Laurence; Vilkov, Grigory and Zhang, Ruishen (2021): “Pricing Climate Change Exposure”. Working paper, available at: https://ssrn.com/abstract=3792366

Stephens, Michael. A. (1986): “Use of the Kolmogorov-Smirnov, Cramer-Von Mises and Related Statistics Without Extensive Tables”. In: D’Agostino, Ralph B. and Stephens, Michael. A. eds.): “Goodness-of-Fit Techniques”. Statistics: Textbooks and Monographs, Vol. 68, Marcel Dekker Inc., New York and Basel, pp. 97-193.

Stephens, M. A. (1991): “Introduction to Kolmogorov (1933) On the Empirical Determination of a Distribution“. In: Kotz, Samuel and Johnson, Norman L. (eds.): “Breakthroughs in Statistics Volume II Methodology and Distribution”, Springer New York, Berlin et al. 1992, pp. 93-105.

van der Beck, Philippe (2021): “Flow-Driven ESG Returns”. Swiss Finance Institute Research Paper No. 21-71, available at: https://ssrn.com/abstract=3929359

Vu, Thanh Nam; Lehkonen, Heikki and Junttila, Juha-Pekka (2022): “ESG Investment Performance: Evidence from Global Markets”. Working paper, available at: https://ssrn.com/abstract=4045911

Wang, Kun Tracy; Kartika, Fiki; Wang, Wanbin Walter and Luo, Guqiang (2021): “Corporate social responsibility, investor protection, and the cost of equity: Evidence from East Asia”. Emerging Markets Review, Vol. 47, https://doi.org/10.1016/j.ememar.2021.100801

Zerbib, Olivier David (2020): “A Sustainable Capital Asset Pricing Model (S-CAPM): Evidence from Green Investing and Sin Stock Exclusion”. Proceedings of Paris December 2020 Finance Meeting EUROFIDAI - ESSEC, available at: https://ssrn.com/abstract=3455090

Zhu, Huiming; Tang, Yiding; Peng, Cheng and Yu, Keming (2018): “The heterogeneous response of the stock market to emission allowance price: evidence from quantile regression“. Carbon Management, Vol. 9, No. 3, pp. 277-289, https://doi.org/10.1080/17583004.2018.1475802

Online Appendix

Online 1 Derivation of an ESG pricing formula for stocks based on Heinkel/Kraus/Zechner (2001) without reformed assets

There are two types of investors, ESG investors who only allow themselves to invest in ESG stocks, but not in non-ESG stocks, and neutral investors, who invest in ESG and non-ESG stocks. Technically speaking, there is mild market segmentation in the sense of Errunza/Losq (1985: 107).

Online 1.1 Preparatory work

The decision problem of neutral investor j with μ-σ-preferences and risk preference parameter a_{n_j} reads

(O1.1)

$$\underset{N_{n_j,t}}{max}\left\{N_{n_j,t}^{T}\begin{pmatrix}E_{n_j}\{P_{G,t+1}\}-(1+r)\cdot P_{G,t}\\ E_{n_j}\{P_{H,t+1}\}-(1+\mathrm{r})\cdot P_{H,t}\end{pmatrix}+(1+r)\cdot W_{n_j,Pf,t}-\frac{a_{n_j}}{2}\cdot N_{n_j,t}^{T}\cdot\Omega_{n_j}\cdot N_{n_j,t}\right\}$$

with

$$\Omega_{n_j}=\begin{pmatrix}\sigma_{n_j,G,G} & \sigma_{n_j,G,H}\\ \sigma_{n_j,H,G} & \sigma_{n_j,H,H}\end{pmatrix}$$

where n_j denotes neutral investor j, N portfolio holdings, G the subset of ESG stocks, H the subset of non-ESG stocks, $P_{G,C}$ the $m \times 1$ vector of prices at times $t+1$ and t of ESG stocks, $P_{H,V}$ the $k \times 1$ vector of prices at times $t+1$ and t of non-ESG stocks, r the riskfree interest rate, $W_{n_j,Pf,t}$ wealth of investor n_j at time t, $E_{n_j}\{\ \}$ the expectation operator, $\sigma_{n_j,G,G}$ the $m \times m$ variance/covariance matrix between ESG stocks, $\sigma_{n_j,G,H}$ ($\sigma_{n_j,H,G}$) the $m \times k$ ($k \times m$) covariance matrix between ESG and non-ESG stocks, and $\sigma_{n_j,H,H}$ $k \times k$ variance/covariance matrix between non-ESG stocks; the subscript n_j with expectations and variances/covariances indicates that expectations are valid for investor n_j only.

The decision problem of ESG investor j with μ-σ-preferences and risk preference parameter a_{e_j} reads

(O1.2)

$$\max_{N_{e_j,t}} \left\{ N_{e_j,t}^T \left(E_{e_j}\{P_{G,t+1}\} - (1+r) \cdot P_{G,t} \right) + (1+\mathrm{r}) \cdot W_{e_j,Pf,t} - \frac{a_{e_j}}{2} \cdot N_{e_j,t}^T \cdot \sigma_{e,G,G} \cdot N_{e_j,t} \right\}$$

Forming necessary conditions for neutral and ESG investors, applying the assumption of homogenous expectations, and aggregating over all neutral (n_x) and ESG investors (e_x) gains:

For neutral investors

(O1.3)

$$\sum_{j=1}^{n_x} \frac{1}{a_{n_j}} \cdot \left(\begin{pmatrix} E\{P_{G,t+1}\} \\ E\{P_{H,t+1}\} \end{pmatrix} - (1+r) \cdot \begin{pmatrix} P_{G,t} \\ P_{H,t} \end{pmatrix} \right) = \begin{pmatrix} \sigma_{n_j,G,G} & \sigma_{n_j,G,H} \\ \sigma_{n_j,H,G} & \sigma_{n_j,H,H} \end{pmatrix} \cdot \begin{pmatrix} \sum_{j=1}^{n_x} N_{n_j,G,t} \\ \sum_{j=1}^{n_x} N_{n_j,H,t} \end{pmatrix}$$

For ESG investors

(O1.4)

$$\sum_{j=1}^{e_x} \frac{1}{a_{e_j}} \cdot \left(E\{P_{G,t+1}\} - (1+r) \cdot P_{G,t} \right) = \sigma_{G,G} \cdot \sum_{j=1}^{e_x} N_{e_j,G,t}$$

Market equilibrium on this segmented market requires

$$\sum_{j=1}^{n_x} N_{n_j,G,t} + \sum_{j=1}^{e_x} N_{e_j,G,t} = N_{M,G}$$

$$\sum_{j=1}^{n_x} N_{n_j,H,t} = N_{M,H}$$

where $N_{M,i}$ refers to the vector of total supply in the market for asset class i

Plugging the market equilibrium relations into (O1.3) and (O1.4) produces

For neutral investors

(O1.5)

$$\underbrace{\sum_{j=1}^{n_x} \frac{1}{a_{n_j}}}_{\equiv \frac{1}{a_n}} \cdot \left(\begin{pmatrix} E\{P_{G,t+1}\} \\ E\{P_{H,t+1}\} \end{pmatrix} - (1+r) \cdot \begin{pmatrix} P_{G,t} \\ P_{H,t} \end{pmatrix} \right) = \begin{pmatrix} \sigma_{n_j,G,G} & \sigma_{n_j,G,H} \\ \sigma_{n_j,H,G} & \sigma_{n_j,H,H} \end{pmatrix} \cdot \begin{pmatrix} N_{M,G} - \sum_{j=1}^{e_x} N_{e_j,G,t} \\ N_{M,H} \end{pmatrix}$$

For ESG investors

(O1.6)

$$\underbrace{\sum_{j=1}^{e_x} \frac{1}{a_{e_j}}}_{\frac{1}{a_e}} \cdot \left(E\{P_{G,t+1}\} - (1+r) \cdot P_{G,t} \right) = \sigma_{G,G} \cdot \sum_{j=1}^{e_x} N_{e_j,G,t}$$

Online 1.2 Risk premia for ESG stocks

Cutting out the all rows from (O1.5) that contain ESG stocks and using (O1.6) to solve for $\sum_{j=1}^{e_x} N_{e_j,G,t}$ delivers

(O1.7)

$$E\{P_{G,t+1}\} - (1+r)\cdot P_{G,t} = \frac{1}{\frac{1}{a_n}+\frac{1}{a_e}}\cdot \sigma_{G,M}$$

with

$$\sigma_{G,M} = \sigma_{G,G}N_{M,G} + \sigma_{G,H}N_{M,H}$$

Online 1.3 Risk premia for non-ESG stocks

Cutting out all rows that contain non-ESG stocks from (O1.5) and, again, using (O1.6) to express the unknown $\sum_{j=1}^{e_x} N_{e_j,t}$ produces together with the expression for $E\{P_{G,t+1}\} - (1+r)\cdot P_{G,t}$ derived in (O1.7)

(O1.8)

$$E\{P_{H,t+1}\} - (1+r)\cdot P_{H,t} = \frac{1}{\frac{1}{a_n}+\frac{1}{a_e}}\cdot \sigma_{H,M} + \frac{a_n^2}{a_e+a_n}\cdot\left[\sigma_{H,M} - \sigma_{G,H}^T\left(\sigma_{G,G}\right)^{-1}\sigma_{G,M}\right]$$

Online 2 Identical aggregate risk preference parameters for ESG and neutral investors

Online 2.1 Pricing model: form that contains risk preference parameters

Assuming identical aggregate risk preference parameters for ESG and neutral investors, pricing equations (O1.7) and (O1.8) simplify to

$$E\{P_{G,t+1}\} - (1+r)\cdot P_{G,t} = \frac{a}{2}\cdot \sigma_{G,M} \tag{O2.1}$$

and

$$E\{P_{H,t+1}\} - (1+r)\cdot P_{H,t} = \frac{a}{2}\cdot \sigma_{H,M} + \frac{a}{2}\cdot \left[\sigma_{H,M} - \sigma_{G,H}^{T}\left(\sigma_{G,G}\right)^{-1}\sigma_{G,M}\right] \tag{O2.2}$$

Online 2.2 Pricing formula: empirically implementable form

Using (A1.2) as starting point and plugging in $a_n = a_e = a$ gives

$$E\{W_{M,t+1}\} - (1+r)\cdot W_{M,t} = \frac{a}{2}\cdot \left[2\cdot \sigma_{M,M} - \sigma_{G,M}^{T}\left(\sigma_{G,G}\right)^{-1}\sigma_{G,M}\right] \tag{O2.3}$$

Hence, it is obtained

$$\frac{a}{2} = \frac{E\{W_{M,t+1}\} - (1+r)\cdot W_{M,t}}{2\cdot \sigma_{M,M} - \sigma_{G,M}^{T}\left(\sigma_{G,G}\right)^{-1}\sigma_{G,M}} \tag{O2.4}$$

Online 2.3 Pricing formula: returns form

Considering the i[th] row of (O2.1) and (O2.2), dividing by $P_{G_i,t}$ and $P_{H_i,t}$ respectively and expanding by $\frac{W_{M,t}}{W_{M,t}}$ gains

$$E\{R_{G_i,t+1}\} = r + \frac{a}{2}\cdot \sigma_{R_{G_i},R_M}\cdot W_{M,t} \tag{O2.5}$$

and

$$E\{R_{H_i,t+1}\} = r + \frac{a}{2}\cdot \sigma_{R_{H_i},R_M}\cdot W_{M,t} + \frac{a}{2}\cdot \left[\sigma_{R_{H_i},R_M} - \sigma_{G,R_{H_i}}^{T}\left(\sigma_{G,G}\right)^{-1}\sigma_{G,R_M}\right]\cdot W_{M,t} \tag{O2.6}$$

Expanding $\sigma_{G,M}^{T}\left(\sigma_{G,G}\right)^{-1}\sigma_{G,M}$ by $diag(P_G)\ diag(P_G)^{-1}(diag(P_G)\ diag(P_G)^{-1})^{-1}$ leads to

(O2.7)

$$E\{R_{H_i,t+1}\} = r + \frac{a}{2}\cdot\sigma_{R_{H_i},R_M}\cdot W_{M,t} + \frac{a}{2}\cdot\left[\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^{T}\left(\sigma_{R_G,R_G}\right)^{-1}\sigma_{R_G,R_M}\right]\cdot W_{M,t}$$

In a last step, (O2.4) is expressed in return form. To that end, it is expanded by $\frac{W_{M,t}}{W_{M,t}}\cdot\frac{W_{M,t}}{W_{M,t}}$ and $\sigma_{G,M}^{T}\left(\sigma_{G,G}\right)^{-1}\sigma_{G,M}$ by $diag(P_G)\ diag(P_G)^{-1}(diag(P_G)\ diag(P_G)^{-1})^{-1}$ to obtain

(O2.8)

$$\frac{a}{2} = \frac{E\{R_{M,t+1} - r\}}{2\cdot\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^{T}\left(\sigma_{R_G,R_G}\right)^{-1}\sigma_{R_G,R_M}}\cdot\frac{1}{W_{M,t}}$$

Plugging (O2.8) into (O2.6) and (O2.7) finally delivers

Cost of capital for ESG stock G_i

(O2.9)

$$E\{R_{G_i,t+1}\} = r + \frac{\sigma_{R_{G_i},R_M}}{2\cdot\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^{T}\left(\sigma_{R_G,R_G}\right)^{-1}\sigma_{R_G,R_M}}\cdot E\{R_{M,t+1} - r\}$$

Cost of capital for non-ESG stock H_i

(O2.10)

$$E\{R_{H_i,t+1}\} = r + \frac{2\cdot\sigma_{R_{H_i},R_M} - \sigma_{R_G,R_{H_i}}^{T}\left(\sigma_{R_G,R_G}\right)^{-1}\sigma_{R_G,R_M}}{2\cdot\sigma_{R_M,R_M} - \sigma_{R_G,R_M}^{T}\left(\sigma_{R_G,R_G}\right)^{-1}\sigma_{R_G,R_M}}\cdot E\{R_{M,t+1} - r\}$$

Expressing (O2.9) and (O2.10) in sample form yields (13) and (14).

Online 3 ESG rating methodologies

Online 3.1 Thomson Reuters S&P 500 ESG Score

Source: https://www.refinitiv.com/en/sustainable-finance/esg-scores

Description: ESG Combined Score Grade (ESGC) provides a rounded and comprehensive scoring of a company's ESG performance based on the reported information pertaining to the ESG pillars, with the ESG controversies overlay captured from global media sources. The main objective of this score is to discount the ESG performance score based on negative media stories. It does this by incorporating the impact of significant, material ESG controversies in the overall ESGC score. When companies are involved in ESG controversies, the ESGC score is calculated as the weighted average of the ESG scores and ESG controversies score per fiscal period, with recent controversies reflected in the latest completed period. When companies are not involved in ESG controversies, the ESGC score is equal to the ESG score.

Statistics for our data set:

ESG Combined Score	Number of Stocks per Score
A+	1
A	18
A-	35
B+	58
B	47
B-	50
C+	114
C	132
C-	34
D+	14

Table 21: Statistics of available stocks per score for Thomson Reuters S&P ESG Combined Score

Filtering type: Scores companies based on reported information on ESG pillars. Since we select the top 2 levels of score, we are conducting positive screening.

Tested data sets: We construct two data sets out of this rating:

Thomson Reuters ESG Combined Score A and better (19 stocks)

Thomson Reuters ESG Combined Score A- and better (54 stocks)

Online 3.2 MSCI KLD 400 Social Index

Source: https://www.msci.com/documents/10199/904492e6-527e-4d64-9904-c710bf1533c6

Description: The MSCI KLD 400 Social Index is a capitalization weighted index of 400 US securities that provides exposure to companies with outstanding Environmental, Social, and Governance (ESG) ratings and excludes companies whose products have negative social or environmental impacts. The parent index is MSCI USA IMI, an equity index of large, mid, and small cap companies. Launched in May 1990 as the Domini 400 Social Index, it is one of the first ESG indexes. Constituent selection is based on data from MSCI ESG Research.

The MSCI KLD 400 Social Index is maintained in two stages. First, securities of companies involved in Nuclear Power, Tobacco, Alcohol, Gambling, Military Weapons, Civilian Firearms, GMOs, and Adult Entertainment are excluded. Then additions are made from the list of eligible companies based on considerations of ESG performance, sector alignment, and size representation. The MSCI KLD 400 Social Index is designed to maintain similar sector weights as the MSCI USA Index and targets a minimum of 200 large and mid-cap constituents. Companies that are not existing constituents of The MSCI KLD 400 Social Index must have an MSCI ESG Rating above 'BB' and the MSCI ESG Controversies Score greater than 2 to be eligible. At each quarterly Index Review, constituents are deleted if they are deleted from the MSCI USA IMI Index, fail the exclusion screens, or if their ESG ratings or scores fall below minimum standards. Additions are made to restore the number of constituents to 400. All eligible securities of each issuer are included in the index, so the index may have more than 400 securities. The Index is float-adjusted market capitalization weighted. It is rebalanced at the regular Semi-Annual and Quarterly Index Reviews in May, August, November, and February.

Statistics for our data set: From the available 402 stocks in the MSCI KLD 400 Social Index, price data covering the analysis period was only found for 350 stocks. From these, only 231 overlap with the S&P 500 stocks – since the MSCI KLD 400 Social Index is primarily based on the MSCI USA Investable Market Index (IMI) Index (consists of over 2,000 stocks) and not the S&P 500.

Filtering type: This is a filtered index, i.e., there are no stock-specific ESG ratings. Instead all constituents are considered “ESG” at the same rating level. It selects companies with outstanding ESG ratings and excludes companies that have negative social or environmental impacts. This is considered a mixed filtering approach: first negative screening to exclude specific industries, then additions are made from those with an MSCI ESG rating above BB and Controversies score above 2 to be eligible. This second step is positive filtering.

Tested data set: MSCI KLD 400 Social Index (231 stocks)

Online 3.3 MSCI USA ESG Select Rating & Trend Leaders Index

Source: https://www.msci.com/eqb/methodology/meth_docs/MSCI_Select_Ratings_and_Trend_Leaders_Dec2020.pdf

Description: The MSCI USA Select ESG Rating and Trend Leaders Index is based on the parent index, MSCI USA Index and includes large and mid-cap stocks of the US market. Overall the Index targets coverage of 50% of the underlying MSCI USA Index.

The MSCI USA Select ESG Rating and Trend Leaders Index is designed to represent the performance of companies that have a robust ESG profile as well as a positive trend in improving that profile. The index uses sector weights that reflect the relative sector weights of the underlying index to limit lack of diversification introduced by the ESG selection process. MSCI ESG Ratings provides an overall company ESG rating—a seven-point scale from "AAA" to "CCC"—together with scores and percentiles indicating how well a company manages each key issue relative to industry peers. The MSCI USA Select ESG Rating and Trend Leaders Index ("regional index") targets 50% of the free float-adjusted market capitalization within each Global Industry Classification Standard (GICS) sector of the underlying MSCI Parent Index. The index is reconstituted on an annual basis in May to coincide with the May Semi-Annual Index Review of the parent index and the changes are implemented at the end of May.

Statistics for our data set: From the available 325 stocks in the MSCI USA Select ESG & Trend Leaders Index, price data covering the analysis period was only found for 281 stocks. From these, only 239 overlap with the S&P 500 stocks—since the MSCI USA Select ESG & Trend Leaders Index is primarily based on the MSCI USA Index (consists of over 600 stocks) and not the S&P 500.

Filtering type: This is a filtered index, i.e., there are no stock-specific ESG ratings. Instead all constituents are considered "ESG" at the same rating level. It begins by eliminating controversial business sectors, then ranks companies and takes the highest two ratings AAA and AA (while keeping in mind to include all possible sectors to maintain a diverse index—thus some companies may be included even if below AA, to ensure their sector is represented). Thus, is employs a mixed approach regarding positive and negative screening.

