# Are You Betting On Sustainability?

Fabio Franceschini*

13th February 2025

**Abstract**

When sustainability of assets is appreciated, its effect on the discount rates does not depend on the sustainability of the asset priced only, but it is intrinsically mediated by the risk profile of the asset itself. This has significant implications for the measurement of the actual spreads associated to sustainability concerns in financial markets as well as for hedging changes in the sustainability concerns. Specifically, (1) average returns of long-short portfolios of assets sorted on sustainability can be totally unrelated to the priced spread and (2) the effectiveness of assets in hedging changes to the sustainability concerns will depend on assets' 'sustainability intensity' and their risk *jointly*. The main implications are tested on a ESG score measure for US stocks, revealing, in fact, a detachment between the average excess return of a high-minus-low ESG portfolio and the measured ESG spread.

**Keywords:** Asset Pricing, Portfolio Choice, ESG, Sustainable Investment

**JEL Codes:** D62, G11, G12, M14, Q5

## Acknowledgements

This study was funded by the European Union - NextGenerationEU, in the framework of the "GRINS -Growing Resilient, INclusive and Sustainable project" (PNRR - M4C2 - I1.3 - PE00000018 – CUP J33C22002910001). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Union be held responsible for them. I thank Davide Stocco and Giuseppe Cavaliere, as well as the participants of The Second International Conference on the Climate-Macro-Finance Interface, for their useful comments.

## 1 Introduction

To manage generational challenges such as climate change, the economy needs to transition into a more sustainable one. This requires a great mobilization of capital, which has in fact started flowing towards investments where Environmental, Social and Governance (ESG) factors are considered in the allocation process. Leaving aside issues concerning close literatures, even critical ones such as what exactly is 'sustainable', a key economic concern about this phenomenon is understanding the *value* of economic activities' 'sustainability'.

*Department of Economics, University of Bologna (Italy); f.franceschini@unibo.it.

The financial literature approaches this by studying the ties between the 'sustainability' characteristic and the discount rates that are applied to assess economic activities' value, which directly reflects how investors' welfare is impacted by sustainability.[1] This paper highlights a peculiar role of assets' risk in the effect of sustainability on the discount rates. Specifically, it is shown that, when risk factors' sustainability level (such as the market's) impact investors, a non-zero market-wide spread associated to sustainability will affect assets' discount rates depending on the asset sustainability score and its risk *jointly*. This implies that average excess returns of naive long-short portfolios of assets sorted on sustainability cannot reliably measure the priced sustainability spread. Also, assets' ability to hedge shocks to sustainability concerns will not only depend on their sustainability intensity.

More specifically, assets' sustainability can affect investors welfare (1) directly, by providing non-pecuniary benefits, as in Pástor et al. (2021); (2) by affecting consumption with inherently different cash flows from the less sustainable counterparts (e.g. being more profitable or hedging better climate and regulations shocks), such as in Yang (2022); or (3) via both, as in Pedersen et al. (2021). While the second channel can have very rich mechanisms and implications, the first one distinctly predicts more sustainable project to have lower expected return than that of an equivalent non-sustainable counterpart.[2] I build on that, showing that increases in the sustainability premium do not impact returns depending on the assets' sustainability measure only, but on their riskiness too. In more practical terms, in a CAPM world, two assets could be identically sustainable, but, if they had different betas, they would react differently to increases in concerns. The reason is that the spread in returns due to sustainability is not only related to sustainability in the first place: it depends on the difference, in the CAPM example, between beta and the sustainability of the asset relatively to the market. This happens because one can always reach the same level of risk of an asset by levering the market, obtaining, per dollar spent, the market ESG score. It follows that only assets with ESG scores greater than the ESG provided by the equivalently-levered market should be appreciated for the sustainability contribution to the portfolio.

I show this mechanism with a simple model, similar to Pástor et al. (2021) in aim and implications, but more flexible in accommodating multiple risk factors and in allowing more interpretations to the sustainability premium's origin. Specifically, a standard investor who maximises expected utility is faced with an inequality constraint on the average ESG score of its portfolio, which, when binding, places a 'sustainability multiplier' in the optimality conditions very similar to that of an agent with linear preferences for sustainability. While the distinction between linear preferences and a binding constraint appears of second order of relevance, I favour this formulation because once sustainability is modelled as affecting welfare, it is not obvious why it should do so in a linear way, while a constraint can well

[1] See, for example, Pástor et al. (2021), Pedersen et al. (2021) and Zerbib (2022).