Tested data set: MSCI USA Select ESG & Trend Leaders index (239 stocks)

Online 3.4 Refinitiv/S-Network ESG Best Practices US Large Cap

Source: https://snetworkglobalindexes.com/presentation/Files/rsnesg-indices-rule-book.pdf

Description: The Refinitiv/S-Network ESG Best Practices Indices (RSNESGI) are a family of indices based on the Refinitiv/S-Network ESG Best Practices Scores ("RSNESG Ratings"), a rating system that evaluates the environmental, social, and corporate governance practices of over 5,000 companies worldwide. Using the RSNESG Ratings derived from the ASSET4 database, half of the companies from each of the ten Thomson Reuters Business Classification (TRBC) sectors of the underlying indices are included. Companies which have the highest RSNESG Ratings in the relevant category are selected for inclusion in the relevant RSNESGI. The indices are reconstituted annually on the third Friday of December and rebalanced quarterly on the third Friday of the last month of each calendar quarter. All stocks selected for inclusion are weighted on a hybrid basis. Fifty percent of the weight assigned to each stock within a sector is based on float market capitalization and fifty percent of the weight assigned to each stock within a sector is based on the stocks relevant rating. Weights of stocks within each sector are then modified by the sectors weights of the S-Network 500 US Large-Cap Index. Stocks' weights will be based on prices as of the close of trading on the Thursday prior to the second Friday of the rebalancing month ("The Record Date").

However, for non-ESG stocks such a hybrid weighting cannot be applied since they have no ranking. Refinitiv thus uses a market-cap weighting. For that reason, we do not use hybrid weighting in our sample for ESG stocks as well to maintain an identical weighting procedure for ESG and non-ESG stocks.

Statistics in our data set: From the available 246 stocks in the Refinitiv/S-Network ESG Best Practices Index, price data covering the analysis period was only found for 228 stocks. From these, only 222 overlap with the S&P 500 stocks—since the Refinitiv/S-Network ESG Best Practices Index is primarily based on the S-Network 500 US Large-Cap Index (consists of 500 stocks) and not the S&P 500.

Filtering type: This is a filtered index, i.e., there are no stock-specific ESG ratings. Instead all constituents are considered "ESG" at the same rating level. Since the index only includes companies with highest Reuters criteria, it applies positive screening.

Tested data set: Refinitiv/S-Network ESG Best Practices Index (222 stocks)

Online 3.5 RepRisk

Source: https://www.fundsmith.co.uk/global/sef/sustainability-factsheet

Description: RepRisk Indicator (RRI) uses an algorithm to access the risk of reputational damage to companies from 28 ESG issues and a variety of specific and thematic "hot topics", e.g., coral reef damage, human trafficking, or threats to endangered species. 0-25 denotes low risk exposure, 26-49 medium risk exposure, 50-59 high-risk exposure, 60-74 very high-risk exposure, and 75-100 extremely high-risk exposure.

RRI change is how much the weighted average RRI score has changed in the last 30 days where best/worst performers are the largest movers. Peak RRI score is the highest weighted average RRI score in the last 2 years. RepRisk Rating (RRR) takes the RRI and combines it with the ratings of the countries/sectors it is involved to calculate the rating, which is ranked AAA to D.

Statistics for our data set: Accessed RepRisk Ratings for S&P 500 companies. Ratings obtained for 423 companies.

RepRisk Rating	Number of Stocks per Rating
AAA	3
AA	169
A	107
BBB	44
BB	44
B	30
CCC	23
CC	3
C	0
D	0

Table 22: Statistics for number of stocks per rating for RepRisk Rating

RepRisk Indicator (RRI) Ranges (non-overlapping)	Number of Stocks per Range
≤10	124
≤20	109
≤30	117
≤40	31
≤50	22
≤60	12
≤70	8
≤80	0
≤90	0
≤100	0

Table 23: Statistics for number of stocks per rating for RepRisk Indicator

Filtering type: Given that our paper selects RepRisk's top categories, a positive screening is employed.

Tested data sets:

RepRisk RRI Below or Equal 10 (133 stocks)

RepRisk RRI Below or Equal 30 (354 stocks)

RepRisk Rating A and better (279 stocks)

RepRisk Rating BB and better (367 stocks)

Online 3.6 Sustainalytics

Source: https://connect.sustainalytics.com/esg-risk-ratings-methodology

Description: Sustainalytics ESG Risk Ratings measure a company's exposure to industry-specific material ESG risks and how well a company is managing these risks. This multi-dimensional way of measuring ESG risk combines the concepts of management and exposure to arrive at an absolute assessment of ESG risk. Sustainalytics identifies five categories of ESG risk severity that could impact a company's enterprise value.

Statistics for our data set: Accessed Sustainalytics Ratings for S&P500 companies list. Ratings were collected for 343 companies. Exposure categories for Total ESG Score and Controversies are official labels by Sustainalytics, exposure categories for the sub-categories environment, social, and governance are introduced by the authors of this paper to create a label that parallels the one of total ESG Score.

Exposure Categories	Total ESG Score	Number of stocks at this score range
Negligible	0-<10	1
Low	10-<20	112
Medium	20-<30	161
High	30-<40	65
Severe	40+	4

Table 24: Statistics for number of stocks per exposure category for Sustainalytics Total ESG Score

Exposure Categories	Environment Score	Number of stocks at this score range
Negligible	0-<5	192
Low	5-<10	75
Medium	10-<15	41
High	15-<20	33
Severe	20+	2

Table 25: Statistics for number of stocks per exposure category for Sustainalytics Environment Score

Exposure Categories	Social Score	Number of stocks at this score range
Negligible	0-5	21
Low	5-10	138
Medium	10-15	144
High	15-20	37
Severe	20+	3

Table 26: Statistics for number of stocks per exposure category for Sustainalytics Social Score

Exposure Categories	Governance Score	Number of stocks at this score range
Negligible	0-5	50
Low	5-10	240
Medium	10-15	50
High	15-20	3
Severe	20+	0

Table 27: Statistics for number of stocks per exposure category for Sustainalytics Governance Score

Controversy Categories	Controversy Score	Number of stocks at this score range
No Controversy	0	23
Little Controversy	1	49
Moderate Controversy	2	173
Relatively High Controversy	3	84
Severe Controversy	4	13
Severe Controversy	5	1

Table 28: Statistics for number of stocks per exposure category for Sustainalytics Controversy Score

Filtering type: Given that our paper selects Sustainalytics's top categories, a positive screening is employed.

Tested data sets:

Sustainalytics Total ESG Score Negligible and Low (113 stocks)

Sustainalytics Total ESG Score Negligible, Low and Medium (274 stocks)

Sustainalytics Environment Score Negligible, Low and Medium (308 stocks)

Sustainalytics Social Score Negligible, Low and Medium (303 stocks)

Sustainalytics Governance Score Negligible, Low and Medium (340 stocks)

Sustainalytics Controversy Score No Controversy (23 stocks)

Sustainalytics Controversy Score No and Low Controversy (72 stocks)

Online 3.7 Upright Project

Source: https://www.uprightproject.com/whitepapers/model

Description: The net impact of a company is the net sum of costs and benefits that the company creates. Costs and benefits include all types of costs and benefits—including externalities.

The Upright net impact model measures costs and benefits in four dimensions: environment, health, society, and knowledge. Examples of costs include, e.g., GHG emissions by a car factory, usage of highly-skilled labor by an IT company, and damage to human health caused by sugar-sweetened beverages. Examples of benefits include improvements in health caused by a cancer medicine, knowledge created by research equipment, and pollution removed by a catalytic converter.

Statistics of our data set: From the available 500 stocks in the US Fortune 500 stocks rated by the Upright project, only 279 overlap with the S&P 500 stocks.

Ranges (non-overlapping)	Absolute Net Impact Score	Number of stocks at this range
Min	-7650091.46	1
Mean	-30857.2271	93
0	0	28
Max	3142223.65	157

Table 29: Statistics for number of stocks per range for Upright Absolute Net Impact Score

Ranges (non-overlapping)	Absolute Net Environment Score	Number of stocks at this range
Min	-8884782.07	1
Mean	-264662.019	52
0	0	223
Max	64219.87	3

Table 30: Statistics for number of stocks per range for Upright Absolute Environment Score. Absolute net environment impact score calculated as: absolute positive environment impact score minus absolute negative environment impact score.

Filtering type: Given that our paper selects Upright's top categories, a positive screening is employed.

Tested data sets:

Upright Absolute Net Impact Score Positive Only (157 stocks)

Upright Absolute Net Impact Score Above Average of Positive Only (38 stocks)

Upright Absolute Environment Impact Score Positive Only (3 stocks)

Online 4 Empirical results

Online 4.1 Statistical significance of the special cases

Online 4.1.1 Special case "excess return of the sub-market portfolio of ESG stocks can be explained by the excess return of the market portfolio using the linear factor model (7)"

Table 5a and b: Cramér/von Mises test statistics for cost of capital differences Equation (8) – (3) for ESG stocks and (9) – (4) for non-ESG stocks.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
monthly	6.65 ***	17.33 ***	74.33 ***	80.00 ***	77.33 ***	38.00 ***	91.67 ***	103.00 ***	101.33 ***	113.67 ***	7.98 ***	24.33 ***	52.66 ***	12.99 ***	1.24 ***	44.66 ***	118.33 ***	93.33 ***	122.67 ***
quarterly	6.65 ***	17.33 ***	74.33 ***	79.00 ***	77.33 ***	38.00 ***	90.67 ***	102.00 ***	100.33 ***	112.67 ***	7.98 ***	24.33 ***	51.66 ***	12.99 ***	1.24 ***	44.66 ***	117.33 ***	92.33 ***	121.67 ***
annual	5.65 ***	16.33 ***	65.66 ***	69.46 ***	68.64 ***	34.10 ***	82.00 ***	91.43 ***	85.23 ***	95.67 ***	6.08 ***	21.41 ***	42.37 ***	9.32 ***	1.24 ***	39.82 ***	100.3 ***	78.2 ***	101.93 ***
Non-ESG stocks																			
monthly	64.77 ***	59.58 ***				27.50 ***					43.06 ***	48.19 ***		62.13 ***	48.22 ***	26.67 ***			
quarterly	52.98 ***										38.40 ***			39.57 ***	41.46 ***				
annual															36.75 ***				

Industry portfolios: Cramér/von Mises test statistics																		
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
daily	3.63 ***	5.98 ***	9.32 ***	9.32 ***	9.32 ***	6.98 ***	9.32 ***	9.65 ***	9.32 ***	9.65 ***	3.29 ***	7.31 ***	7.31 ***	3.63 ***	1.07 **	7.98 ***	9.65 ***	9.32 ***	9.65 ***
monthly	3.63 ***	5.98 ***	9.32 ***	9.32 ***	9.32 ***	6.98 ***	9.32 ***	9.65 ***	9.32 ***	9.65 ***	3.29 ***	7.31 ***	7.31 ***	3.63 ***	1.07 **	7.98 ***	9.65 ***	9.32 ***	9.65 ***
quarterly	3.63 ***	5.98 ***	9.32 ***	9.32 ***	9.32 ***	6.98 ***	9.32 ***	9.65 ***	9.32 ***	9.65 ***	3.29 ***	7.31 ***	7.31 ***	3.63 ***	1.07 **	7.98 ***	9.65 ***	9.32 ***	9.65 ***
annual	3.63 ***	5.98 ***	9.32 ***	8.32 ***	9.32 ***	6.98 ***	9.32 ***	9.65 ***	9.32 ***	9.65 ***	1.56 ***	5.42 ***	7.31 ***	2.64 ***	1.07 **	6.98 ***	9.65 ***	9.32 ***	9.65 ***
Non-ESG stocks																			
daily	5.06 ***	3.48 ***	2.41 ***	3.48 ***	3.48 ***	2.57 ***	6.88 ***	7.40 ***	2.59 ***	7.99 ***	2.92 ***	3.21 ***	8.06 ***	8.06 ***	5.06 ***	3.57 ***	2.54 ***	2.87 ***	2.33 ***
monthly	5.06 ***	3.48 ***	2.33 ***	3.48 ***	2.41 ***	2.71 ***	5.40 ***	3.94 ***	2.59 ***	3.67 ***	2.71 ***	2.71 ***	7.20 ***	6.42 ***	3.99 ***	3.57 ***	2.27 ***	2.87 ***	2.09 ***
quarterly	5.06 ***	3.94 ***	2.56 ***	2.41***	2.33 ***	2.50 ***	2.99 ***	2.33 ***	2.39 ***	2.87 ***	2.57 ***	3.21 ***	3.57 ***	7.20 ***	3.21 ***	3.21 ***	2.09 ***	2.39 ***	1.95 ***
annual	3.57 ***							3.48 ***	7.99 ***	3.23 ***	3.21 ***			2.50 ***	2.92 ***				

Online 4.1.2 Special case “there is just one ESG stock”

Table 6a and b: Cramér/von Mises test statistics for cost of capital differences Equation (11) – (3) for ESG stocks and (12) – (4) for non-ESG stocks.
Equation (12) is only illustrated for the case that United Rentals is the “only” ESG stock; United Rentals is contained in a maximum number of data sets.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
monthly	2.32 ***	5.17 ***	19.74 ***	21.29 ***	21.53 ***	10.89 ***	24.53 ***	26.58 ***	27.01 ***	29.37 ***	1.99 ***	6.58 ***	14.33 ***	3.67 ***	0.36 (sig. at 10%)	11.39 ***	30.83 ***	24.09 ***	32.05 ***
quarterly	1.99 ***	5.17 ***	21.19 ***	21.29 ***	21.53 ***	12.89 ***	25.79 ***	28.30 ***	28.21 ***	30.41 ***	1.99 ***	6.43 ***	15.36 ***	4.97 ***	0.36 (sig. at 10%)	12.54 ***	30.95 ***	24.09 ***	32.44 ***
annual	1.99 ***	5.17 ***	21.64 ***	23.65 ***	25.78 ***	11.12 ***	27.40 ***	29.97 ***	29.50 ***	32.68 ***	1.99 ***	6.98 ***	15.60 ***	4.21 ***	0.36 (sig. at 10%)	11.39 ***	31.50 ***	24.20 ***	32.17 ***

Single stocks: Cramér/von Mises test statistics																		
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
Non-ESG stocks																		
monthly	United Rentals not contained in data set	United Rentals not contained in data set				27.46 ***					United Rentals not contained in data set	48.18 ***	25.62 ***	United Rentals not contained in data set	50.63 ***	26.66 ***			
quarterly	United Rentals not contained in data set	United Rentals not contained in data set									United Rentals not contained in data set			United Rentals not contained in data set	41.45 ***				
annual	United Rentals not contained in data set	United Rentals not contained in data set									United Rentals not contained in data set			United Rentals not contained in data set	36.80 ***				

Industry portfolios: Cramér/von Mises test statistics																		
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
daily	1.32 ***	1.87 ***	2.33 ***	3.10 ***	2.56 ***	1.94 ***	2.56 ***	2.44 ***	2.33 ***	2.44 ***	0.82 *	1.83 ***	2.83 ***	0.99 **	†	2.09 ***	2.55 ***	2.41 ***	2.55 ***
monthly	1.32 ***	1.87 ***	2.41 ***	2.56 ***	2.41 ***	1.78 ***	2.33 ***	2.44 ***	2.33 ***	2.40 ***	0.82 *	1.83 ***	2.13 ***	0.88 **	†	1.99 ***	2.55 ***	2.41 ***	2.55 ***
quarterly	0.99 **	1.62 ***	2.79 ***	2.41 ***	2.56 ***	1.94 ***	2.33 ***	2.44 ***	2.41 ***	2.44 ***	0.82 *	1.83 ***	2.83 ***	0.99 **	†	1.99 ***	2.55 ***	2.33 ***	2.40 ***
annual	1.32 ***	1.87 ***	3.48 ***	3.94 ***	3.48 ***	2.57 ***	3.48 ***	3.33 ***	3.48 ***	3.33 ***	0.82 *	2.13 ***	2.83 ***	0.99 **	†	2.09 ***	2.99 ***	2.56 ***	2.74 ***
Non-ESG stocks																			
daily	5.06 ***	3.94 ***	2.78 ***	3.09 ***	3.94 ***	2.92 ***	6.87 ***	8.32 ***	4.79 ***	8.98 ***	3.20 ***	3.20 ***	8.06 ***	8.98 ***	†	2.92 ***	1.99 ***	2.27 ***	2.08 ***
monthly	4.49 ***	2.32 ***	2.78 ***	2.40 ***	2.55 ***	2.56 ***	4.77 ***	4.47 ***	3.23 ***	4.19 ***	2.92 ***	3.20 ***	5.70 ***	5.06 ***	†	2.56 ***	1.99 ***	2.23 ***	1.89 ***
quarterly	5.06 ***	3.94 ***	2.55 ***	2.32 ***	2.40 ***	2.92 ***	2.99 ***	2.55 ***	2.27 ***	2.59 ***	2.49 ***	2.70 ***	5.70 ***	5.06 ***	†	2.49 ***	1.99 ***	2.39 ***	2.08 ***
annual	3.56***										2.92 ***			3.20 ***	†				

Online 4.2 Statistical significance of empirical and theory-based capital cost

Online 4.2.1 Models with different factor loadings (but identical factors)

Table 7a and b: Cramér/von Mises test statistics for cost of capital differences Equation (5) – (3) for ESG stocks and (6) – (4) for non-ESG stocks.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
monthly	2.32 ***	5.17 ***	28.16 ***	22.52 ***	25.45 ***	29.64 ***	55.28 ***	51.55 ***	53.05 ***	53.38 ***	2.54 ***	6.98 ***	32.91 ***	9.32 ***	0.36 (sig. at 10%)	11.26 ***	29.68 ***	24.84 ***	32.17 ***
quarterly	1.77 ***	5.45 ***	24.12 ***	27.23 ***	29.56 ***	20.75 ***	43.52 ***	37.87 ***	38.68 ***	46.36 ***	1.99 ***	6.77 ***	30.83 ***	7.80 ***	0.36 (sig. at 10%)	11.26 ***	29.99 ***	23.44 ***	30.72 ***
annual	1.77 ***	4.45 ***	29.01 ***	27.59 ***	31.78 ***	17.27 ***	25.79 ***	28.88 ***	29.51 ***	28.71 ***	2.09 ***	6.98 ***	18.37 ***	7.13 ***	0.36 (sig. at 10%)	12.35 ***	29.63 ***	24.31 ***	31.41 ***
Non-ESG stocks																			
monthly	47.34 ***	43.22 ***				33.68 ***					42.24 ***	39.60 ***		34.14 ***	36.98 ***	26.03 ***			
quarterly	37.24 ***										36.16 ***			34.48 ***	36.92 ***				
annual															37.12 ***				

Industry portfolios: Cramér/von Mises test statistics																		
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
daily	1.32 ***	1.87 ***	6.55 ***	4.48 ***	6.55 ***	5.09 ***	5.79 ***	4.22 ***	6.55 ***	5.40 ***	1.56 ***	3.92 ***	4.62 ***	1.32 ***	†	3.90 ***	2.44 ***	2.41 ***	2.40 ***
monthly	0.99 **	1.87 ***	5.09 ***	3.48 ***	2.56 ***	5.09 ***	5.79 ***	4.77 ***	5.09 ***	6.10 ***	1.56 ***	3.32 ***	4.62 ***	1.32 ***	†	2.27 ***	2.99 ***	2.41 ***	2.44 ***
quarterly	1.32 ***	1.87 ***	5.09 ***	2.56 ***	2.79 ***	4.30 ***	5.09 ***	4.77 ***	4.48 ***	6.10 ***	0.82 *	2.13 ***	4.62 ***	1.32 ***	†	1.99 ***	2.40 ***	2.41 ***	2.55 ***
annual	0.99 **	1.62 ***	4.48 ***	3.10 ***	4.48 ***	3.04 ***	2.33 ***	3.33 ***	2.56 ***	2.40 ***	0.82 *	2.43 ***	3.92 ***	1.32 ***	†	2.54 ***	2.74 ***	2.33 ***	2.44 ***
Non-ESG stocks																			
daily	2.92 ***	3.10 ***	5.09 ***	3.10 ***	5.79 ***	3.99 ***	3.33 ***	3.10 ***	2.87 ***	3.23 ***	3.21 ***	5.71 ***	2.92 ***	2.71 ***	†	2.92 ***	3.36 ***	2.87 ***	2.66 ***
monthly	3.21 ***	2.33 ***	4.48 ***	2.79 ***	3.10 ***	3.21 ***	2.40 ***	2.41 ***	2.39 ***	2.59 ***	2.57 ***	3.99 ***	3.21 ***	2.57 ***	†	2.57 ***	1.99 ***	2.27 ***	1.90 ***
quarterly	3.57 ***	2.33 ***	3.10 ***	2.3 3***	2.41 ***	5.06 ***	2.99 ***	3.10 ***	3.67 ***	3.23 ***	2.50 ***	3.21 ***	2.50 ***	2.57 ***	†	2.50 ***	2.09 ***	2.59 ***	1.95 ***
annual	3.57 ***										3.21 ***			2.50 ***	†				

Online 4.2.2 Models with different factors and factor loadings

Table 8a and b: Cramér/von Mises test statistics for cost of capital differences Equation (15) – (3) for ESG stocks and (16) – (4) for non-ESG stocks.
Critical values according to Stephens (1986: 105) for the modified Cramér/von Mises test statistic $T = \left(W^2 - \frac{0.4}{n} + \frac{0.6}{n^2}\right) \cdot \left(1 + \frac{1}{n}\right)$: 1.167 significance 0.1% (***), 0.869 significance 0.05% (**), 0.743 significance 1% (*).
† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Single stocks: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
monthly	5.65 ***	7.97 ***	22.13 ***	31.58 ***	23.38 ***	32.27 ***	51.93 ***	53.32 ***	44.21 ***	50.74 ***	6.96 ***	22.36 ***	25.86 ***	6.51 ***	1.24 ***	26.85 ***	78.20 ***	50.87 ***	75.78 ***
quarterly	5.65 ***	8.53 ***	40.12 ***	20.05 ***	25.12 ***	29.64 ***	44.63 ***	42.17 ***	37.86 ***	38.34 ***	6.98 ***	16.34 ***	19.93 ***	5.43 ***	1.24 ***	20.71 ***	53.56 ***	43.30 ***	65.86 ***
annual	2.77 ***	5.77 ***	27.74 ***	39.14 ***	36.86 ***	23.43 ***	48.76 ***	52.72 ***	54.90 ***	52.31 ***	2.09 ***	7.22 ***	30.17 ***	7.13 ***	1.24 ***	17.76 ***	49.10 ***	39.24 ***	53.04 ***
Non-ESG stocks																			
monthly	41.24 ***	38.31 ***				34.25 ***					48.17 ***	44.10 ***		34.00 ***	53.27 ***	31.29 ***			
quarterly	49.47 ***										43.06 ***			33.83 ***	45.75 ***				
annual															65.53 ***				

Industry portfolios: Cramér/von Mises test statistics																			
	Thomson Reuters ESG Combined Score A and better	Thomson Reuters ESG Combined Score A- and better	Refinitiv/S-Network ESG Best Practices Index	MSCI KLD 400 Social Index	MSCI USA Select ESG & Trend Leaders index	Sustainalytics Total ESG Score Negligible and Low	Sustainalytics Total ESG Score Negligible, Low and Medium	Sustainalytics Environment Score Negligible, Low and Medium	Sustainalytics Social Score Negligible, Low and Medium	Sustainalytics Governance Score Negligible, Low and Medium	Sustainalytics Controversy Score No Controversy	Sustainalytics Controversy Score No and Low Controversy	Upright Absolute Net Impact Score Positive Only	Upright Absolute Net Impact Score Above Average of Positive Only	Upright Absolute Environment Impact Score Positive Only	RepRisk RRI Below or Equal 10	RepRisk RRI Below or Equal 30	RepRisk Rating A and better	RepRisk Rating BB and better
ESG stocks																			
daily	3.63 ***	5.98 ***	7.40 ***	2.56 ***	3.1 ***	6.99 ***	5.10 ***	4.22 ***	2.33 ***	2.41 ***	3.30 ***	7.32 ***	2.43 ***	1.32 ***	†	2.54 ***	4.78 ***	2.41 ***	3.74 ***
monthly	3.63 ***	4.11 ***	2.56 ***	3.49 ***	3.49 ***	4.31 ***	3.49 ***	3.00 ***	3.49 ***	3.33 ***	3.30 ***	7.32 ***	2.13 ***	0.99 ***	†	4.54 ***	6.88 ***	4.48 ***	4.78 ***
quarterly	3.63 ***	2.74 ***	6.56 ***	2.33 ***	3.95 ***	4.31 ***	4.48 ***	3.00 ***	2.33 ***	2.44 ***	3.30 ***	5.42 ***	1.93 ***	0.88 ***	†	2.54 ***	2.44 ***	3.95 ***	4.78 ***
annual	2.64 ***	2.25 ***	3.95 ***	5.1 ***	5.1 ***	5.10 ***	5.10 ***	4.22 ***	5.79 ***	4.22 ***	1.57 ***	2.43 ***	3.93 ***	1.32 ***	†	2.54 ***	3.33 ***	3.95 ***	4.22 ***
Non-ESG stocks																			
daily	6.42 ***	3.95 ***	2.41 ***	2.56 ***	2.41 ***	2.50 ***	3.33 ***	4.48 ***	3.24 ***	3.24 ***	2.50 ***	2.93 ***	2.71 ***	3.21 ***	†	2.5 ***	2.27 ***	2.40 ***	2.09 ***
monthly	2.71 ***	2.41 ***	3.1 ***	3.1 ***	2.33 ***	2.57 ***	5.40 ***	3.95 ***	3.24 ***	2.40 ***	3.21 ***	2.93 ***	4.50 ***	2.50 ***	†	2.71 ***	2.54 ***	2.24 ***	1.95 ***
quarterly	2.57 ***	2.56 ***	3.49 ***	2.79 ***	3.1 ***	2.71 ***	2.44 ***	5.10 ***	5.48 ***	2.40 ***	2.93 ***	9.99 ***	2.71 ***	2.71 ***	†	2.93 ***	2.27 ***	2.60 ***	2.33 ***
annual	2.50 ***										2.93 ***			5.07 ***	†				

Online 4.3 Economic significance of differences between regression- and theory-based cost of capital

Online 4.3.1 Models with different factor loadings (but identical factors)

Table 9 a to g: Percentage of stocks in a data set where the (positive or negative) cost of capital difference Equation (5) – (3) for ESG stocks and (6) – (4) for non-ESG stocks is greater than the benchmark fitted to the respective investment horizon. Formally,

$$|(5) - (3)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

and

$$|(6) - (4)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Single stock: monthly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	100 %	100 %	85%	100 %	77%	67%	54%	33%	46%	17%	46%	99%	99%	95%	96%	87%	91%	74%	69%	63%	54%	55%	40%
Thomson Reuters ESG Combined Score A- and better	84%	100 %	84%	97%	79%	91%	63%	75%	47%	66%	32%	50%	97%	95%	91%	79%	78%	54%	53%	29%	29%	18%	14%	9%
Refinitiv/S-Network ESG Best Practices Index	91%	95%	75%	87%	57%	64%	28%	25%	9%	4%	2%	0%												
MSCI KLD 400 Social Index	72%	85%	47%	66%	22%	48%	4%	18%	0%	7%	0%	3%												
MSCI USA Select ESG & Trend Leaders index	85%	92%	64%	82%	35%	57%	4%	21%	2%	10%	0%	4%												
Sustainalytics Total ESG Score Negligible and Low	100 %	100 %	100 %	99%	100 %	95%	89%	88%	67%	81%	44%	70%	100 %	100 %	100 %	100 %	97%	98%	97%	97%	97%	96%	92%	94%
Sustainalytics Total ESG Score Negligible, Low and Medium	79%	97%	58%	87%	42%	67%	12%	30%	7%	6%	7%	2%												
Sustainalytics Environment Score Negligible, Low and Medium	82%	89%	57%	67%	25%	40%	6%	5%	3%	2%	0%	1%												
Sustainalytics Social Score Negligible, Low and Medium	82%	95%	48%	81%	23%	57%	10%	16%	5%	3%	3%	1%												
Sustainalytics Governance Score Negligible, Low and Medium	69%	84%	26%	53%	6%	11%	0%	2%	0%	0%	0%	0%												
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	100 %	100 %	100 %	100 %	87%	100 %	80%	88%	73%	84%	89%	60%	73%	25%	52%	6%	19%	1%	5%	1%	2%
Sustainalytics Controversy Score No and Low Controversy	93%	98%	82%	93%	79%	89%	57%	77%	54%	64%	46%	52%	90%	94%	73%	83%	49%	65%	30%	35%	16%	12%	7%	4%
Upright Absolute Net Impact Score Positive Only	96%	99%	70%	97%	48%	86%	26%	60%	17%	37%	9%	22%												
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	97%	100 %	94%	100 %	91%	75%	85%	75%	74%	75%	65%	96%	99%	91%	94%	85%	85%	67%	73%	48%	59%	39%	44%
Upright Absolute Environment Impact Score Positive Only	100 %	100 %	100 %	100 %	100 %	100 %	100 %	50%	100 %	50%	100 %	50%	89%	93%	79%	85%	67%	72%	37%	45%	11%	22%	1%	13%
RepRisk RRI Below or Equal 10	100 %	94%	84%	94%	75%	86%	60%	67%	46%	50%	33%	40%	99%	97%	94%	90%	77%	77%	57%	55%	38%	38%	25%	27%
RepRisk RRI Below or Equal 30	93%	91%	84%	83%	61%	65%	33%	39%	14%	19%	4%	10%												
RepRisk Rating A and better	93%	94%	80%	87%	65%	70%	39%	40%	21%	21%	14%	13%												
RepRisk Rating BB and better	93%	92%	83%	77%	60%	62%	27%	25%	14%	11%	5%	4%												

Single stock: quarterly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	100 %	75%	100 %	63%	100 %	63%	73%	63%	73%	50%	64%	98%	99%	97%	98%	95%	97%	90%	88%	86%	81%	82%	74%
Thomson Reuters ESG Combined Score A- and better	94%	97%	89%	94%	67%	91%	67%	79%	56%	67%	50%	52%												
Refinitiv/S-Network ESG Best Practices Index	92%	97%	80%	93%	59%	82%	34%	54%	21%	36%	12%	18%												
MSCI KLD 400 Social Index	85%	98%	70%	95%	52%	87%	34%	65%	21%	46%	10%	30%												
MSCI USA Select ESG & Trend Leaders index	88%	98%	79%	96%	65%	82%	36%	60%	15%	43%	13%	31%												
Sustainalytics Total ESG Score Negligible and Low	100 %	99%	95%	98%	86%	93%	67%	91%	52%	90%	48%	86%												
Sustainalytics Total ESG Score Negligible, Low and Medium	84%	97%	76%	90%	63%	75%	32%	54%	15%	34%	6%	19%												
Sustainalytics Environment Score Negligible, Low and Medium	85%	95%	63%	84%	38%	61%	17%	27%	3%	10%	1%	3%												
Sustainalytics Social Score Negligible, Low and Medium	94%	93%	77%	87%	61%	75%	31%	47%	16%	26%	6%	13%												
Sustainalytics Governance Score Negligible, Low and Medium	72%	82%	42%	60%	16%	24%	2%	2%	0%	0%	0%	0%												
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	100 %	91%	100 %	91%	100 %	91%	100 %	82%	83%	97%	98%	92%	91%	81%	82%	64%	69%	51%	55%	37%	40%
Sustainalytics Controversy Score No and Low Controversy	93%	100 %	93%	100 %	90%	93%	79%	93%	76%	84%	66%	77%												
Upright Absolute Net Impact Score Positive Only	96%	99%	85%	97%	58%	93%	42%	83%	27%	69%	15%	50%												
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	100 %	83%	100 %	83%	100 %	83%	100 %	67%	100 %	67%	94%	98%	98%	95%	97%	93%	95%	84%	88%	74%	81%	65%	73%
Upright Absolute Environment Impact Score Positive Only	100 %	100 %	100 %	100 %	100 %	100 %	100 %	50%	100 %	50%	100 %	50%	92%	89%	79%	78%	54%	54%	17%	21%	3%	13%	2%	5%
RepRisk RRI Below or Equal 10	100 %	96%	94%	93%	87%	91%	75%	80%	65%	70%	59%	63%												
RepRisk RRI Below or Equal 30	97%	97%	90%	94%	85%	90%	75%	75%	61%	62%	47%	49%												
RepRisk Rating A and better	99%	95%	96%	90%	81%	84%	66%	68%	56%	53%	43%	37%												
RepRisk Rating BB and better	95%	98%	90%	94%	83%	87%	66%	72%	55%	52%	40%	42%												

Single stock: annual investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100%	100%	100%	88%	91%	88%	73%	75%	36%	75%	18%	75%												
Thomson Reuters ESG Combined Score A- and better	96%	96%	79%	91%	75%	87%	71%	83%	64%	70%	43%	65%												
Refinitiv/S-Network ESG Best Practices Index	97%	99%	92%	94%	73%	82%	43%	65%	33%	51%	24%	37%												
MSCI KLD 400 Social Index	85%	93%	81%	85%	66%	72%	39%	51%	19%	33%	10%	27%												
MSCI USA Select ESG & Trend Leaders index	92%	93%	79%	87%	56%	72%	32%	54%	25%	39%	10%	24%												
Sustainalytics Total ESG Score Negligible and Low	93%	100%	93%	100%	89%	95%	74%	92%	59%	90%	56%	74%												
Sustainalytics Total ESG Score Negligible, Low and Medium	93%	93%	81%	82%	52%	73%	28%	50%	15%	32%	4%	18%												
Sustainalytics Environment Score Negligible, Low and Medium	84%	89%	67%	75%	46%	57%	14%	30%	3%	14%	0%	7%												
Sustainalytics Social Score Negligible, Low and Medium	86%	93%	65%	80%	35%	58%	15%	28%	3%	11%	1%	5%												
Sustainalytics Governance Score Negligible, Low and Medium	83%	86%	64%	67%	35%	44%	9%	19%	2%	11%	0%	6%												
Sustainalytics Controversy Score No Controversy	100%	100%	85%	100%	77%	100%	62%	100%	54%	80%	38%	70%												
Sustainalytics Controversy Score No and Low Controversy	93%	98%	86%	95%	75%	91%	61%	68%	43%	48%	25%	32%												
Upright Absolute Net Impact Score Positive Only	94%	97%	88%	94%	72%	84%	56%	75%	44%	60%	30%	47%												
Upright Absolute Net Impact Score Above Average of Positive Only	100%	100%	86%	100%	86%	97%	86%	97%	86%	84%	86%	81%												
Upright Absolute Environment Impact Score Positive Only	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	93%	94%	82%	86%	64%	75%	39%	54%	19%	35%	10%	24%
RepRisk RRI Below or Equal 10	98%	99%	93%	95%	87%	87%	76%	71%	52%	59%	43%	44%												
RepRisk RRI Below or Equal 30	96%	93%	87%	79%	70%	62%	45%	38%	27%	20%	16%	13%												
RepRisk Rating A and better	96%	93%	90%	82%	81%	68%	57%	43%	39%	28%	24%	18%												
RepRisk Rating BB and better	96%	96%	90%	89%	76%	75%	52%	58%	40%	39%	31%	26%												

Industry portfolio: daily investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	86%	67%	86%	67%	71%	33%	29%	33%	14%	33%	14%	61%	73%	39%	27%	11%	9%	0%	9%	0%	0%	0%	0%
Thomson Reuters ESG Combined Score A- and better	83%	100 %	83%	100 %	50%	82%	33%	18%	17%	9%	17%	0%	67%	44%	39%	11%	0%	0%	0%	0%	0%	0%	0%	0%
Refinitiv/S-Network ESG Best Practices Index	67%	79%	67%	38%	33%	4%	0%	0%	0%	0%	0%	0%	95%	100 %	91%	100 %	64%	100 %	23%	20%	5%	20%	5%	0%
MSCI KLD 400 Social Index	100 %	88%	67%	50%	33%	4%	0%	0%	0%	0%	0%	0%	91%	100 %	65%	50%	26%	50%	4%	25%	0%	0%	0%	0%
MSCI USA Select ESG & Trend Leaders index	33%	81%	17%	43%	17%	5%	0%	0%	0%	0%	0%	0%	56%	22%	17%	22%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Total ESG Score Negligible and Low	100 %	100 %	100 %	100 %	100 %	100 %	50%	89%	50%	61%	50%	33%	100 %	100 %	100 %	100 %	88%	100 %	50%	71%	25%	67%	25%	57%
Sustainalytics Total ESG Score Negligible, Low and Medium	75%	100 %	75%	78%	50%	43%	0%	9%	0%	0%	0%	0%	100 %	100 %	100 %	95%	89%	89%	78%	79%	44%	58%	44%	47%
Sustainalytics Environment Score Negligible, Low and Medium	43%	86%	43%	52%	0%	19%	0%	5%	0%	0%	0%	0%	89%	100 %	89%	94%	89%	89%	78%	61%	56%	61%	44%	39%
Sustainalytics Social Score Negligible, Low and Medium	100 %	92%	100 %	58%	33%	13%	0%	0%	0%	0%	0%	0%	89%	100 %	78%	94%	44%	82%	11%	29%	11%	0%	11%	0%
Sustainalytics Governance Score Negligible, Low and Medium	60%	61%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	100 %	100 %	100 %	100 %	100 %	78%	63%	50%	50%	33%	25%	28%
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	100 %	100 %	100 %	50%	86%	50%	86%	50%	71%	20%	47%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	100 %	100 %	100 %	94%	75%	76%	50%	41%	50%	24%	0%	0%	80%	71%	40%	21%	20%	4%	0%	0%	0%	0%	0%	0%
Upright Absolute Net Impact Score Positive Only	100 %	100 %	100 %	100 %	100 %	72%	0%	28%	0%	11%	0%	0%	100 %	100 %	100 %	89%	73%	72%	27%	33%	18%	17%	18%	0%
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	100 %	100 %	100 %	100 %	100 %	67%	100 %	67%	71%	33%	43%	88%	75%	82%	50%	53%	33%	18%	25%	6%	8%	0%	8%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	60%	94%	60%	83%	60%	22%	20%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 30	69%	60%	23%	13%	0%	7%	0%	0%	0%	0%	0%	0%	6%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk Rating A and better	83%	80%	42%	33%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk Rating BB and better	64%	36%	14%	7%	0%	7%	0%	0%	0%	0%	0%	0%	20%	14%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Industry portfolio: monthly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100%	100%	100%	100%	100%	83%	50%	67%	25%	50%	25%	33%	95%	95%	84%	84%	79%	79%	42%	42%	21%	21%	16%	16%
Thomson Reuters ESG Combined Score A- and better	100%	100%	67%	100%	67%	82%	67%	73%	50%	55%	50%	45%	86%	86%	64%	64%	57%	57%	14%	14%	0%	0%	0%	0%
Refinitiv/S-Network ESG Best Practices Index	100%	95%	60%	86%	40%	55%	40%	5%	0%	0%	0%	0%	100%	100%	90%	90%	90%	90%	62%	62%	43%	43%	19%	19%
MSCI KLD 400 Social Index	100%	100%	100%	100%	50%	100%	50%	100%	50%	94%	50%	78%	72%	72%	17%	17%	0%	0%	0%	0%	0%	0%	0%	0%
MSCI USA Select ESG & Trend Leaders index	75%	74%	50%	42%	38%	11%	0%	5%	0%	0%	0%	0%	30%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Total ESG Score Negligible and Low	55%	81%	55%	50%	0%	13%	0%	6%	0%	0%	0%	0%	100%	100%	100%	100%	90%	90%	70%	70%	70%	70%	70%	70%
Sustainalytics Total ESG Score Negligible, Low and Medium	75%	100%	75%	91%	50%	57%	25%	35%	0%	4%	0%	0%	100%	100%	100%	100%	86%	86%	86%	86%	86%	86%	71%	71%
Sustainalytics Environment Score Negligible, Low and Medium	67%	82%	50%	68%	0%	41%	0%	14%	0%	9%	0%	0%	100%	100%	92%	92%	92%	92%	92%	92%	83%	83%	75%	75%
Sustainalytics Social Score Negligible, Low and Medium	80%	95%	80%	77%	60%	55%	20%	18%	0%	5%	0%	0%	82%	82%	82%	82%	45%	45%	36%	36%	18%	18%	9%	9%
Sustainalytics Governance Score Negligible, Low and Medium	100%	71%	50%	38%	0%	8%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	80%	80%	80%	80%	60%	60%	40%	40%
Sustainalytics Controversy Score No Controversy	100%	100%	100%	100%	100%	100%	100%	71%	100%	71%	100%	71%	85%	85%	46%	46%	15%	15%	15%	15%	0%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	100%	100%	80%	100%	80%	100%	40%	63%	40%	38%	40%	25%	88%	88%	50%	50%	25%	25%	25%	25%	13%	13%	0%	0%
Upright Absolute Net Impact Score Positive Only	100%	94%	100%	89%	100%	83%	33%	67%	33%	44%	0%	22%	100%	100%	90%	90%	70%	70%	60%	60%	50%	50%	40%	40%
Upright Absolute Net Impact Score Above Average of Positive Only	100%	100%	100%	100%	100%	100%	67%	86%	67%	86%	67%	71%	100%	100%	94%	94%	75%	75%	56%	56%	38%	38%	19%	19%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	100%	93%	78%	86%	67%	71%	44%	57%	0%	29%	0%	7%	69%	55%	54%	45%	8%	27%	0%	9%	0%	9%	0%	0%
RepRisk RRI Below or Equal 30	90%	94%	70%	67%	60%	28%	10%	11%	10%	0%	0%	0%	55%	0%	45%	0%	27%	0%	9%	0%	9%	0%	0%	0%
RepRisk Rating A and better	73%	83%	47%	50%	40%	25%	13%	8%	7%	8%	0%	0%	0%	82%	0%	55%	0%	36%	0%	9%	0%	0%	0%	0%
RepRisk Rating BB and better	80%	77%	53%	62%	13%	31%	7%	0%	0%	0%	0%	0%	82%	95%	55%	84%	36%	79%	9%	42%	0%	21%	0%	16%