[2] This, in a way, has been challenged by the empirical observation that in recent years more environmentally-sustainable ('green') assets had higher returns, not lower. However, as clearly shown by Pástor et al. (2022), this is likely due to sustained increases in environmental concerns that intensified the demand for greener assets. This, in turn, while lowering expected returns of greener assets, mechanically lead to greater contemporaneous returns.

be closely interpreted as a requirement set by households to intermediaries, or even as a physical requirement to achieve aggregate environmental targets, e.g. emit less than a certain amount of CO2 to avoid catastrophes. The model boils down to a pricing equation that, with standard CAPM assumptions on either returns distribution or wealth utility functional form, closely adheres to the results in Pástor et al. (2021). Nonetheless, following Franceschini (2023), I also show a way to extend the analysis to a more realistic multi-factor setting, keeping track of all the risks with a synthetic measure. This theoretical formulation enables empirical analysis that are potentially able to distinguish between the static ESG-'preferences' premium and the premia associated with sustainability-risk motives, via wealth dynamics or sustainability dynamics directly – as that displayed in the climate extension of the model of Pástor et al. (2021).

Theoretically, ceteris paribus, more sustainable firms are expected to yield lower returns, which is a known result. The main result, however, is that determining how assets react to sustainability concern shocks is not a straightforward because the premium for sustainability is proportional to the difference between risk and the asset sustainability relative to the market. Specifically, to be positively covarying with concerns overall, the relative sustainability has to be greater than the risk (one can think of the beta in the CAPM formulation). This is an important fact to establish because it affects the hedging abilities of most standard 'sustainability' portfolios, such as a market-neutral portfolio that is long on more sustainable assets and short on the least ones. In facts, this portfolio earns the sustainability-spread proportionally to the difference in sustainability of the two components forming it *minus* the difference in the risk levels of the two. Thus, for certain cross-sectional risk distributions, the spread could perfectly be negative while this portfolio's average return is consistently positive. It follows that contemporaneous returns of this sustainability portfolio in reaction to changes in the sustainability spread can make it an effective or a terrible hedge. Also, while this consideration might not have had an impact until now, it might in the future. For example, were the greener assets to be given better funding to invest in innovation, they would become riskier in the cross-section and this would harm their ability of hedging later shocks to environmental concerns.[3]

This theoretically holds for any characteristic that is associated with a constraint on the portfolio weighted value. Empirically, I test whether Refinitiv ESG data is relevant in this sense in US data and how the risk profile of a high-minus-low portfolio impacts its expected returns, which in turn determine its hedging abilities. Marginal utilities are proxied by three sets of factors: the market, the 3 factors from Fama and French (1993) and the market plus two factors agnostically extracted from the test assets returns. In principles, the agnostic factors can capture the sustainability risks that can also affect expected returns besides the

[3]From an aggregate perspective, green innovation mitigates environmental concerns. So, green firms increasing innovation efforts would work as an hedge to environmental concern, but once the innovation levels are set, and with them the new risk levels, their ability of hedge later shocks to environment concerns would likely worsen. Notice that whether mitigating environmental issues is pro- or counter-cyclical is not obvious, as highlighted by Giglio et al. (2021), so whether greener firms' returns show a positive or negative sensitivity to environment concerns is not so clear either. Consequently, the effect of more aggregate green innovation is not necessarily counter-acting the argument made in the example.

'static' sustainability spread. The analysis return a sustainability-related spread that is not significant in all specifications, but it is always negative. The crucial result is that in the specifications where the sustainability multiplier is significantly different from 0, the excess return of the long-short sustainability portfolio is not, and vice-versa. These implications can and will have to be tested on more sustainability dimensions,[4] such as CO2 emissions, and possibly other countries too. For some sustainability measures, the theoretical framework can easily be extended to include sustainable bonds, which reduces the number of relevant parameters to be estimated.