Industry portfolio: quarterly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100%	100%	100%	86%	100%	86%	67%	57%	67%	57%	67%	43%	100%	100%	90%	89%	85%	89%	75%	56%	75%	33%	65%	22%
Thomson Reuters ESG Combined Score A- and better	100%	100%	100%	91%	100%	91%	100%	64%	67%	55%	50%	45%	92%	79%	85%	64%	69%	57%	38%	36%	15%	0%	15%	0%
Refinitiv/S-Network ESG Best Practices Index	80%	100%	80%	86%	80%	64%	40%	27%	40%	9%	0%	5%	94%	100%	94%	100%	89%	100%	89%	89%	72%	67%	61%	56%
MSCI KLD 400 Social Index	91%	94%	55%	88%	36%	81%	36%	44%	9%	31%	0%	13%	100%	100%	100%	100%	100%	100%	87%	83%	80%	58%	53%	50%
MSCI USA Select ESG & Trend Leaders index	100%	100%	100%	100%	100%	100%	67%	94%	33%	88%	33%	82%	100%	86%	100%	86%	85%	71%	77%	50%	62%	29%	54%	21%
Sustainalytics Total ESG Score Negligible and Low	80%	94%	80%	82%	60%	76%	30%	41%	10%	24%	0%	6%	100%	100%	100%	100%	100%	91%	100%	87%	100%	87%	100%	78%
Sustainalytics Total ESG Score Negligible, Low and Medium	100%	100%	80%	95%	60%	68%	40%	50%	0%	32%	0%	18%	100%	100%	100%	100%	80%	94%	80%	94%	70%	94%	70%	94%
Sustainalytics Environment Score Negligible, Low and Medium	67%	91%	50%	82%	33%	45%	0%	23%	0%	14%	0%	9%	100%	100%	100%	100%	100%	89%	78%	83%	67%	83%	44%	78%
Sustainalytics Social Score Negligible, Low and Medium	67%	95%	50%	86%	50%	81%	33%	33%	17%	19%	0%	19%	86%	100%	86%	100%	71%	100%	71%	84%	71%	84%	43%	79%
Sustainalytics Governance Score Negligible, Low and Medium	75%	83%	50%	38%	25%	8%	0%	0%	0%	0%	0%	0%	88%	100%	75%	89%	75%	78%	75%	72%	75%	67%	75%	61%
Sustainalytics Controversy Score No Controversy	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	80%	87%	93%	80%	64%	53%	50%	40%	21%	0%	7%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	100%	92%	100%	92%	88%	92%	75%	92%	50%	92%	25%	77%	90%	100%	80%	89%	60%	74%	40%	47%	40%	21%	20%	5%
Upright Absolute Net Impact Score Positive Only	100%	89%	100%	89%	100%	89%	100%	83%	67%	72%	0%	44%	86%	93%	71%	93%	64%	87%	43%	73%	29%	67%	21%	60%
Upright Absolute Net Impact Score Above Average of Positive Only	100%	100%	100%	100%	100%	100%	100%	100%	67%	100%	67%	100%	92%	88%	69%	75%	62%	50%	8%	31%	8%	25%	8%	13%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	100%	100%	100%	82%	83%	73%	58%	64%	33%	64%	25%	64%	93%	87%	71%	73%	57%	60%	36%	40%	21%	20%	7%	13%
RepRisk RRI Below or Equal 30	93%	100%	93%	100%	93%	86%	57%	50%	21%	36%	14%	14%	90%	92%	70%	92%	40%	62%	20%	15%	20%	8%	0%	0%
RepRisk Rating A and better	100%	83%	93%	75%	87%	67%	67%	42%	47%	17%	27%	17%	88%	80%	75%	70%	56%	60%	38%	40%	13%	20%	0%	0%
RepRisk Rating BB and better	88%	92%	88%	83%	69%	83%	38%	75%	25%	33%	19%	17%	100%	83%	90%	67%	50%	58%	30%	42%	30%	33%	30%	17%

Industry portfolio: annual investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	100 %	100 %	83%	100 %	83%	75%	83%	50%	33%	25%	33%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Thomson Reuters ESG Combined Score A- and better	100 %	100 %	86%	90%	86%	80%	71%	70%	29%	60%	14%	60%												
Refinitiv/S-Network ESG Best Practices Index	83%	90%	83%	90%	67%	76%	50%	48%	33%	29%	33%	19%												
MSCI KLD 400 Social Index	83%	95%	83%	86%	67%	57%	17%	14%	0%	5%	0%	5%												
MSCI USA Select ESG & Trend Leaders index	89%	89%	56%	89%	44%	61%	11%	22%	0%	11%	0%	11%												
Sustainalytics Total ESG Score Negligible and Low	100 %	100 %	80%	100 %	60%	100 %	40%	100 %	40%	93%	40%	87%												
Sustainalytics Total ESG Score Negligible, Low and Medium	85%	93%	46%	86%	38%	57%	15%	43%	8%	29%	0%	14%												
Sustainalytics Environment Score Negligible, Low and Medium	78%	68%	44%	58%	33%	37%	0%	21%	0%	11%	0%	5%												
Sustainalytics Social Score Negligible, Low and Medium	91%	88%	64%	75%	36%	50%	9%	13%	0%	6%	0%	0%												
Sustainalytics Governance Score Negligible, Low and Medium	71%	86%	29%	43%	0%	29%	0%	7%	0%	7%	0%	7%												
Sustainalytics Controversy Score No Controversy	100 %	100 %	80%	100 %	60%	100 %	40%	75%	40%	25%	20%	25%	100 %	100 %	100 %	100 %	90%	100 %	90%	89%	90%	84%	90%	84%
Sustainalytics Controversy Score No and Low Controversy	100 %	93%	100 %	93%	86%	79%	29%	50%	29%	36%	14%	29%												
Upright Absolute Net Impact Score Positive Only	100 %	100 %	75%	94%	50%	82%	50%	65%	25%	47%	25%	35%												
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	100 %	67%	100 %	67%	100 %	67%	100 %	67%	100 %	67%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	88%	93%	88%	93%	88%	93%	63%	47%	63%	13%	38%	13%												
RepRisk RRI Below or Equal 30	100 %	88%	82%	82%	73%	41%	45%	18%	27%	12%	9%	0%												
RepRisk Rating A and better	86%	85%	57%	62%	57%	31%	43%	15%	21%	8%	7%	0%												
RepRisk Rating BB and better	100 %	100 %	92%	93%	77%	64%	54%	29%	38%	14%	23%	14%												

Online 4.3.2 Models with different factor loadings (but identical factors)

Table 10a to g: Percentage of stocks in a data set where the (positive or negative) cost of capital difference Equation (15) – (3) for ESG stocks and (16) – (4) for non-ESG stocks is greater than the benchmark fitted to the respective investment horizon. Formally,

$$|(15) - (3)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

and

$$|(16) - (4)| \geq (1 + benchmark)^{\frac{1}{investment\ horizon\ expressed\ in\ years}} - 1$$

† Special case of only one ESG stock leading to identical capital costs.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.
#DIV/0! Either means no positive (solely negative) or no negative (solely positive) cost of capital differences.

Single stock: monthly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	100 %	100 %	100 %	100 %	100 %	94%	100 %	94%	100 %	94%	100 %	97%	99%	95%	89%	91%	82%	81%	66%	69%	53%	59%	46%
Thomson Reuters ESG Combined Score A- and better	97%	92%	95%	92%	90%	83%	77%	58%	62%	58%	44%	42%	96%	92%	93%	87%	89%	80%	77%	63%	64%	46%	53%	37%
Refinitiv/S-Network ESG Best Practices Index	99%	99%	94%	94%	86%	82%	74%	72%	63%	54%	54%	46%												
MSCI KLD 400 Social Index	100 %	94%	94%	92%	76%	87%	62%	80%	52%	70%	35%	62%												
MSCI USA Select ESG & Trend Leaders index	90%	99%	85%	97%	79%	92%	63%	82%	54%	71%	40%	67%												
Sustainalytics Total ESG Score Negligible and Low	83%	100 %	67%	100 %	67%	99%	0%	95%	0%	93%	0%	90%	99%	100 %	97%	100 %	95%	99%	93%	97%	90%	96%	86%	95%
Sustainalytics Total ESG Score Negligible, Low and Medium	96%	99%	88%	97%	77%	96%	48%	92%	35%	87%	27%	79%												
Sustainalytics Environment Score Negligible, Low and Medium	97%	100 %	92%	98%	81%	97%	52%	91%	39%	83%	27%	75%												
Sustainalytics Social Score Negligible, Low and Medium	93%	96%	89%	94%	82%	90%	66%	79%	53%	68%	39%	60%												
Sustainalytics Governance Score Negligible, Low and Medium	96%	97%	90%	94%	83%	89%	71%	81%	54%	71%	35%	62%												
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	0%	95%	0%	82%	98%	98%	94%	95%	83%	91%	68%	83%	57%	76%	50%	69%
Sustainalytics Controversy Score No and Low Controversy	100 %	100 %	100 %	99%	100 %	96%	100 %	93%	50%	83%	50%	73%	95%	100 %	94%	98%	87%	93%	73%	88%	68%	82%	57%	76%
Upright Absolute Net Impact Score Positive Only	97%	99%	97%	96%	88%	93%	65%	86%	41%	75%	24%	67%												
Upright Absolute Net Impact Score Above Average of Positive Only	88%	93%	75%	93%	75%	90%	50%	83%	38%	70%	13%	70%	98%	96%	95%	91%	87%	86%	77%	70%	66%	61%	59%	53%
Upright Absolute Environment Impact Score Positive Only	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	97%	99%	95%	97%	92%	94%	80%	90%	68%	84%	56%	78%
RepRisk RRI Below or Equal 10	95%	97%	86%	94%	76%	90%	57%	79%	52%	69%	38%	58%	100 %	99%	98%	97%	95%	93%	86%	86%	71%	79%	63%	76%
RepRisk RRI Below or Equal 30	100 %	100 %	98%	98%	91%	94%	65%	90%	41%	82%	24%	75%												
RepRisk Rating A and better	90%	96%	83%	95%	75%	90%	56%	82%	52%	70%	33%	62%												
RepRisk Rating BB and better	96%	100 %	95%	97%	89%	93%	71%	86%	47%	78%	33%	69%												

Single stock: quarterly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	100 %	100 %	0%	100 %	0%	100 %	0%	100 %	0%	100 %	0%	99%	98%	98%	98%	95%	96%	91%	90%	88%	83%	85%	77%
Thomson Reuters ESG Combined Score A- and better	98%	100 %	98%	91%	93%	91%	83%	45%	78%	45%	73%	18%												
Refinitiv/S-Network ESG Best Practices Index	100 %	95%	98%	90%	97%	88%	89%	71%	78%	60%	68%	45%												
MSCI KLD 400 Social Index	97%	95%	95%	84%	88%	70%	76%	57%	64%	51%	55%	41%												
MSCI USA Select ESG & Trend Leaders index	97%	97%	92%	92%	86%	80%	76%	67%	61%	53%	54%	41%												
Sustainalytics Total ESG Score Negligible and Low	89%	100 %	78%	99%	78%	99%	78%	98%	67%	97%	44%	95%												
Sustainalytics Total ESG Score Negligible, Low and Medium	90%	99%	85%	97%	77%	93%	55%	88%	48%	83%	38%	80%												
Sustainalytics Environment Score Negligible, Low and Medium	95%	98%	90%	97%	82%	94%	63%	88%	49%	82%	39%	76%												
Sustainalytics Social Score Negligible, Low and Medium	100 %	97%	93%	95%	86%	91%	68%	87%	53%	78%	47%	73%												
Sustainalytics Governance Score Negligible, Low and Medium	98%	100 %	93%	96%	85%	94%	74%	87%	53%	79%	43%	69%												
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	100 %	100 %	100 %	100 %	95%	100 %	91%	100 %	86%	98%	100 %	98%	99%	93%	96%	89%	92%	79%	86%	74%	84%
Sustainalytics Controversy Score No and Low Controversy	100 %	100 %	100 %	100 %	67%	98%	44%	98%	22%	97%	11%	90%												
Upright Absolute Net Impact Score Positive Only	96%	100 %	93%	97%	89%	96%	67%	85%	54%	81%	46%	74%												
Upright Absolute Net Impact Score Above Average of Positive Only	80%	93%	80%	93%	60%	86%	30%	86%	30%	75%	20%	71%	100 %	100 %	100 %	99%	99%	97%	99%	95%	99%	93%	97%	91%
Upright Absolute Environment Impact Score Positive Only	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	99%	100 %	97%	99%	90%	96%	79%	87%	67%	82%	58%	74%
RepRisk RRI Below or Equal 10	94%	100 %	84%	98%	74%	93%	61%	88%	39%	79%	26%	73%												
RepRisk RRI Below or Equal 30	95%	99%	89%	97%	82%	94%	61%	88%	49%	83%	38%	75%												
RepRisk Rating A and better	95%	99%	89%	97%	75%	94%	63%	88%	49%	83%	34%	75%												
RepRisk Rating BB and better	99%	99%	90%	97%	83%	94%	66%	89%	50%	85%	37%	77%												

Single stock: annual investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	80%	100 %	80%	100 %	80%	86%	80%	79%	60%	71%	60%												
Thomson Reuters ESG Combined Score A- and better	94%	100 %	91%	100 %	85%	100 %	82%	82%	74%	65%	62%	59%												
Refinitiv/S-Network ESG Best Practices Index	94%	97%	86%	97%	82%	96%	67%	89%	59%	83%	52%	76%												
MSCI KLD 400 Social Index	96%	100 %	94%	98%	87%	98%	73%	94%	67%	90%	62%	84%												
MSCI USA Select ESG & Trend Leaders index	96%	99%	87%	98%	85%	96%	69%	94%	67%	90%	58%	83%												
Sustainalytics Total ESG Score Negligible and Low	100 %	100 %	100 %	97%	100 %	96%	100 %	94%	94%	92%	88%	90%												
Sustainalytics Total ESG Score Negligible, Low and Medium	96%	99%	91%	98%	89%	96%	75%	94%	70%	91%	62%	88%												
Sustainalytics Environment Score Negligible, Low and Medium	100 %	98%	97%	97%	90%	96%	81%	93%	76%	91%	65%	86%												
Sustainalytics Social Score Negligible, Low and Medium	100 %	99%	96%	97%	91%	96%	79%	94%	70%	90%	60%	86%												
Sustainalytics Governance Score Negligible, Low and Medium	95%	100 %	90%	99%	79%	98%	73%	95%	66%	90%	60%	84%												
Sustainalytics Controversy Score No Controversy	100 %	100 %	100 %	92%	100 %	92%	80%	85%	80%	77%	60%	69%												
Sustainalytics Controversy Score No and Low Controversy	93%	96%	89%	93%	85%	91%	81%	87%	67%	78%	59%	67%												
Upright Absolute Net Impact Score Positive Only	96%	99%	93%	98%	89%	96%	78%	94%	74%	91%	63%	87%												
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	100 %	100 %	100 %	86%	100 %	57%	97%	43%	97%	43%	94%												
Upright Absolute Environment Impact Score Positive Only	#DIV/0!	67%	#DIV/0!	67%	#DIV/0!	67%	#DIV/0!	67%	#DIV/0!	67%	#DIV/0!	67%	100 %	99%	95%	98%	91%	95%	79%	91%	72%	85%	66%	81%
RepRisk RRI Below or Equal 10	97%	99%	84%	95%	81%	91%	76%	86%	70%	75%	62%	68%												
RepRisk RRI Below or Equal 30	99%	99%	94%	98%	89%	95%	78%	89%	71%	83%	61%	77%												
RepRisk Rating A and better	100 %	99%	92%	98%	85%	95%	73%	89%	66%	82%	55%	75%												
RepRisk Rating BB and better	98%	98%	92%	97%	90%	93%	77%	88%	71%	81%	62%	75%												

Industry portfolio: daily investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	96%	75%	88%	75%	60%	75%	32%	75%	20%	25%	8%	0%
Thomson Reuters ESG Combined Score A- and better	100 %	#DIV/0!	100 %	#DIV/0!	94%	#DIV/0!	88%	#DIV/0!	71%	#DIV/0!	59%	#DIV/0!	95%	100 %	80%	71%	70%	43%	60%	29%	40%	0%	20%	0%
Refinitiv/S-Network ESG Best Practices Index	100 %	50%	88%	50%	80%	50%	64%	0%	56%	0%	48%	0%	100 %	100 %	93%	100 %	80%	83%	47%	75%	27%	50%	13%	25%
MSCI KLD 400 Social Index	94%	89%	89%	78%	78%	44%	67%	11%	33%	11%	11%	11%	100 %	92%	100 %	83%	93%	42%	60%	25%	13%	17%	0%	8%
MSCI USA Select ESG & Trend Leaders index	100 %	100 %	100 %	81%	100 %	75%	55%	50%	18%	31%	9%	13%	100 %	100 %	81%	82%	75%	45%	25%	18%	25%	9%	13%	9%
Sustainalytics Total ESG Score Negligible and Low	#DIV/0!	95%	#DIV/0!	90%	#DIV/0!	90%	#DIV/0!	90%	#DIV/0!	80%	#DIV/0!	65%	100 %	100 %	100 %	100 %	93%	100 %	93%	86%	73%	71%	60%	50%
Sustainalytics Total ESG Score Negligible, Low and Medium	80%	95%	60%	91%	40%	77%	40%	59%	20%	41%	20%	23%	95%	100 %	95%	100 %	95%	78%	89%	67%	79%	56%	74%	33%
Sustainalytics Environment Score Negligible, Low and Medium	100 %	95%	86%	81%	43%	71%	29%	43%	29%	33%	14%	19%	95%	100 %	90%	100 %	86%	67%	81%	33%	76%	17%	67%	17%
Sustainalytics Social Score Negligible, Low and Medium	92%	100 %	77%	93%	54%	86%	31%	43%	15%	36%	8%	21%	100 %	100 %	94%	100 %	94%	100 %	89%	63%	78%	50%	44%	13%
Sustainalytics Governance Score Negligible, Low and Medium	86%	93%	79%	93%	50%	79%	21%	36%	7%	29%	7%	14%	94%	100 %	94%	88%	83%	63%	78%	25%	67%	13%	67%	0%
Sustainalytics Controversy Score No Controversy	#DIV/0!	100 %	#DIV/0!	89%	#DIV/0!	67%	#DIV/0!	0%	#DIV/0!	0%	#DIV/0!	0%	93%	86%	67%	71%	60%	57%	40%	29%	20%	14%	13%	7%
Sustainalytics Controversy Score No and Low Controversy	#DIV/0!	100 %	#DIV/0!	95%	#DIV/0!	81%	#DIV/0!	43%	#DIV/0!	33%	#DIV/0!	24%	100 %	94%	100 %	89%	64%	89%	45%	61%	36%	44%	18%	22%
Upright Absolute Net Impact Score Positive Only	100 %	86%	71%	71%	43%	64%	43%	36%	29%	14%	29%	7%	100 %	92%	94%	83%	82%	67%	65%	33%	53%	25%	24%	8%
Upright Absolute Net Impact Score Above Average of Positive Only	100 %	100 %	100 %	100 %	67%	71%	67%	43%	33%	29%	0%	14%	100 %	100 %	100 %	80%	74%	80%	74%	30%	53%	0%	16%	0%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	93%	88%	87%	63%	47%	50%	0%	13%	0%	0%	0%	0%	93%	93%	86%	93%	86%	73%	43%	47%	29%	27%	21%	13%
RepRisk RRI Below or Equal 30	50%	91%	0%	64%	0%	55%	0%	32%	0%	9%	0%	0%	89%	93%	78%	86%	67%	79%	56%	71%	44%	64%	44%	29%
RepRisk Rating A and better	100 %	100 %	100 %	93%	75%	60%	25%	27%	0%	20%	0%	13%	93%	100 %	87%	100 %	67%	91%	33%	73%	27%	36%	27%	36%
RepRisk Rating BB and better	63%	90%	50%	90%	38%	80%	0%	60%	0%	30%	0%	15%	100 %	85%	100 %	77%	78%	77%	44%	69%	33%	62%	33%	31%

Industry portfolio: monthly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	94%	100 %	88%	92%	82%	75%	82%	67%	47%	58%	41%	58%
Thomson Reuters ESG Combined Score A- and better	93%	100 %	87%	100 %	73%	100 %	67%	100 %	53%	100 %	40%	0%	92%	93%	92%	87%	83%	87%	67%	80%	58%	53%	50%	33%
Refinitiv/S-Network ESG Best Practices Index	100 %	100 %	88%	91%	69%	82%	56%	73%	44%	55%	31%	55%	100 %	100 %	100 %	100 %	89%	100 %	83%	89%	72%	78%	72%	78%
MSCI KLD 400 Social Index	67%	100 %	67%	100 %	67%	100 %	0%	88%	0%	82%	0%	82%	100 %	92%	100 %	92%	100 %	92%	79%	77%	64%	69%	64%	62%
MSCI USA Select ESG & Trend Leaders index	100 %	100 %	100 %	100 %	100 %	95%	88%	89%	88%	79%	88%	74%	100 %	100 %	100 %	94%	89%	89%	67%	78%	67%	72%	67%	56%
Sustainalytics Total ESG Score Negligible and Low	100 %	100 %	88%	100 %	88%	95%	75%	84%	75%	74%	63%	47%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Sustainalytics Total ESG Score Negligible, Low and Medium	100 %	95%	100 %	95%	100 %	95%	88%	95%	88%	95%	88%	89%	80%	100 %	80%	100 %	80%	100 %	80%	96%	80%	87%	80%	78%
Sustainalytics Environment Score Negligible, Low and Medium	100 %	100 %	100 %	100 %	90%	100 %	90%	100 %	80%	94%	70%	83%	100 %	100 %	71%	100 %	71%	95%	71%	85%	57%	80%	14%	80%
Sustainalytics Social Score Negligible, Low and Medium	100 %	95%	100 %	95%	100 %	95%	100 %	79%	100 %	68%	88%	58%	100 %	100 %	100 %	100 %	88%	83%	88%	78%	75%	72%	75%	61%
Sustainalytics Governance Score Negligible, Low and Medium	100 %	95%	100 %	95%	100 %	89%	100 %	79%	100 %	74%	89%	53%	100 %	100 %	100 %	93%	100 %	93%	64%	93%	64%	87%	64%	80%
Sustainalytics Controversy Score No Controversy	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	78%	100 %	100 %	100 %	100 %	100 %	84%	100 %	74%	90%	63%	80%	63%
Sustainalytics Controversy Score No and Low Controversy	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	100 %	#DIV/0!	90%	#DIV/0!	71%	100 %	100 %	100 %	100 %	91%	100 %	82%	94%	82%	94%	82%	78%
Upright Absolute Net Impact Score Positive Only	100 %	100 %	100 %	100 %	75%	92%	75%	92%	75%	85%	50%	77%	100 %	100 %	100 %	100 %	86%	100 %	57%	95%	43%	86%	43%	86%
Upright Absolute Net Impact Score Above Average of Positive Only	83%	100 %	83%	100 %	83%	100 %	50%	75%	33%	75%	0%	75%	100 %	100 %	100 %	93%	93%	93%	79%	73%	79%	67%	57%	67%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	100 %	100 %	75%	89%	75%	84%	75%	63%	75%	53%	25%	53%	100 %	94%	100 %	94%	100 %	82%	100 %	82%	92%	76%	75%	76%
RepRisk RRI Below or Equal 30	100 %	100 %	100 %	100 %	100 %	100 %	100 %	96%	0%	76%	0%	56%	100 %	100 %	100 %	100 %	100 %	100 %	88%	93%	88%	93%	88%	93%
RepRisk Rating A and better	83%	95%	83%	95%	67%	95%	67%	81%	67%	67%	50%	67%	92%	92%	92%	92%	92%	85%	92%	85%	77%	77%	77%	77%
RepRisk Rating BB and better	100 %	100 %	100 %	95%	100 %	95%	83%	95%	67%	77%	50%	73%	100 %	100 %	100 %	92%	100 %	92%	100 %	92%	90%	92%	90%	83%

Industry portfolio: quarterly investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100%	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	100%	100%	100%	100%	100%	100%	94%	100%	94%	85%	88%	85%
Thomson Reuters ESG Combined Score A- and better	100%	100%	100%	75%	92%	75%	92%	25%	92%	25%	92%	25%	100%	100%	100%	100%	94%	100%	94%	91%	88%	91%	81%	82%
Refinitiv/S-Network ESG Best Practices Index	100%	100%	96%	100%	96%	100%	88%	100%	75%	67%	63%	67%	100%	100%	100%	88%	95%	88%	79%	75%	79%	63%	68%	50%
MSCI KLD 400 Social Index	100%	93%	100%	93%	92%	71%	85%	64%	69%	50%	62%	29%	100%	100%	100%	89%	100%	78%	89%	78%	89%	56%	83%	44%
MSCI USA Select ESG & Trend Leaders index	100%	100%	100%	100%	100%	100%	100%	100%	67%	100%	33%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	94%
Sustainalytics Total ESG Score Negligible and Low	100%	100%	90%	86%	80%	71%	65%	71%	55%	57%	35%	43%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	92%	94%
Sustainalytics Total ESG Score Negligible, Low and Medium	83%	95%	83%	95%	83%	86%	83%	81%	83%	67%	67%	67%	92%	100%	92%	100%	92%	100%	69%	100%	69%	100%	62%	100%
Sustainalytics Environment Score Negligible, Low and Medium	90%	94%	90%	83%	80%	78%	70%	78%	60%	72%	50%	67%	100%	95%	100%	95%	100%	95%	80%	86%	40%	77%	40%	73%
Sustainalytics Social Score Negligible, Low and Medium	100%	100%	77%	100%	69%	100%	46%	93%	46%	86%	38%	86%	100%	100%	100%	100%	100%	95%	100%	82%	100%	77%	100%	73%
Sustainalytics Governance Score Negligible, Low and Medium	100%	100%	100%	100%	87%	92%	67%	85%	47%	85%	47%	62%	100%	100%	100%	93%	91%	87%	91%	87%	82%	87%	64%	80%
Sustainalytics Controversy Score No Controversy	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	100%	#DIV/0!	89%	#DIV/0!	89%	100%	100%	100%	100%	91%	89%	91%	83%	64%	72%	64%	67%
Sustainalytics Controversy Score No and Low Controversy	100%	100%	100%	100%	50%	100%	0%	100%	0%	100%	0%	95%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Upright Absolute Net Impact Score Positive Only	89%	100%	89%	100%	89%	100%	56%	92%	56%	92%	44%	83%	100%	100%	100%	100%	92%	100%	92%	94%	83%	94%	83%	94%
Upright Absolute Net Impact Score Above Average of Positive Only	60%	80%	60%	80%	60%	60%	40%	60%	40%	60%	40%	60%	100%	100%	100%	100%	100%	94%	100%	88%	100%	82%	100%	76%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	88%	100%	88%	93%	75%	87%	63%	87%	50%	60%	38%	53%	100%	100%	82%	100%	73%	100%	73%	89%	55%	89%	45%	78%
RepRisk RRI Below or Equal 30	92%	100%	77%	93%	77%	93%	62%	87%	38%	53%	23%	47%	100%	100%	100%	100%	78%	100%	78%	93%	67%	93%	56%	93%
RepRisk Rating A and better	100%	90%	86%	85%	71%	85%	57%	85%	57%	80%	43%	70%	100%	100%	100%	100%	80%	100%	80%	100%	80%	100%	80%	100%
RepRisk Rating BB and better	100%	100%	83%	91%	83%	86%	67%	82%	67%	77%	50%	73%	100%	100%	100%	100%	100%	100%	88%	100%	88%	100%	88%	86%

Industry portfolio: annual investment horizon	ESG stocks												Non-ESG stocks											
	0.10%		0.25%		0.50%		1%		1.50%		2%		0.10%		0.25%		0.50%		1%		1.50%		2%	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Thomson Reuters ESG Combined Score A and better	100%	100%	100%	100%	100%	100%	78%	100%	67%	100%	67%	100%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	79%	93%	71%	93%	71%
Thomson Reuters ESG Combined Score A- and better	83%	100%	75%	100%	75%	100%	67%	80%	58%	60%	50%	60%												
Refinitiv/S-Network ESG Best Practices Index	100%	100%	71%	100%	71%	100%	57%	90%	57%	75%	43%	75%												
MSCI KLD 400 Social Index	100%	100%	80%	95%	80%	95%	60%	95%	60%	91%	60%	77%												
MSCI USA Select ESG & Trend Leaders index	100%	100%	80%	100%	80%	100%	80%	95%	80%	91%	80%	86%												
Sustainalytics Total ESG Score Negligible and Low	100%	100%	100%	94%	100%	94%	100%	89%	100%	83%	100%	78%												
Sustainalytics Total ESG Score Negligible, Low and Medium	100%	95%	80%	95%	80%	91%	60%	86%	60%	77%	60%	77%												
Sustainalytics Environment Score Negligible, Low and Medium	100%	95%	100%	95%	86%	95%	71%	90%	71%	86%	57%	81%												
Sustainalytics Social Score Negligible, Low and Medium	100%	100%	100%	96%	50%	96%	50%	96%	25%	87%	25%	83%												
Sustainalytics Governance Score Negligible, Low and Medium	100%	100%	100%	100%	86%	95%	71%	95%	57%	90%	57%	81%												
Sustainalytics Controversy Score No Controversy	100%	100%	100%	86%	100%	86%	100%	86%	100%	71%	50%	57%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	89%	82%	61%	64%	61%
Sustainalytics Controversy Score No and Low Controversy	71%	100%	57%	100%	57%	100%	57%	100%	43%	79%	43%	71%												
Upright Absolute Net Impact Score Positive Only	100%	100%	100%	100%	100%	100%	100%	94%	100%	82%	100%	82%												
Upright Absolute Net Impact Score Above Average of Positive Only	100%	100%	100%	100%	100%	100%	33%	100%	0%	100%	0%	100%	100 %	100 %	100 %	100 %	100 %	100 %	83%	91%	83%	91%	83%	91%
Upright Absolute Environment Impact Score Positive Only	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
RepRisk RRI Below or Equal 10	100%	93%	100%	93%	100%	87%	100%	67%	100%	60%	75%	53%												
RepRisk RRI Below or Equal 30	100%	95%	100%	89%	100%	89%	89%	74%	89%	63%	67%	63%												
RepRisk Rating A and better	100%	100%	100%	100%	100%	100%	86%	90%	86%	85%	71%	75%												
RepRisk Rating BB and better	100%	95%	100%	95%	100%	90%	100%	86%	83%	76%	67%	67%												

Online 4.4 Explaining economic significance: ESG score methodology

Online 4.4.1 Regression outputs for explaining different percentages of economically significant cost of capital differences

Online 4.4.1.1 Models with different factor loadings (but identical factors)

Table 12a to d: Regression results for the controversy dummy (results for the constant are not depicted) of a regression that explains the percentage of economically significant cost of capital differences per data set with the help of the controversy dummy and the ESG dimension of the data set:

$$proc_{data\ set_i} = a + b_{contr} \cdot dummy_{contr,data\ set_i} + b_{ESG\ dimension} \cdot dummy_{ESG\ dimension,data\ set_i} + \varepsilon_{data\ set_i}$$

For industry portfolios the data set Upright Absolute Environment Impact Score Positive Only is omitted because it consists of just one industry and, hence, belongs to the special case of "just one ESG stock".
Therefore, there are 19 data sets for single stocks and 18 for industry portfolios.
There is no dummy trap.

Single stocks	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Monthly investment horizon												
Controversy Dummy	-0.0631	-0.0168	0.0487	0.1900	0.1581	0.0583	Too few observations available for non-ESG stocks					
Standard Errors	0.1029	0.1581	0.2184	0.1975	0.1361	0.0567						
P-Value	54.81%	91.67%	82.64%	35.02%	26.26%	31.97%						
ESG dimension Dummy	0.2086	0.2146	0.2082	0.1767	0.1192	0.0583						
Standard Errors	0.1722	0.1772	0.1719	0.1459	0.0984	0.0481						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.0219	0.0543	0.1302	0.2487	0.2909	0.2099						
Quarterly investment horizon												
Controversy Dummy	-0.0223	0.0133	0.0949	0.1281	0.1049	0.0449	Too few observations available for non-ESG stocks					
Standard Errors	0.3001	0.3411	0.2559	0.1414	0.0959	0.0504						
P-Value	94.17%	96.93%	71.57%	37.81%	29.01%	38.66%						
ESG dimension Dummy	0.1697	0.1587	0.1455	0.1177	0.0783	0.0438						
Standard Errors	0.1402	0.1310	0.1201	0.0972	0.0647	0.0362						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.2524	0.3510	0.3242	0.2670	0.3082	0.2476						
Annual investment horizon												
Controversy Dummy	0.1854	0.1300	0.1674	0.1638	0.1164	0.0513	Too few observations available for non-ESG stocks					
Standard Errors	-0.0159	0.0415	0.1104	0.0850	0.0294	0.0344						
P-Value	0.00%	0.64%	14.88%	7.19%	0.11%	15.53%						
ESG dimension Dummy	0.1395	0.1708	0.1523	0.1035	0.0580	0.0294						
Standard Errors	0.1152	0.1410	0.1258	0.0855	0.0479	0.0243						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.1119	0.0627	0.1798	0.2746	0.2987	0.3594						

Single stocks	ESG stocks – negative differences						Non-ESG stocks– negative differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Monthly investment horizon												
Controversy Dummy	0.1067	0.1753	0.2863	0.2040	0.1192	0.0275	Too few observations available for non-ESG stocks					
Standard Errors	0.1232	0.1328	0.1123	0.0725	0.0220	0.0122						
P-Value	39.93%	20.55%	2.14%	1.25%	0.01%	3.91%						
ESG dimension Dummy	0.1701	0.1779	0.1603	0.1349	0.0770	0.0311						
Standard Errors	0.1404	0.1469	0.1324	0.1114	0.0636	0.0257						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.1133	0.1664	0.2890	0.2172	0.1883	0.0965						
Quarterly investment horizon												
Controversy Dummy	0.3010	0.3828	0.4071	0.2243	0.1295	0.0548	Too few observations available for non-ESG stocks					
Standard Errors	0.1145	0.1024	0.0733	0.0453	0.0010	-0.0033						
P-Value	1.82%	0.18%	0.00%	0.01%	0.00%	0.00%						
ESG dimension Dummy	0.1511	0.1353	0.1043	0.0946	0.0498	0.0224						
Standard Errors	0.1248	0.1117	0.0861	0.0782	0.0411	0.0185						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.3324	0.4632	0.5943	0.3570	0.3457	0.3038						
Annual investment horizon												
Controversy Dummy	0.1435	0.2170	0.2473	0.1707	0.1123	0.0453	Too few observations available for non-ESG stocks					
Standard Errors	-0.0104	-0.0311	-0.0213	0.0019	-0.0186	0.0040						
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%						
ESG dimension Dummy	0.1885	0.1767	0.1516	0.0934	0.0557	0.0237						
Standard Errors	0.1557	0.1459	0.1252	0.0771	0.0460	0.0196						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.0401	0.0930	0.1594	0.2076	0.2143	0.2380						

Industry portfolios	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	0.1190	0.1667	0.1667	0.5079	0.2738	0.1452	-0.1368	-0.2488	-0.2192	-0.2181	-0.0958	-0.0251
Standard Errors	0.0060	0.0208	0.0667	-0.1690	-0.1387	0.0038	-0.1317	-0.1401	-0.2854	-0.5208	-0.6125	-0.5837
P-Value	0.00%	0.00%	2.45%	0.89%	6.71%	0.00%	31.51%	9.60%	45.43%	68.13%	87.78%	96.62%
ESG dimension Dummy	0.1292	0.1650	0.1620	0.2453	0.2392	0.1554	0.0854	0.0940	0.1478	0.1651	0.1619	0.1688
Standard Errors	0.0969	0.1238	0.1215	0.1840	0.1794	0.1165	0.0641	0.0705	0.1108	0.1238	0.1214	0.1266
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.0665	0.0859	0.1257	0.2227	0.0870	0.0666	0.4279	0.5459	0.4855	0.6547	0.6910	0.6341
Monthly investment horizon												
Controversy Dummy	0.1667	0.2143	0.2405	0.3393	0.1708	0.0414	-0.1005	-0.1297	-0.2165	-0.1363	-0.2103	-0.0791
Standard Errors	0.1021	0.0753	0.1067	0.1190	-0.0277	0.0655	-0.2934	-0.3554	-0.3333	-0.2777	-0.2032	-0.1626
P-Value	12.34%	1.23%	3.97%	1.22%	0.00%	53.69%	0.7368	0.7202	0.5258	0.6306	0.3169	0.6338
ESG dimension Dummy	0.2104	0.2032	0.1876	0.2257	0.1421	0.1037	0.1578	0.1684	0.1779	0.2251	0.2185	0.1884
Standard Errors	0.1578	0.1524	0.1407	0.1693	0.1066	0.0778	0.1183	0.1263	0.1334	0.1689	0.1639	0.1413
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.1036	0.1234	0.1922	0.2223	0.0911	0.0829	0.3828	0.4484	0.4461	0.2348	0.2134	0.1302
Quarterly investment horizon												
Controversy Dummy	0.1429	0.2670	0.4789	0.4051	0.3494	0.2354	-0.0161	-0.1103	-0.0573	0.0062	0.0382	0.0500
Standard Errors	0.2651	0.1897	0.1116	0.1327	0.1178	0.0456	-0.3530	-0.3321	-0.2942	-0.2389	-0.1060	-0.0365
P-Value	59.79%	17.97%	0.06%	0.80%	0.96%	0.01%	96.41%	74.45%	84.82%	97.97%	72.33%	19.13%
ESG dimension Dummy	0.1806	0.1733	0.1731	0.1256	0.0765	0.0486	0.1756	0.1750	0.1600	0.1006	0.0782	0.0395
Standard Errors	0.1354	0.1300	0.1298	0.0942	0.0574	0.0364	0.1317	0.1312	0.1200	0.0754	0.0587	0.0296
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.3113	0.3334	0.4496	0.5597	0.7211	0.7034	0.3695	0.3906	0.3519	0.4395	0.1817	0.1294
Annual investment horizon												
Controversy Dummy	0.2357	0.2467	0.3266	0.3290	0.2446	0.1141	Too few observations available for non-ESG stocks					
Standard Errors	-0.0477	0.1243	0.1677	0.2209	0.1555	0.0520						
P-Value	0.02%	6.58%	7.04%	15.71%	13.67%	4.43%						
ESG dimension Dummy	0.1204	0.1246	0.1216	0.0997	0.1009	0.0526						
Standard Errors	0.0903	0.0934	0.0912	0.0748	0.0756	0.0395						
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%						
Adj R^2	0.2066	0.3823	0.5358	0.6852	0.5280	0.4091						