This study is clearly related to the recent theoretical literature on ESG investment, most importantly with Pástor et al. (2021) and Pedersen et al. (2021), to which this paper adds the study of the peculiar role that risk, in its generality, has in sustainability premium dynamics. This model resembles the model of Pedersen et al. (2021) if it was only populated by investors who have average ESG score in the utility function and ESG scores had no informational value on fundamentals. They end up characterizing the security market line in terms of Sharpe Ratios and Sustainability Score (relative to the market's), reaching the similar conclusions that alphas relative to CAPM depend on individual ESG scores. As they consider a predictive power of ESG scores on profits, however, a higher relative ESG does not guarantee a lower expected return in their model. Just as with Pástor et al. (2021), this paper departs by considering risk beyond mean-variance optimization set-ups and displays in greater detail risk's impact on predictions that seem to be independent from it, such as the expected returns on market-neutral sustainable portfolios.

Further, this paper is related to the recent empirical green finance literature, which has been mainly focused on isolating returns dynamics due to concern increases and the 'static' sustainability spread, such as Pástor et al. (2022), Hsu et al. (2020) and Ardia et al. (2022). This paper shows another reason why greener assets have not displayed lower returns besides a sustained increase in environmental concerns, which is that risk may be not properly taken into account when measuring the 'greenium'. Second, the framework used here allows to include environmental sensitivity as a risk and potentially disentangle the risk-led sustainability premium from the 'static preferences' spread. At the current stage, this is not formally studied in this paper. The empirical application also makes this paper take part to the literatures employing General Method of Moments (GMM) to estimate marginal utility loadings, and to those modelling marginal utility in an agnostic way that do not employ pre-determined factors.

In section 2 I outline the theoretical set-up and show the impact of risk on sustainability-related pricing implications, in the simple framework of CAPM; in section 3, I consider the existence of a risk-free asset that also provides a sustainability score and the existence of multiple risks priced in the market; in section 4, I explore the main implications on US data employing the Refinitiv ESG scores; in section 5 I conclude.

[4] Further motivated by the findings of Berg et al. (2022).

## 2 Basic theoretical set-up

Consider a standard two-period economy where there are $I+1$ assets indexed by $i$, with $i=0$ being a risk-less asset. Then, assume a single agent living in this economy, who is born at time $t$ and simply chooses assets holdings $\{x_t^i\}_{i=1}^I$ to maximize utility from second-period consumption, which corresponds to the entirety of the accumulated wealth $W_{t+1}$, i.e.

$$\begin{aligned} &\max_{\{x_t^i\}_{i=0}^I} \mathbb{E}_t\left[u(W_{t+1})\right] \\ \text{s.t.} \quad & W_t = x_t^0 + \sum_{i=1}^I x_t^i P_t^i \\ & W_{t+1} = x_t^0 R_t^f + \sum_{i=1}^I x_t^i (P_{t+1}^i + D_{t+1}^i), \end{aligned} \tag{1}$$

where $P_t^i$ and $D_{t+1}^i$ are the price and dividend of asset $i$ at time $t$, respectively, and $R_t^f$ is the gross risk-free return. Growing concerns about sustainability of investments might enforce an exogenous level of greenness of the portfolio held by this agent, either imposed by a second agent in the form of a ruling government or a household whose savings are managed by the agent just described.

A simple way to capture this phenomenon is to require average sustainability of portfolio holdings to be greater than a certain threshold $q_t$,[5] which can be expressed as the inequality

$$\sum_{i=1}^I (x_t^i P_t^i) \cdot \mathrm{ESG}_t^i > q_t \cdot W_t. \tag{2}$$

This is close in spirit to Frazzini and Pedersen (2014), who consider leverage constraints instead of sustainability requirements. Exploiting $W_{t+1} = W_t R_t^f + \sum_{i=1}^I x_t^i (P_{t+1}^i + D_{t+1}^i - P_t^i R_t^f)$, the Lagrangian related to this problem can be expressed as

$$\mathcal{L}_t = \mathbb{E}_t\left[u\left(W_t R_t^f + \sum_{i=1}^I x_t^i (P_{t+1}^i + D_{t+1}^i - P_t^i R_t^f)\right)\right] + \lambda_t \left\{\sum_{i=1}^I (x_t^i P_t^i) \cdot \mathrm{ESG}_t^i - q_t \cdot W_t\right\} \tag{3}$$