Industry portfolios	ESG stocks – negative differences						Non-ESG stocks– negative differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	0.1088	0.2052	0.3061	0.3645	0.3141	0.1310	-0.0610	-0.0726	-0.1060	-0.1943	-0.2392	-0.1468
Standard Errors	-0.0017	-0.0394	-0.0979	-0.0125	-0.0804	-0.1053	-0.1612	-0.2422	-0.3511	-0.6192	-0.6486	-0.5203
P-Value	0.00%	0.01%	0.70%	0.00%	0.14%	23.27%	71.04%	76.86%	76.69%	75.80%	71.74%	78.16%
ESG dimension Dummy	0.1437	0.1952	0.2371	0.2727	0.2337	0.1243	0.1203	0.1415	0.1320	0.1660	0.1458	0.1895
Standard Errors	0.1078	0.1464	0.1779	0.2045	0.1753	0.0932	0.0903	0.1061	0.0990	0.1245	0.1094	0.1421
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.0429	0.0702	0.1000	0.1205	0.1079	0.1022	0.2487	0.3371	0.5515	0.7094	0.7836	0.5637
Monthly investment horizon												
Controversy Dummy	0.2449	0.2816	0.3271	0.2504	0.1882	0.0942	-0.1406	-0.1751	-0.2554	-0.2112	-0.2459	-0.1759
Standard Errors	-0.0169	-0.0141	0.0042	0.0538	0.0318	0.0133	-0.3497	-0.3971	-0.4109	-0.3886	-0.2022	-0.0557
P-Value	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%	69.33%	66.54%	54.36%	59.48%	24.29%	0.65%
ESG dimension Dummy	0.1972	0.2243	0.2325	0.2315	0.1515	0.0693	0.1625	0.1731	0.2062	0.2347	0.2145	0.1864
Standard Errors	0.1479	0.1682	0.1744	0.1736	0.1136	0.0520	0.1219	0.1298	0.1547	0.1760	0.1609	0.1398
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.1027	0.1063	0.1374	0.1085	0.1310	0.1479	0.4654	0.5051	0.4711	0.3659	0.2431	0.0968
Quarterly investment horizon												
Controversy Dummy	0.2889	0.3998	0.4412	0.3772	0.2316	0.0685	-0.1944	-0.1712	-0.0732	-0.0405	-0.0286	-0.0478
Standard Errors	0.0629	0.0579	0.0512	0.0204	-0.0287	-0.0077	-0.4598	-0.4313	-0.3546	-0.2114	-0.1728	-0.0600
P-Value	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	67.84%	69.70%	83.92%	85.05%	87.07%	43.85%
ESG dimension Dummy	0.2136	0.2069	0.1639	0.1220	0.0850	0.0384	0.1359	0.1314	0.1205	0.1018	0.0729	0.0485
Standard Errors	0.1602	0.1552	0.1229	0.0915	0.0637	0.0288	0.1019	0.0986	0.0904	0.0763	0.0546	0.0363
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.1605	0.2610	0.3976	0.4462	0.3456	0.1855	0.6862	0.6684	0.5836	0.4087	0.4694	0.2843
Annual investment horizon												
Controversy Dummy	0.3460	0.3680	0.4239	0.3781	0.3355	0.1481	Too few observations available for non-ESG stocks					
Standard Errors	-0.1692	-0.1963	-0.0763	-0.0484	-0.0510	-0.0047						
P-Value	5.88%	8.05%	0.01%	0.00%	0.00%	0.00%						
ESG dimension Dummy	0.1929	0.1853	0.1952	0.1441	0.0737	0.0443						
Standard Errors	0.1447	0.1390	0.1464	0.1081	0.0553	0.0333						
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%						
Adj R^2	0.1875	0.2267	0.2448	0.3278	0.5911	0.4613						

Online 4.4.1.2 Models with different factors and factor loadings

Table 13a to d: Regression results for the controversy dummy (results for the constant are not depicted) of a regression that explains the percentage of economically significant cost of capital differences per data set with the help of the controversy dummy and the ESG dimension of the data set:

$$proc_{data\ set_i} = a + b_{contr} \cdot dummy_{contr,data\ set_i} + b_{ESG\ dimension} \cdot dummy_{ESG\ dimension,data\ set_i} + \varepsilon_{data\ set_i}$$

For industry portfolios the data set Upright Absolute Environment Impact Score Positive Only is omitted because it consists of just one industry and, hence, belongs to the special case of "just one ESG stock".
Therefore, there are 19 data sets for single stocks and 18 for industry portfolios.
There is no dummy trap.

Single stocks	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Monthly investment horizon												
Controversy Dummy	-0.0642	-0.0811	-0.1115	-0.0337	-0.0492	-0.0241	Too few observations available for non-ESG stocks					
Standard Errors	0.1191	0.0944	0.2587	0.1175	0.0879	0.0431						
P-Value	59.77%	40.43%	67.26%	77.81%	58.36%	58.46%						
ESG dimension Dummy	0.1495	0.1527	0.1401	0.0574	0.0584	0.0323						
Standard Errors	0.1121	0.1145	0.1050	0.0430	0.0438	0.0242						
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%						
Adj R^2	0.0700	0.0463	0.2894	0.3412	0.2117	0.1742						
Quarterly investment horizon												
Controversy Dummy	0.0366	0.0579	-0.0099	-0.0203	-0.0344	-0.0513	Too few observations available for non-ESG stocks					
Standard Errors	0.0590	0.0329	0.0509	0.0218	0.0501	0.0487						
P-Value	54.45%	9.94%	84.84%	36.49%	50.25%	30.88%						
ESG dimension Dummy	0.1738	0.1506	0.1274	0.0782	0.0457	0.0329						
Standard Errors	0.1304	0.1130	0.0955	0.0587	0.0343	0.0246						
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%						
Adj R^2	0.0252	0.0249	0.0199	0.0101	0.1263	0.2354						
Annual investment horizon												
Controversy Dummy	-0.0057	-0.0308	-0.0327	0.0122	-0.0154	-0.0137	Too few observations available for non-ESG stocks					
Standard Errors	0.0054	0.0433	0.0492	0.0149	-0.0018	0.0063						
P-Value	31.25%	48.87%	51.60%	42.51%	0.00%	4.72%						
ESG dimension Dummy	0.0654	0.0727	0.0620	0.0454	0.0368	0.0181						
Standard Errors	0.0491	0.0545	0.0465	0.0341	0.0276	0.0136						
P-Value	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%						
Adj R^2	0.0010	0.0412	0.0701	0.0275	0.0158	0.0386						

Single stocks	ESG stocks – negative differences						Non-ESG stocks– negative differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Monthly investment horizon												
Controversy Dummy	-0.0559	-0.0628	-0.0352	-0.0266	-0.0111	-0.0080	Too few observations available for non-ESG stocks					
Standard Errors	-0.1110	-0.0736	-0.1085	-0.1046	-0.1132	0.0058						
P-Value	62.14%	40.59%	75.00%	80.23%	92.28%	18.38%						
ESG dimension Dummy	0.1310	0.1363	0.1390	0.1395	0.1422	0.0170						
Standard Errors	0.1081	0.1125	0.1147	0.1152	0.1174	0.0140						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.1117	0.0657	0.0831	0.0728	0.0720	0.0170						
Quarterly investment horizon												
Controversy Dummy	-0.1560	-0.1342	-0.1157	-0.0729	-0.0400	-0.0179	Too few observations available for non-ESG stocks					
Standard Errors	0.0561	0.0653	0.0530	0.0552	0.0176	0.0026						
P-Value	1.34%	5.64%	4.42%	20.50%	3.71%	0.00%						
ESG dimension Dummy	0.1312	0.1004	0.0893	0.0476	0.0346	0.0310						
Standard Errors	0.1083	0.0829	0.0737	0.0393	0.0286	0.0256						
P-Value	24.35%	24.35%	24.35%	24.35%	24.35%	24.35%						
Adj R^2	0.0813	0.1030	0.0965	0.1583	0.0778	0.0222						
Annual investment horizon												
Controversy Dummy	0.0521	0.0590	0.0651	0.0755	0.0794	0.0840	Too few observations available for non-ESG stocks					
Standard Errors	-0.1808	-0.1586	-0.0829	-0.0498	-0.0442	-0.0312						
P-Value	77.73%	71.51%	44.46%	15.06%	9.25%	1.68%						
ESG dimension Dummy	0.0438	0.0516	0.0415	0.0488	0.0508	0.0538						
Standard Errors	0.0373	0.0440	0.0354	0.0416	0.0433	0.0459						
P-Value	25.92%	25.92%	25.92%	25.92%	25.92%	25.92%						
Adj R^2	0.6195	0.4677	0.2816	0.1545	0.1475	0.1399						

Industry portfolios	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	0.0976	0.1454	0.2887	0.1898	0.0432	0.0307	-0.3085	-0.2742	-0.1784	-0.0320	0.0166	0.0269
Standard Errors	0.0701	-0.0314	-0.2025	-0.0900	-0.1194	-0.1144	-0.0523	-0.1495	-0.2049	-0.1583	-0.0917	-0.0432
P-Value	18.92%	0.06%	17.95%	5.67%	72.40%	79.31%	0.00%	8.65%	39.75%	84.27%	85.92%	54.34%
ESG dimension Dummy	0.2116	0.2169	0.2199	0.2042	0.1996	0.1099	0.1355	0.1187	0.1151	0.0596	0.0604	0.0211
Standard Errors	0.1727	0.1771	0.1795	0.1667	0.1629	0.0897	0.1016	0.0891	0.0863	0.0447	0.0453	0.0158
P-Value	24.42%	24.42%	24.42%	24.42%	24.42%	24.42%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.0503	0.0369	0.1516	0.0694	0.0435	0.1238	0.3365	0.4718	0.4659	0.5321	0.2283	0.3332
Monthly investment horizon												
Controversy Dummy	-0.3659	-0.3589	-0.3506	-0.1363	-0.1071	-0.0714	0.1805	0.0683	0.0357	0.0460	0.0667	-0.0286
Standard Errors	-0.0137	0.0284	0.2034	0.0280	0.0155	0.0325	0.0378	0.0583	0.1108	0.0271	-0.0062	0.0012
P-Value	0.00%	0.00%	10.84%	0.03%	0.00%	4.69%	0.02%	25.96%	75.19%	10.99%	0.00%	0.00%
ESG dimension Dummy	0.2258	0.2124	0.1589	0.0946	0.0735	0.0680	0.1405	0.1115	0.0863	0.0601	0.0579	0.0376
Standard Errors	0.1821	0.1712	0.1281	0.0763	0.0592	0.0548	0.1053	0.0836	0.0647	0.0451	0.0435	0.0282
P-Value	23.68%	23.68%	23.68%	23.68%	23.68%	23.68%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.1955	0.1928	0.2992	0.1397	0.1457	0.0813	0.1457	0.0870	0.2253	0.0943	0.0878	0.0420
Quarterly investment horizon												
Controversy Dummy	0.0122	0.1005	0.0844	0.0365	-0.0417	-0.0635	0.1616	0.1469	-0.0048	-0.0001	-0.0110	-0.0110
Standard Errors	-0.0768	-0.1281	-0.1334	-0.0632	0.0212	0.0442	-0.1257	-0.1248	-0.0107	-0.0732	-0.0260	0.0000
P-Value	87.60%	44.57%	53.71%	57.33%	6.92%	17.26%	21.93%	25.89%	65.89%	99.88%	67.87%	0.00%
ESG dimension Dummy	0.1147	0.1241	0.1525	0.0934	0.0859	0.0763	0.1286	0.1184	0.0744	0.0526	0.0342	0.0186
Standard Errors	0.0888	0.0961	0.1181	0.0723	0.0665	0.0591	0.0996	0.0917	0.0577	0.0408	0.0265	0.0144
P-Value	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%
Adj R^2	0.0546	0.1182	0.0844	0.0520	0.0179	0.0607	0.1403	0.1489	0.0040	0.2135	0.0988	0.0286
Annual investment horizon												
Controversy Dummy	0.1684	0.1412	0.0578	0.1354	-0.1265	0.0000	Too few observations available for non-ESG stocks					
Standard Errors	-0.0473	0.1082	0.1168	0.0134	0.0134	-0.0754						
P-Value	0.35%	21.46%	62.88%	0.00%	0.00%	100.00%						
ESG dimension Dummy	0.1806	0.2003	0.1417	0.1123	0.0974	0.0525						
Standard Errors	0.1456	0.1615	0.1142	0.0905	0.0785	0.0423						
P-Value	23.68%	23.68%	23.68%	23.68%	23.68%	23.68%						
Adj R^2	0.0627	0.1037	0.1196	0.1257	0.1217	0.2206						

Industry portfolios	ESG stocks – negative differences						Non-ESG stocks– negative differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
Controversy Dummy	0.0071	-0.0309	0.0078	-0.1108	-0.0869	-0.0817	0.0943	0.0615	0.0742	-0.0569	-0.0605	-0.0238
Standard Errors	-0.1028	-0.1404	-0.1228	-0.0213	0.0207	0.0687	-0.0186	0.0154	0.0896	0.0225	-0.0694	-0.0687
P-Value	94.58%	82.91%	95.05%	0.02%	0.10%	25.58%	0.01%	0.12%	42.07%	2.33%	39.74%	73.39%
ESG dimension Dummy	0.1100	0.1383	0.1683	0.0950	0.1017	0.0865	0.1047	0.1650	0.1584	0.1295	0.0682	0.0439
Standard Errors	0.0887	0.1115	0.1356	0.0766	0.0820	0.0697	0.0785	0.1238	0.1188	0.0971	0.0512	0.0329
P-Value	23.68%	23.68%	23.68%	23.68%	23.68%	23.68%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.1034	0.1415	0.0659	0.1304	0.0535	0.0946	0.0524	0.0149	0.0784	0.0130	0.2218	0.3064
Monthly investment horizon												
Controversy Dummy	0.0672	-0.0115	-0.0072	-0.0069	0.0146	0.0276	0.0146	0.0026	0.0149	0.0581	-0.0062	-0.0110
Standard Errors	-0.1102	-0.0798	-0.0516	-0.0120	-0.0435	0.0007	-0.0483	-0.0393	-0.0352	-0.0830	-0.0260	-0.0143
P-Value	55.19%	88.72%	89.05%	57.66%	74.27%	0.00%	76.64%	94.84%	67.75%	49.48%	81.41%	45.45%
ESG dimension Dummy	0.1143	0.1310	0.1346	0.0534	0.0448	0.0145	0.1132	0.0948	0.0688	0.0486	0.0298	0.0209
Standard Errors	0.0886	0.1015	0.1043	0.0414	0.0347	0.0112	0.0849	0.0711	0.0516	0.0364	0.0224	0.0157
P-Value	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	20.23%	20.23%	20.23%	20.23%	20.23%	20.23%
Adj R^2	0.1003	0.0540	0.0221	0.0108	0.1026	0.2383	0.0219	0.0228	0.0303	0.2603	0.1120	0.1059
Quarterly investment horizon												
Controversy Dummy	-0.0729	-0.1054	-0.0389	-0.0595	-0.0104	-0.0271	0.0389	0.0453	0.0578	0.0167	0.0036	0.0152
Standard Errors	0.1118	0.0962	0.1026	0.0897	0.0125	0.0313	0.0153	0.0051	-0.0041	0.0083	0.0108	-0.0110
P-Value	52.48%	29.16%	71.01%	51.81%	41.89%	40.18%	2.37%	0.00%	0.00%	6.19%	74.17%	18.96%
ESG dimension Dummy	0.1456	0.1190	0.0857	0.0868	0.0507	0.0384	0.1106	0.0937	0.0551	0.0507	0.0327	0.0148
Standard Errors	0.1128	0.0922	0.0664	0.0672	0.0392	0.0298	0.0856	0.0726	0.0426	0.0393	0.0254	0.0115
P-Value	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%
Adj R^2	0.0665	0.0886	0.1469	0.1148	0.0078	0.0794	0.0169	0.0218	0.0800	0.0171	0.0191	0.0919
Annual investment horizon												
Controversy Dummy	0.0079	-0.0203	-0.0089	0.0188	0.0094	0.0094	Too few observations available for non-ESG stocks					
Standard Errors	-0.1847	-0.1506	-0.0979	-0.0407	-0.0308	-0.0174						
P-Value	96.66%	89.45%	92.87%	65.07%	76.40%	59.73%						
ESG dimension Dummy	0.0527	0.0599	0.0542	0.0340	0.0292	0.0173						
Standard Errors	0.0408	0.0464	0.0420	0.0264	0.0226	0.0134						
P-Value	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%						
Adj R^2	0.6267	0.4913	0.3260	0.1455	0.1204	0.1072						

Online 4.5 Explaining economic significance: covariances of single stocks

Online 4.5.1 Collinearity

Table 14a and b: Variance Inflation Factors (VIF) for the three covariance variables $\hat{s}_{R_{H_i},R_M}$, $\hat{s}_{R_{H_i},R_{M_G}}$, and $\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$

Variance Inflation Factor (VIF) Single Stocks	$\hat{s}_{R_{H_i},R_M}$		$\hat{s}_{R_{H_i},R_{M_G}}$		$\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$		$\hat{s}_{R_{H_i},R_M}+\hat{s}_{R_{H_i},R_{M_G}}$		$\hat{s}_{R_{H_i},R_M}+\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$		$\hat{s}_{R_{H_i},R_{M_G}}+\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Monthly investment horizon												
$\hat{s}_{R_{H_i},R_M}$			15.59	13.46	25.63	11.81					31.26	18.78
$\hat{s}_{R_{H_i},R_{M_G}}$	15.59	13.46			12.22	8.95			16.21	14.68		
$\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	25.63	11.81	12.22	8.95			26.66	12.48				
Quarterly investment horizon												
$\hat{s}_{R_{H_i},R_M}$			7.79	9.02	7.81	6.3					13.52	12.32
$\hat{s}_{R_{H_i},R_{M_G}}$	7.79	9.02			4.53	4.76			58.25	9.31		
$\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	7.81	6.3	4.53	4.76			7.86	6.5				
Annual investment horizon												
$\hat{s}_{R_{H_i},R_M}$			5.19	3.81	7.9	5.99					10.23	8.77
$\hat{s}_{R_{H_i},R_{M_G}}$	5.19	3.81			44.99	33.36			16.13	48.85		
$\hat{s}^T_{R_G,R_{H_i}}\left(\hat{s}_{R_G,R_G}\right)^{-1}\hat{s}_{R_G,R_M}$	7.9	5.99	44.99	33.36			88.63	76.77				

Variance Inflation Factor (VIF) Industry portfolios	$\hat{S}_{R_{H_i},R_M}$		$\hat{S}_{R_{H_i},R_{M_G}}$		$\hat{S}^T_{R_G,R_{H_i}}\left(\hat{S}_{R_G,R_G}\right)^{-1}\hat{S}_{R_G,R_M}$		$\hat{S}_{R_{H_i},R_M}+\hat{S}_{R_{H_i},R_{M_G}}$		$\hat{S}_{R_{H_i},R_M}+\hat{S}^T_{R_G,R_{H_i}}\left(\hat{S}_{R_G,R_G}\right)^{-1}\hat{S}_{R_G,R_M}$		$\hat{S}_{R_{H_i},R_{M_G}}+\hat{S}^T_{R_G,R_{H_i}}\left(\hat{S}_{R_G,R_G}\right)^{-1}\hat{S}_{R_G,R_M}$	
	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.	pos.	neg.
Monthly investment horizon												
$\hat{S}_{R_{H_i},R_M}$			25.27	18.21	63.30	66.04					94.88	123.78
$\hat{S}_{R_{H_i},R_{M_G}}$	25.27	18.21			19.92	11.18			25.36	20.95		
$\hat{S}^T_{R_G,R_{H_i}}\left(\hat{S}_{R_G,R_G}\right)^{-1}\hat{S}_{R_G,R_M}$	63.30	66.04	16.92	11.18			63.54	75.96				
Quarterly investment horizon												
$\hat{S}_{R_{H_i},R_M}$			15.34	14.66	28.58	52.68					14.61	67.37
$\hat{S}_{R_{H_i},R_{M_G}}$	15.34	14.66			9.93	11.42			15.29	43.98		
$\hat{S}^T_{R_G,R_{H_i}}\left(\hat{S}_{R_G,R_G}\right)^{-1}\hat{S}_{R_G,R_M}$	28.58	52.68	9.93	11.42			28.47	52.51				
Annual investment horizon												
$\hat{S}_{R_{H_i},R_M}$			4.09	2.91	14047.5	1440.61					15143.54	1980.21
$\hat{S}_{R_{H_i},R_{M_G}}$	4.09	2.91			4.13	2.8			4.45	3.85		
$\hat{S}^T_{R_G,R_{H_i}}\left(\hat{S}_{R_G,R_G}\right)^{-1}\hat{S}_{R_G,R_M}$	14047.5	1440.61	4.13	2.8			15286.29	1906.45				

Online 4.5.2 Logit regression results

Online 4.5.2.1 Models with different factor loadings (but identical factors)

Table 15a to d: Logit regression results for the covariance terms that explain cost of capital differences of single stocks:

ESG stocks	
$1_{\geq benchmark}(pos.difference_{G_i}) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$	$1_{\geq benchmark}(\lvert neg.difference_{G_i}\rvert) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$
non-ESG stocks	
$1_{\geq benchmark}(pos.difference_{H_i}) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$	$1_{\geq benchmark}(\lvert neg.difference_{H_i}\rvert) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$

where cov_{G_i} and cov_{H_i} are specified in the most left column of the ensuing tables.

Single stocks	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	417.40180	657.53877	340.63885	670.96441	103.08830	594.25358	Too few observations available for non-ESG stocks					
Standard Errors	166.88511	102.61692	132.49238	88.66194	109.00967	74.23555						
P-Value	1.24%	0.00%	1.01%	0.00%	34.43%	0.00%						
Adj R^2	0.0046	0.0167	0.0050	0.0239	0.0000	0.0285						
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	17.47407	240.41617	23.48313	207.28370	32.96996	170.57178	Too few observations available for non-ESG stocks					
Standard Errors	39.45513	30.12544	36.63916	28.15472	35.52283	27.85409						
P-Value	65.78%	0.00%	52.16%	0.00%	35.33%	0.00%						
Adj R^2	-0.0007	0.0283	-0.0005	0.0237	-0.0001	0.0158						
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	35.85900	61.32727	34.20916	59.93919	30.03086	56.94494	Too few observations available for non-ESG stocks					
Standard Errors	6.57630	5.56122	5.93460	5.24633	5.57577	5.14763						
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%						
Adj R^2	0.0239	0.0670	0.0247	0.0695	0.0208	0.0642						
	ESG stocks – negative differences						**Non-ESG stocks– negative differences**					
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	26.81745	471.59818	-69.85377	539.72513	69.60194	664.16420	Too few observations available for non-ESG stocks					
Standard Errors	96.33112	70.55399	105.74923	88.15307	150.11370	139.24448						
P-Value	78.07%	0.00%	50.89%	0.00%	64.29%	0.00%						
Adj R^2	-0.0008	0.0191	-0.0005	0.0157	-0.0007	0.0096						
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	22.01445	148.96149	39.89941	144.64695	53.38115	152.54139	Too few observations available for non-ESG stocks					
Standard Errors	37.92564	32.27383	45.83683	43.37182	65.55065	63.81577						
P-Value	56.16%	0.00%	38.40%	0.09%	41.54%	1.68%						
Adj R^2	-0.0006	0.0088	-0.0003	0.0047	-0.0004	0.0020						
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	26.57473	58.27829	15.59790	55.06126	14.65313	56.26810	Too few observations available for non-ESG stocks					
Standard Errors	5.91776	5.80769	7.17298	7.26189	10.33394	10.93507						
P-Value	0.00%	0.00%	2.97%	0.00%	15.62%	0.00%						
Adj R^2	0.0135	0.0503	0.0026	0.0272	0.0007	0.0118						

Industry portfolios	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	4541.79873	20723.15764	17540.56904	13729.02212	21552.28745	15820.99620	11.39560	8.45831	9.75960	8.64207	5.38954	8.32756
Standard Errors	23062.44581	14083.77538	19649.09029	9747.23006	18159.52762	7967.28301	4.94382	3.47084	4.50930	3.09190	3.49797	2.74007
P-Value	84.39%	14.12%	37.20%	15.90%	23.53%	4.71%	2.12%	1.48%	3.04%	0.52%	12.34%	0.24%
Adj R^2	-0.0097	0.0083	0.0008	0.0061	0.0118	0.0156	0.0473	0.0272	0.0347	0.0296	0.0107	0.0394
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	72.67623	703.69646	156.73189	603.14704	251.39009	546.66075	8.13455	5.27662	5.93789	3.54370	6.35735	3.08072
Standard Errors	667.00098	332.82912	604.93505	285.34998	475.09661	250.51958	2.29723	2.13205	1.99815	1.96228	1.90401	1.85452
P-Value	91.32%	3.45%	79.56%	3.45%	59.67%	2.91%	0.04%	1.33%	0.30%	7.09%	0.08%	9.67%
Adj R^2	-0.0086	0.0176	-0.0082	0.0158	-0.0064	0.0160	0.0708	0.0239	0.0402	0.0099	0.0475	0.0077
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-307.56770	462.02923	-67.65004	355.02738	-114.50453	322.67960	5.40111	6.34338	6.25627	6.18206	1.99945	3.30921
Standard Errors	199.24448	139.83468	177.70948	123.82165	168.48429	117.59777	3.14300	2.44777	3.09091	2.41415	2.98301	2.37487
P-Value	12.27%	0.10%	70.34%	0.41%	49.67%	0.61%	8.57%	0.96%	4.30%	1.04%	50.27%	16.35%
Adj R^2	0.0098	0.0578	-0.0066	0.0357	-0.0041	0.0260	0.0090	0.0229	0.0141	0.0219	-0.0025	0.0038
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	98.67686	133.62726	85.71541	121.65379	105.36079	89.40206	Too few observations available for non-ESG stocks					
Standard Errors	28.75153	27.52278	25.55483	25.49193	26.87130	21.94912						
P-Value	0.06%	0.00%	0.08%	0.00%	0.01%	0.00%						
Adj R^2	0.1060	0.1405	0.0979	0.1268	0.1391	0.0738						
	ESG stocks – negative differences						**Non-ESG stocks– negative differences**					
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	21532.41668	8721.75405	17713.05029	9359.24107	27169.33662	3763.46068	4.43395	7.85659	8.01976	8.49604	9.06321	6.40781
Standard Errors	12476.13122	5928.25461	10632.96048	5494.04721	11602.64343	7437.12526	2.70691	2.42574	2.63942	2.41438	2.73014	2.47452
P-Value	8.44%	14.12%	9.57%	8.85%	1.92%	61.28%	10.14%	0.12%	0.24%	0.04%	0.09%	0.96%
Adj R^2	0.0211	0.0054	0.0218	0.0055	0.0585	-0.0027	0.0083	0.0426	0.0349	0.0501	0.0419	0.0224
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-156.71671	614.11433	-502.53993	371.18886	-957.15480	790.75732	4.95612	3.11076	4.04490	1.84245	3.44505	2.66887
Standard Errors	389.43854	238.36447	422.38606	269.16426	590.44097	397.85394	1.80619	1.79256	1.88215	1.84104	2.28865	2.17332
P-Value	68.74%	1.00%	23.41%	16.79%	10.50%	4.69%	0.61%	8.27%	3.16%	31.69%	13.23%	21.94%
Adj R^2	-0.0073	0.0200	0.0040	0.0023	0.0082	0.0067	0.0296	0.0082	0.0176	-0.0004	0.0077	0.0007
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-66.96059	294.01187	-50.99131	98.60414	-114.23812	147.38939	3.81681	0.04011	1.90154	-1.28306	2.76819	-2.14556
Standard Errors	192.67700	124.67283	232.81044	150.08237	304.36141	235.85604	3.36640	2.69670	4.18120	3.38539	6.16040	4.70080
P-Value	72.82%	1.84%	82.66%	51.12%	70.74%	53.20%	25.69%	98.81%	64.93%	70.47%	65.32%	64.81%
Adj R^2	-0.0066	0.0136	-0.0073	-0.0027	-0.0068	-0.0029	0.0006	-0.0038	-0.0039	-0.0030	-0.0039	-0.0026
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	91.03761	92.59661	58.01371	87.58351	9.71768	74.88392	Too few observations available for non-ESG stocks					
Standard Errors	26.02791	22.93526	25.05294	28.33219	33.82886	36.44119						
P-Value	0.05%	0.01%	2.06%	0.20%	77.39%	3.99%						
Adj R^2	0.0847	0.0613	0.0263	0.0312	-0.0065	0.0085						

	non ESG stocks – positive differences: single stocks						non-ESG stocks– positive differences: industry portfolios					
	2%	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**	**2%**	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**
Daily investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	20886.17660	11622.34580	8928.42784	5611.71346	9255.07800	12830.92292	4541.79873	20723.1576	17540.569	13729.0221	21552.2875	15820.99620
Standard Errors	-8828.90344	-4502.36587	-5746.79497	-3524.10757	-4545.94062	-2613.98987	-23062.4458	-14083.7754	-19649.0903	-9747.23006	-18159.5276	-7967.28301
P-Value	1.80%	0.98%	12.03%	11.13%	4.18%	0.00%	84.39%	14.12%	37.20%	15.90%	23.53%	4.71%
Adj R^2	0.0054	0.0024	0.0017	0.0007	0.0026	0.011	-0.0097	0.0083	0.0008	0.0061	0.0118	0.0156
Monthly investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						72.67623	703.69646	156.73189	603.14704	251.39009	546.66075
Standard Errors							-667.00098	-332.82912	-604.93505	-285.34998	-475.09661	-250.51958
P-Value							91.32%	3.45%	79.56%	3.45%	59.67%	2.91%
Adj R^2							-0.0086	0.0176	-0.0082	0.0158	-0.0064	0.016
Quarterly investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						-307.5677	462.02923	-67.65004	355.02738	-114.50453	322.67960
Standard Errors							-199.24448	-139.83468	-177.70948	-123.82165	-168.48429	-117.59777
P-Value							12.27%	0.10%	70.34%	0.41%	49.67%	0.61%
Adj R^2							0.0098	0.0578	-0.0066	0.0357	-0.0041	0.026
Annual investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												
	non ESG stocks – negative differences: single stocks						**non-ESG stocks– negative differences: industry stocks**					
Daily investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	3833.73788	14495.96127	5339.21851	14777.71023	8708.86840	10496.79349	21532.41668	8721.75405	17713.05029	9359.24107	27169.33662	3763.46068
Standard Errors	-2983.81725	-1747.08891	-2426.26953	-1605.1681	-2665.08412	-2130.29725	-12476.1312	-5928.25461	-10632.9605	-5494.04721	-11602.6434	-7437.12526
P-Value	19.88%	0.00%	2.78%	0.00%	0.11%	0.00%	8.44%	14.12%	9.57%	8.85%	1.92%	61.28%
Adj R^2	0.0007	0.0311	0.004	0.0327	0.0077	0.0072	0.0211	0.0054	0.0218	0.0055	0.0585	-0.0027
Monthly investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						-156.71671	614.11433	-502.53993	371.18886	-957.1548	790.75732
Standard Errors							-389.43854	-238.36447	-422.38606	-269.16426	-590.44097	-397.85394
P-Value							68.74%	1.00%	23.41%	16.79%	10.50%	4.69%
Adj R^2							-0.0073	0.02	0.004	0.0023	0.0082	0.0067
Quarterly investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						-66.96059	294.01187	-50.99131	98.60414	-114.23812	147.38939
Standard Errors							-192.677	-124.67283	-232.81044	-150.08237	-304.36141	-235.85604
P-Value							72.82%	1.84%	82.66%	51.12%	70.74%	53.20%
Adj R^2							-0.0066	0.0136	-0.0073	-0.0027	-0.0068	-0.0029
Annual investment horizon												
$\hat{s}_{R_G,R_{H_i}}^T(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												

	non ESG stocks – positive differences: single stocks						non-ESG stocks– positive differences: industry portfolios					
	2%	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**	**2%**	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**
Daily investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	0.90713	6.44346	1.52893	5.58181	3.10750	4.07121	11.39560	8.45831	9.75960	8.64207	5.38954	8.32756
Standard Errors	-1.37715	-0.80601	-1.06272	-0.72803	-0.84397	-0.64729	-4.94382	-3.47084	-4.5093	-3.0919	-3.49797	-2.74007
P-Value	51.01%	0.00%	15.02%	0.00%	0.02%	0.00%	2.12%	1.48%	3.04%	0.52%	12.34%	0.24%
Adj R^2	-0.0001	0.0251	0.0008	0.0238	0.0068	0.0161	0.0473	0.0272	0.0347	0.0296	0.0107	0.0394
Monthly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						8.13455	5.27662	5.93789	3.54370	6.35735	3.08072
Standard Errors							-2.29723	-2.13205	-1.99815	-1.96228	-1.90401	-1.85452
P-Value							0.04%	1.33%	0.30%	7.09%	0.08%	9.67%
Adj R^2							0.0708	0.0239	0.0402	0.0099	0.0475	0.0077
Quarterly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						5.40111	6.34338	6.25627	6.18206	1.99945	3.30921
Standard Errors							-3.143	-2.44777	-3.09091	-2.41415	-2.98301	-2.37487
P-Value							8.57%	0.96%	4.30%	1.04%	50.27%	16.35%
Adj R^2							0.009	0.0229	0.0141	0.0219	-0.0025	0.0038
Annual investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												
	non ESG stocks – negative differences: single stocks						**non-ESG stocks– negative differences: industry stocks**					
Daily investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	6.31768	1.93425	4.48834	3.16817	3.55435	5.25290	4.43395	7.85659	8.01976	8.49604	9.06321	6.40781
Standard Errors	-0.68087	-0.57828	-0.63495	-0.57525	-0.68454	-0.69975	-2.70691	-2.42574	-2.63942	-2.41438	-2.73014	-2.47452
P-Value	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	10.14%	0.12%	0.24%	0.04%	0.09%	0.96%
Adj R^2	0.0394	0.0041	0.0213	0.0117	0.0109	0.0231	0.0083	0.0426	0.0349	0.0501	0.0419	0.0224
Monthly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						4.95612	3.11076	4.04490	1.84245	3.44505	2.66887
Standard Errors							-1.80619	-1.79256	-1.88215	-1.84104	-2.28865	-2.17332
P-Value							0.61%	8.27%	3.16%	31.69%	13.23%	21.94%
Adj R^2							0.0296	0.0082	0.0176	-0.0004	0.0077	0.0007
Quarterly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						3.81681	0.04011	1.90154	-1.28306	2.76819	-2.14556
Standard Errors							-3.3664	-2.6967	-4.1812	-3.38539	-6.1604	-4.7008
P-Value							25.69%	98.81%	64.93%	70.47%	65.32%	64.81%
Adj R^2							0.0006	-0.0038	-0.0039	-0.003	-0.0039	-0.0026
Annual investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												

Online 4.5.2.2 Models with different factors and factor loadings

Table 16a to d: Logit regression results for the covariance terms that explain cost of capital differences of single stocks:

ESG stocks	
$1_{\geq benchmark}(pos.difference_{G_i}) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$	$1_{\geq benchmark}(\lvert neg.difference_{G_i} \rvert) = a + b \cdot cov_{G_i} + \varepsilon_{G_i}$
non-ESG stocks	
$1_{\geq benchmark}(pos.difference_{H_i}) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$	$1_{\geq benchmark}(\lvert neg.difference_{H_i} \rvert) = a + b \cdot cov_{H_i} + \varepsilon_{H_i}$

where cov_{G_i} and cov_{H_i} are specified in the most left column of the ensuing tables.

Single stocks	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	715.7404	339.8759	203.5615	8.1696	467.9108	595.0887	Too few observations available for non-ESG stocks					
Standard Errors	148.7835	141.6627	148.1113	185.6328	260.3762	383.435						
P-Value	0.00%	1.64%	16.93%	96.49%	7.23%	12.07%						
Adj R^2	0.0261	0.0058	0.0013	-0.0012	0.0034	0.0024						
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	114.8066	81.1418	47.436	49.9478	100.2471	164.9611	Too few observations available for non-ESG stocks					
Standard Errors	38.9003	39.4857	43.1508	55.7676	75.3904	117.7019						
P-Value	0.32%	3.99%	27.16%	37.04%	18.36%	16.11%						
Adj R^2	0.0065	0.0027	0.0002	-0.0002	0.0004	0.0004						
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	28.8722	34.6026	42.5932	40.9407	53.6087	43.4465	Too few observations available for non-ESG stocks					
Standard Errors	8.197	8.9908	10.0253	12.8108	16.4153	26.9168						
P-Value	0.04%	0.01%	0.00%	0.14%	0.11%	10.65%						
Adj R^2	0.0132	0.0165	0.0218	0.0116	0.0108	0.0025						
	ESG stocks – negative differences						**Non-ESG stocks– negative differences**					
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	2154.9384	2016.8849	1737.9578	1626.8666	1665.2368	1567.79	Too few observations available for non-ESG stocks					
Standard Errors	101.2306	104.7821	115.0041	147.0639	200.0461	283.0041						
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%						
Adj R^2	0.2326	0.1909	0.1081	0.0586	0.0315	0.014						
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	611.1569	617.3356	557.7327	523.8018	619.0887	486.5695	Too few observations available for non-ESG stocks					
Standard Errors	38.6371	41.5619	45.1034	55.8211	75.2472	122.8957						
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%						
Adj R^2	0.1422	0.128	0.0897	0.0537	0.0474	0.008						
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	55.7669	51.8319	56.6205	62.6622	59.7221	89.0821	Too few observations available for non-ESG stocks					
Standard Errors	5.9181	6.741	8.3486	11.3471	14.5133	22.5405						
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%						
Adj R^2	0.0346	0.0234	0.0187	0.013	0.0069	0.0042						