The first-order condition for the optimality of this problem solution when the constraint binds, for each $i$, is

$$\mathbb{E}_t\left[u'(W_{t+1})(R_{t+1}^i - R_t^f)\right] + \lambda_t \mathrm{ESG}_t^i = 0 \tag{4}$$

or

$$\mathbb{E}_t\left[r_{t+1}^i\right] = \frac{-\lambda_t}{\mathbb{E}_t\left[u'(W_{t+1})\right]} \cdot \mathrm{ESG}_t^i - \mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t\left[u'(W_{t+1})\right]}, r_{t+1}^i\right], \tag{5}$$

[5]A key assumption here is that the risk-free asset does not contribute to the greenness of a portfolio, which might can be counterfactual. An extension which allows for this is immediate and will follow in the paper. This also implies more testable conditions.

where $r^i_{t+1}$ is the excess return $R^i_{t+1} - R^f_t$. Then, the market, defined by portfolio weights $\omega^i_t$ that ensure $\sum_{i=1}^I \omega^i_t = 1$, has expected excess return

$$\mathbb{E}_t\left[r^M_{t+1}\right] = \frac{-\lambda_t}{\mathbb{E}_t\left[u'(W_{t+1})\right]}\text{ESG}^M_t - \text{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t\left[u'(W_{t+1})\right]}, r^M_{t+1}\right], \tag{6}$$

where $\text{ESG}^M$ is the ESG score per dollar of market holding. The risk-free, not impacting the sustainability constraint is not determined differently from more standard frameworks.

Taking the approximation $u'(W_{t+1}) \approx u'(W_t)R^f_t + u''(W_t)(R^M_{t+1} - R^f_t)$, $\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]}$ can be expressed as $a_t - b_t \cdot r^M_{t+1}$, and from (6) the SDF loading $b_t$ can be derived as

$$b_t = \frac{\mathbb{E}_t\left[r^M_{t+1}\right] + \frac{\lambda_t}{\mathbb{E}_t[u'(W_{t+1})]}\text{ESG}^M_t}{\text{Var}_t\left[r^M_{t+1}\right]}. \tag{7}$$

Then, any asset abides by the following relation

$$\mathbb{E}_t\left[r^i_{t+1}\right] = \frac{-\lambda_t}{\mathbb{E}_t\left[u'(W_{t+1})\right]} \cdot \text{ESG}^i_t + \left(\mathbb{E}_t\left[r^M_{t+1}\right] + \frac{\lambda_t}{\mathbb{E}_t\left[u'(W_{t+1})\right]}\text{ESG}^M_t\right)\frac{\text{Cov}_t\left[r^M_{t+1}, r^i_{t+1}\right]}{\text{Var}_t\left[r^M_{t+1}\right]}, \tag{8}$$

or, more simply,

$$\mathbb{E}_t\left[r^i_{t+1}\right] = \tilde{\lambda}_t\left(\frac{\text{ESG}^i_t}{\text{ESG}^M_t} - \beta^i_t\right) + \beta^i_t \cdot \mathbb{E}_t\left[r^M_{t+1}\right], \tag{9}$$

where $\beta^i_t$ is the standard label for $\frac{\text{Cov}_t[r^M_{t+1}, r^i_{t+1}]}{\text{Var}_t[r^M_{t+1}]}$. $\tilde{\lambda}_t = \frac{-\lambda_t \cdot \text{ESG}^M_t}{\mathbb{E}_t[u'(W_{t+1})]}$ is a negative constant whose magnitude increases the more constrained the agent is and the higher market ESG score is. The key implication is that an expected excess return is proportional to the respective CAPM beta, as in the standard CAPM, and the difference between the 'ESG-intensity' $\text{ESG}^i_t/\text{ESG}^M_t$ and the beta. This comes from the fact that riskier assets, having greater discounts, provide less ESG-weighted capital per unit of cash-flows claimed by holding that asset. For example, if two assets have identical expected cash-flows and ESG ratings but different betas, the cash-flows of one with the lower beta will be discounted less and have a higher price, thus helping alleviating the constraint more than the other one.