Industry portfolios	ESG stocks – positive differences						Non-ESG stocks– positive differences					
	2%	1.50%	1%	0.50%	0.25%	0.10%	2%	1.50%	1%	0.50%	0.25%	0.10%
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	189.417	-117.2322	5767.0431	5640.6364	-4286.8049	-10136.2627	2.5487	1.7379	2.2596	0.6297	-0.4341	-11.1717
Standard Errors	8410.016	7756.5102	7269.8447	7555.6071	9904.2124	14976.5202	2.336	2.1659	2.1975	2.6014	3.6456	6.2914
P-Value	98.20%	98.79%	42.76%	45.53%	66.51%	49.85%	27.52%	42.23%	30.38%	80.87%	90.52%	7.58%
Adj R^2	-0.0059	-0.0059	-0.002	-0.0028	-0.0051	-0.0047	0.0007	-0.0013	0.0002	-0.0032	-0.0034	0.0059
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	496.0756	290.3729	339.4116	554.481	583.4203	469.1181	3.3369	2.2252	1.3609	-2.1623	-1.0021	0.6552
Standard Errors	362.6414	383.5336	421.9558	510.7192	689.9494	1008.1849	2.0999	2.1891	2.552	3.4463	5.1191	6.8142
P-Value	17.13%	44.90%	42.12%	27.76%	39.78%	64.17%	11.20%	30.94%	59.39%	53.04%	84.48%	92.34%
Adj R^2	0.0066	-0.0035	-0.0025	-0.0011	-0.0034	-0.0068	0.0063	-0.0007	-0.0039	-0.004	-0.005	-0.0051
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-128.5973	-178.1371	-256.7201	-244.6853	2.763	-8.7276	-2.933	-4.5881	-2.1039	-2.8982	-10.9948	-14.6528
Standard Errors	160.6232	168.9281	187.0566	233.6751	269.2053	408.6079	3.3238	3.624	4.2607	5.5098	8.9871	13.7139
P-Value	42.34%	29.16%	16.99%	29.50%	99.18%	98.30%	37.75%	20.55%	62.14%	59.89%	22.12%	28.53%
Adj R^2	-0.0021	0.0007	0.0051	-0.0011	-0.0057	-0.0057	0.0005	0.0082	-0.0029	-0.0038	-0.0075	-0.0092
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-0.8579	-1.8699	-5.0805	-10.759	-31.5276	-42.9699	Too few observations available for non-ESG stocks					
Standard Errors	21.823	23.0967	24.6678	30.4428	33.2301	50.0954						
P-Value	96.86%	93.55%	83.68%	72.38%	34.27%	39.10%						
Adj R^2	-0.0092	-0.0092	-0.0089	-0.0084	-0.0038	-0.0043						
	ESG stocks – negative differences						**Non-ESG stocks– negative differences**					
Daily investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-2367.081	-2674.2397	3461.513	-4663.887	-6956.9492	-1347.9563	-7.2475	-6.1418	-3.6216	-2.6814	-3.1698	-1.7595
Standard Errors	8093.483	6828.7978	6342.1188	7041.7938	8914.5419	13735.2676	3.4282	2.8422	2.6622	2.9992	4.037	5.9859
P-Value	76.99%	69.53%	58.52%	50.78%	43.52%	92.18%	3.45%	3.07%	17.37%	37.13%	43.23%	76.88%
Adj R^2	-0.004	-0.0037	-0.003	-0.0024	-0.0016	-0.0043	0.0169	0.0224	0.0043	-0.0016	-0.0017	-0.0048
Monthly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-82.2871	124.9103	386.5522	419.903	675.0027	1034.5644	-0.8183	-0.2614	-2.1462	-2.134	-5.1523	-1.9104
Standard Errors	253.2009	286.0684	364.3588	543.561	709.9623	997.0833	1.7829	1.9315	2.2226	2.8746	4.0625	6.6303
P-Value	74.52%	66.24%	28.87%	43.98%	34.17%	29.95%	64.62%	89.24%	33.42%	45.79%	20.47%	77.32%
Adj R^2	-0.0032	-0.003	0.0004	-0.0012	-0.0001	0.0016	-0.0028	-0.0034	-0.0007	-0.0021	-0.0003	-0.0033
Quarterly investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	197.6971	292.1428	155.8583	248.9701	235.6429	353.5694	-0.4832	0.0042	2.3312	-11.314	0.9697	19.3105
Standard Errors	124.71	134.0584	156.8339	175.43	222.6387	333.7791	3.0932	3.5685	4.2906	5.5237	9.8399	19.5665
P-Value	11.29%	2.93%	32.03%	15.58%	28.99%	28.95%	87.59%	99.91%	58.69%	4.05%	92.15%	32.37%
Adj R^2	0.0073	0.0201	0.0012	0.0086	-0.0001	0.0011	-0.0037	-0.0038	-0.0023	0.0146	-0.0038	-0.0048
Annual investment horizon												
$\hat{S}_{R_{G_i},R_M}, \hat{S}_{R_{G_i},R_M}$	-8.6438	3.0145	-9.7614	-7.2779	15.4797	-36.0174	Too few observations available for non-ESG stocks					
Standard Errors	20.6896	22.8149	28.8395	41.6351	50.1347	65.6352						
P-Value	67.61%	89.49%	73.50%	86.12%	75.75%	58.32%						
Adj R^2	-0.0029	-0.0034	-0.0031	-0.0034	-0.0033	-0.0032						

	non ESG stocks – positive differences: single stocks						non-ESG stocks– positive differences: industry portfolios					
	2%	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**	**2%**	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**
Daily investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	5.3759	5.9199	5.4787	4.2883	3.414	3.2222	4.1718	3.1422	3.6882	2.1811	1.357	-10.0406
Standard Errors	0.7175	0.6273	0.5973	0.6826	0.8925	1.356	2.3358	2.159	2.1935	2.5738	3.5847	6.1573
P-Value	0.00%	0.00%	0.00%	0.00%	0.01%	1.75%	7.41%	14.56%	9.27%	39.68%	70.50%	10.30%
Adj R^2	0.0212	0.0321	0.0311	0.0143	0.005	0.0017	0.008	0.0039	0.0064	-0.0005	-0.0029	0.0058
Monthly investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						3.4237	2.0338	0.9145	-2.2251	-1.3485	0.5097
Standard Errors							2.111	2.1924	2.5497	3.4319	5.0909	6.8222
P-Value							10.48%	35.36%	71.98%	51.68%	79.11%	94.04%
Adj R^2							0.007	-0.0013	-0.0045	-0.0038	-0.0048	-0.0051
Quarterly investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						-3.4125	-4.812	-3.0048	-3.0242	-10.8152	-15.294
Standard Errors							3.2856	3.5826	4.1756	5.4428	9.0378	13.6554
P-Value							29.90%	17.92%	47.18%	57.85%	23.14%	26.27%
Adj R^2							0.0029	0.0104	-0.0004	-0.0036	-0.0069	-0.0098
Annual investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												
	non ESG stocks – negative differences: single stocks						**non-ESG stocks– negative differences: industry stocks**					
Daily investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	12.8276	11.1256	8.9694	6.4165	5.5863	3.93	-6.1577	-4.9279	-2.8665	-2.2453	-2.2935	-0.5338
Standard Errors	0.8731	0.7641	0.6869	0.7154	0.9037	1.288	3.4039	2.7849	2.6061	2.9344	3.9366	5.875
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.23%	7.05%	7.68%	27.14%	44.42%	56.02%	92.76%
Adj R^2	0.1237	0.1148	0.0898	0.041	0.017	0.0037	0.0115	0.0135	0.001	-0.0026	-0.0031	-0.0051
Monthly investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						-0.5598	0.1946	-1.6356	-1.7229	-5.5568	-2.4105
Standard Errors							1.7711	1.924	2.209	2.8601	3.9902	6.5146
P-Value							75.19%	91.94%	45.90%	54.69%	16.37%	71.14%
Adj R^2							-0.0032	-0.0034	-0.0018	-0.0025	0.0005	-0.0031
Quarterly investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						-0.1199	0.3955	2.8291	-10.0966	0.0427	18.0078
Standard Errors							3.1002	3.5814	4.3258	5.5137	9.7952	19.8373
P-Value							96.92%	91.21%	51.31%	6.71%	99.65%	36.40%
Adj R^2							-0.0038	-0.0038	-0.0017	0.0118	-0.0038	-0.0046
Annual investment horizon												
$\hat{s}^T_{R_G,R_{H_i}}(\hat{s}_{R_G,R_G})^{-1}\hat{s}_{R_G,R_M}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												

	non ESG stocks – positive differences: single stocks						non-ESG stocks– positive differences: industry portfolios					
	2%	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**	**2%**	**1.50%**	**1%**	**0.50%**	**0.25%**	**0.10%**
Daily investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	2.8872	3.9917	3.7266	2.9362	2.4655	2.0285	0.7165	-0.0125	0.6598	-0.9881	-2.3185	-11.5192
Standard Errors	0.6582	0.5744	0.5494	0.6342	0.8342	1.2657	2.1377	1.9933	2.0241	2.4169	3.3969	5.9648
P-Value	0.00%	0.00%	0.00%	0.00%	0.31%	10.90%	73.75%	99.50%	74.44%	68.27%	49.49%	5.35%
Adj R^2	0.007	0.0173	0.0167	0.0075	0.0027	0.0005	-0.0031	-0.0035	-0.0031	-0.0027	-0.0014	0.0046
Monthly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						3.218	2.165	1.5692	-2.028	-0.6955	0.1724
Standard Errors							1.9645	2.0485	2.3937	3.2233	4.795	6.3448
P-Value							10.14%	29.06%	51.21%	52.92%	88.47%	97.83%
Adj R^2							0.0073	-0.0003	-0.0032	-0.0039	-0.005	-0.0051
Quarterly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						-2.9118	-4.668	-1.9355	-2.5223	-8.4422	-12.3307
Standard Errors							3.1565	3.4538	4.0531	5.2723	9.3088	14.241
P-Value							35.63%	17.65%	63.30%	63.24%	36.45%	38.66%
Adj R^2							0.0007	0.0091	-0.0031	-0.004	-0.0056	-0.0071
Annual investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												
	non ESG stocks – negative differences: single stocks						**non-ESG stocks– negative differences: industry stocks**					
Daily investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	12.4613	11.4682	9.4824	7.2972	6.0715	4.2224	-6.7665	-6.3839	-4.051	-3.2089	-5.0812	-5.6513
Standard Errors	0.8242	0.7365	0.6559	0.6692	0.8276	1.1684	3.1707	2.6293	2.4534	2.7592	3.7395	5.5265
P-Value	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	3.28%	1.52%	9.87%	24.48%	17.42%	30.65%
Adj R^2	0.1295	0.1376	0.1163	0.0632	0.0248	0.0052	0.017	0.0283	0.0089	0.0012	0.0059	-0.0003
Monthly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						-1.6615	-1.0235	-2.3896	-2.5459	-5.1469	-2.1361
Standard Errors							1.6764	1.8097	2.0923	2.7015	3.8704	6.2324
P-Value							32.16%	57.17%	25.34%	34.60%	18.36%	73.18%
Adj R^2							-0.0002	-0.0024	0.0004	-0.0012	-0.0001	-0.0032
Quarterly investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						-2.0585	-1.7263	0.9979	-12.8045	1.682	17.8946
Standard Errors							2.8778	3.3078	3.9633	5.461	9.1717	18.7459
P-Value							47.44%	60.17%	80.12%	1.90%	85.45%	33.98%
Adj R^2							-0.0017	-0.0027	-0.0035	0.0211	-0.0038	-0.0046
Annual investment horizon												
$\hat{S}_{R_{H_i},R_{M_G}}$	Too few observations available for non-ESG stocks						Too few observations available for non-ESG stocks					
Standard Errors												
P-Value												
Adj R^2												

Online 4.6 Cost of capital empirical versus theory-based: different statistical significance of explanatory variables

Online 4.6.1 Models with different factor loadings (but identical factors)

Table 19a to c: Percentage of explanatory variables whose significance level changes (increase or decrease) from an arbitrary value x to 10% (5%, 1%) when explaining regression-based compared to theory-based cost of capital:

$$coc_{regr,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$
$$coc_{theo,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$

Three data sets were excluded because no differentiation in ESG rating was possible: MSCI USA Select ESG & Trend Leaders index, MSCI KLD 400 Social Index, and Refinitiv/S-Network ESG Best Practices Index.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{s}_{R_G,R_G}$ non-invertible.

Significance Level	10%				5%				1%			
No distinction between ESG and non-ESG stocks	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**
Thomson Reuters ESG Combined Score A and better	0%	0%	0%	25%	25%	0%	0%	0%	0%	0%	0%	0%
Thomson Reuters ESG Combined Score A- and better	0%	0%	0%		0%	0%	0%		0%	0%	0%	
Sustainalytics Total ESG Score Negligible and Low	50%	50%			50%	25%			25%	25%		
Sustainalytics Total ESG Score Negligible, Low and Medium	0%				0%				0%			
Sustainalytics Environment Score Negligible, Low and Medium	0%				0%				0%			
Sustainalytics Social Score Negligible, Low and Medium	0%				0%				25%			
Sustainalytics Governance Score Negligible, Low and Medium	0%				0%				0%			
Sustainalytics Controversy Score No Controversy	0%	0%	0%	0%	0%	25%	0%	0%	25%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	25%	0%	0%		0%	25%	0%		25%	0%	25%	
Upright Absolute Net Impact Score Positive Only	0%	0%			0%	0%			0%	0%		
Upright Absolute Net Impact Score Above Average of Positive Only	25%	25%	25%		0%	0%	0%		0%	0%	0%	
Upright Absolute Environment Impact Score Positive Only	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 10	0%	0%	0%		0%	0%	0%		0%	0%	0%	
RepRisk RRI Below or Equal 30	0%				0%				0%			
RepRisk Rating A and better	0%	0%			0%	0%			25%	0%		
RepRisk Rating BB and better	0%				25%				25%			

Significance Level	**10%**				**5%**				**1%**			
Solely ESG stocks considered	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**
Thomson Reuters ESG Combined Score A and better	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%	0%
Thomson Reuters ESG Combined Score A- and better	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Total ESG Score Negligible and Low	0%	25%	0%	0%	0%	25%	0%	0%	0%	0%	25%	0%
Sustainalytics Total ESG Score Negligible, Low and Medium	25%	25%	25%	25%	0%	0%	0%	0%	0%	0%	25%	0%
Sustainalytics Environment Score Negligible, Low and Medium	0%	0%	0%	0%	25%	0%	0%	25%	0%	0%	0%	0%
Sustainalytics Social Score Negligible, Low and Medium	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Governance Score Negligible, Low and Medium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Controversy Score No Controversy	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Upright Absolute Net Impact Score Positive Only	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Upright Absolute Net Impact Score Above Average of Positive Only	0%	0%	0%	0%	0%	25%	25%	0%	50%	50%	25%	0%
Upright Absolute Environment Impact Score Positive Only	*											
RepRisk RRI Below or Equal 10	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 30	0%	25%	0%	0%	0%	0%	25%	0%	0%	0%	0%	0%
RepRisk Rating A and better	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk Rating BB and better	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%

* In the case of Upright Absolute Environment Impact Score Positive Only no results were obtained since number of stocks was less than the number of explanatory variables used in the regression.

Significance Level	**10%**				**5%**				**1%**			
Solely non-ESG stocks considered	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**
Thomson Reuters ESG Combined Score A and better	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%
Thomson Reuters ESG Combined Score A- and better	0%	0%	0%		0%	0%	0%		0%	0%	0%	
Sustainalytics Total ESG Score Negligible and Low	25%	25%			25%	25%			0%	0%		
Sustainalytics Total ESG Score Negligible, Low and Medium	0%				0%				25%			
Sustainalytics Environment Score Negligible, Low and Medium	0%				0%				0%			
Sustainalytics Social Score Negligible, Low and Medium	0%				0%				25%			
Sustainalytics Governance Score Negligible, Low and Medium	*				*				*			
Sustainalytics Controversy Score No Controversy	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	0%	0%	0%		0%	0%	0%		0%	0%	0%	
Upright Absolute Net Impact Score Positive Only	0%	25%			0%	25%			0%	25%		
Upright Absolute Net Impact Score Above Average of Positive Only	0%	0%	25%		0%	25%	0%		0%	0%	25%	
Upright Absolute Environment Impact Score Positive Only	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 10	0%	0%	0%		0%	0%	0%		0%	0%	0%	
RepRisk RRI Below or Equal 30	0%				0%				0%			
RepRisk Rating A and better	0%	0%			0%	0%			0%	0%		
RepRisk Rating BB and better	0%				0%				0%			

* In the case of Sustainalytics Environment Score Negligible, Low and Medium no results were obtained since number of stocks was less than the number of explanatory variables used in the regression.

Online 4.6.2 Models with different factor loadings (but identical factors)

Table 20a to c: Percentage of explanatory variables whose significance level changes (increase or decrease) from an arbitrary value x to 10% (5%, 1%) when explaining regression-based compared to theory-based cost of capital:

$$coc_{regr,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$
$$coc_{theo,i} = a + b_{ESG} \cdot ESGrating_i + b_{mv} \cdot market\ value_i + b_{ta} \cdot total\ asset_i + b_{oi} \cdot operating\ income_i + \varepsilon_i$$

Three data sets were excluded because no differentiation in ESG rating was possible: MSCI USA Select ESG & Trend Leaders index, MSCI KLD 400 Social Index, and Refinitiv/S-Network ESG Best Practices Index.
Empty cells signify that cost of capital according to Equation (4) cannot be computed because the number of observations in the sample is less than the number of ESG stocks rendering $\hat{S}_{R_G,R_G}$ non-invertible.

Significance Level	10%				5%				1%			
No distinction between ESG and non-ESG stocks	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**
Thomson Reuters ESG Combined Score A and better	25%	25%	25%	75%	25%	25%	25%	25%	25%	25%	25%	0%
Thomson Reuters ESG Combined Score A- and better	25%	50%	100%		25%	25%	50%		25%	25%	0%	
Sustainalytics Total ESG Score Negligible and Low	25%	0%			25%	0%			50%	25%		
Sustainalytics Total ESG Score Negligible, Low and Medium	25%				25%				50%			
Sustainalytics Environment Score Negligible, Low and Medium	25%				25%				25%			
Sustainalytics Social Score Negligible, Low and Medium	50%				50%				25%			
Sustainalytics Governance Score Negligible, Low and Medium	25%				25%				25%			
Sustainalytics Controversy Score No Controversy	25%	25%	75%	25%	50%	25%	75%	25%	0%	25%	25%	0%
Sustainalytics Controversy Score No and Low Controversy	25%	25%	25%		25%	0%	0%		0%	0%	0%	
Upright Absolute Net Impact Score Positive Only	25%	0%			25%	25%			0%	50%		
Upright Absolute Net Impact Score Above Average of Positive Only	25%	50%	0%		25%	50%	0%		0%	25%	0%	
Upright Absolute Environment Impact Score Positive Only	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 10	25%	0%	50%		25%	50%	25%		25%	50%	0%	
RepRisk RRI Below or Equal 30	25%				50%				25%			
RepRisk Rating A and better	25%	25%			50%	25%			50%	0%		
RepRisk Rating BB and better	25%				50%				25%			

Significance Level	**10%**				**5%**				**1%**			
Solely ESG stocks considered	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**
Thomson Reuters ESG Combined Score A and better	0%	75%	0%	25%	0%	50%	25%	0%	0%	50%	25%	0%
Thomson Reuters ESG Combined Score A- and better	0%	25%	50%	25%	50%	25%	50%	25%	0%	0%	25%	0%
Sustainalytics Total ESG Score Negligible and Low	25%	25%	75%	25%	0%	0%	50%	0%	25%	0%	0%	0%
Sustainalytics Total ESG Score Negligible, Low and Medium	50%	50%	50%	0%	50%	50%	50%	0%	25%	50%	50%	0%
Sustainalytics Environment Score Negligible, Low and Medium	50%	50%	50%	0%	50%	50%	50%	0%	25%	25%	50%	0%
Sustainalytics Social Score Negligible, Low and Medium	25%	50%	50%	50%	50%	25%	50%	25%	25%	0%	25%	0%
Sustainalytics Governance Score Negligible, Low and Medium	25%	50%	50%	0%	25%	50%	50%	25%	50%	50%	25%	0%
Sustainalytics Controversy Score No Controversy	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sustainalytics Controversy Score No and Low Controversy	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Upright Absolute Net Impact Score Positive Only	25%	0%	50%	25%	25%	25%	50%	25%	25%	50%	25%	25%
Upright Absolute Net Impact Score Above Average of Positive Only	0%	0%	25%	0%	25%	0%	25%	25%	50%	25%	0%	50%
Upright Absolute Environment Impact Score Positive Only	*											
RepRisk RRI Below or Equal 10	25%	25%	50%	0%	25%	0%	25%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 30	0%	50%	50%	50%	25%	50%	50%	50%	25%	25%	25%	25%
RepRisk Rating A and better	25%	50%	75%	25%	25%	50%	75%	25%	0%	25%	50%	0%
RepRisk Rating BB and better	0%	25%	25%	25%	25%	25%	25%	50%	25%	0%	25%	25%

* In the case of Upright Absolute Environment Impact Score Positive Only no results were obtained since number of stocks was less than the number of explanatory variables used in the regression.

Significance Level	**10%**				**5%**				**1%**			
Solely non-ESG stocks considered	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**	**Daily**	**Monthly**	**Quarterly**	**Annual**
Thomson Reuters ESG Combined Score A and better	25%	25%	25%	50%	25%	0%	25%	25%	25%	25%	25%	0%
Thomson Reuters ESG Combined Score A- and better	25%	25%	75%		25%	0%	50%		0%	25%	0%	
Sustainalytics Total ESG Score Negligible and Low	0%	0%			0%	0%			0%	0%		
Sustainalytics Total ESG Score Negligible, Low and Medium	50%				50%				25%			
Sustainalytics Environment Score Negligible, Low and Medium	0%				0%				0%			
Sustainalytics Social Score Negligible, Low and Medium	0%				0%				0%			
Sustainalytics Governance Score Negligible, Low and Medium	*				*				*			
Sustainalytics Controversy Score No Controversy	25%	25%	75%	25%	25%	25%	75%	0%	0%	25%	25%	0%
Sustainalytics Controversy Score No and Low Controversy	25%	25%	0%		25%	0%	0%		0%	0%	0%	
Upright Absolute Net Impact Score Positive Only	0%	0%			25%	0%			25%	0%		
Upright Absolute Net Impact Score Above Average of Positive Only	0%	50%	25%		0%	75%	0%		0%	25%	0%	
Upright Absolute Environment Impact Score Positive Only	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RepRisk RRI Below or Equal 10	25%	25%	0%		25%	25%	0%		0%	25%	0%	
RepRisk RRI Below or Equal 30	25%				50%				0%			
RepRisk Rating A and better	25%	25%			25%	0%			0%	0%		
RepRisk Rating BB and better	25%				50%				0%			

* In the case of Sustainalytics Environment Score Negligible, Low and Medium no results were obtained since number of stocks was less than the number of explanatory variables used in the regression.