## 2.1 Naive responsible portfolios

Let us consider a portfolio that tries to isolate the spread related to sustainability without having any exposure to market risk: arguably, the most intuitive way would be to hold a portfolio $S$ of more sustainable stocks, financing this by shorting a portfolio $NS$ of less sustainable ones and hedge the resulting sensitivity to the market by holding it in an opposite proportion. The expected excess return of this 'sustainability' portfolio, $r^{SUS}$, would be

$$\mathbb{E}\left[r^{SUS}\right] = \mathbb{E}_t\left[r^S\right] - \mathbb{E}_t\left[r^{NS}\right] - (\beta^S - \beta^{NS})\mathbb{E}_t\left[r^M\right] \tag{10}$$

$$= \tilde{\lambda} \left[ \left( \frac{\mathrm{ESG}_t^S}{\mathrm{ESG}_t^M} - \frac{\mathrm{ESG}_t^{NS}}{\mathrm{ESG}_t^M} \right) - (\beta^S - \beta^{NS}) \right]. \tag{11}$$

This portfolio effectively has no exposure to the market, the only source of risk here, but its return will reflect the sustainability spread $\tilde{\lambda}$ only if the risk is distributed evenly across assets with different sustainability. This means that testing the existence of any premium associated to characteristics that can be linked to constraints as those defined in this model on a generic ESG score, cannot rely on plain univariate-sort portfolios, even with controls for risk exposure.[6] If the beta of more sustainable stocks is sufficiently higher than that of less sustainable ones, a portfolio like this would even get to show positive average returns, despite the multiplier on sustainability definitely being negative.

The $SUS$ portfolio effectively has 0 beta, so it might not be obvious from (9) why betas' differential appears in (11). The reason is that the ESG intensity of this portfolio $\frac{\mathrm{ESG}_t^{SUS}}{\mathrm{ESG}_t^M}$ is not simply $\frac{\mathrm{ESG}_t^S}{\mathrm{ESG}_t^M} - \frac{\mathrm{ESG}_t^{NS}}{\mathrm{ESG}_t^M}$, but is augmented by the ESG intensity of the market portfolio, which is 1, times the position in it, which depends on the $S$ and $NS$ betas' differential.

### 2.2 Hedging sustainability concerns risk

It follows that risk also impacts how more sustainable assets hedge sustainability concerns shocks too. This can be seen decomposing unexpected returns into changes to expected discount rates and to expected cash-flows growth rates, as in Campbell (1996). Making the simplifying assumption of independence of aggregate sustainability concern shocks with market returns expectations and firm $i$ fundamentals, the contemporaneous relation between an assets return and sustainability concerns is characterized by

$$\frac{\partial(r_t^i - \mathbb{E}_{t-1}[r_t^i])}{\partial(\lambda_t - \mathbb{E}_{t-1}[\lambda_t])} \propto \left( \frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^M} - \beta_t^i \right). \tag{12}$$

Specifically, for the $SUS$ portfolio, this is

$$\frac{\partial(r_t^{SUS} - \mathbb{E}_{t-1}[r_t^i])}{\partial(\lambda_t - \mathbb{E}_{t-1}[\lambda_t])} \propto \left( \frac{\mathrm{ESG}_t^S}{\mathrm{ESG}_t^M} - \frac{\mathrm{ESG}_t^{NS}}{\mathrm{ESG}_t^M} \right) - (\beta^S - \beta^{NS}), \tag{13}$$

meaning that hedging the risk of a high-minus-low sustainable portfolio can be considered an hedge only as long as more sustainable assets are not significantly riskier than lowly or non-sustainable. This is a fact that has relevance for the future as the risk pattern can change over time. For example, being R&D generally considered a risky activity, as more sustainable firm were to become the ones closer to the technology frontier and in need of innovation, as it is happening with the automotive sector, then, the sustainable portfolio can potentially become a terrible hedge for sustainability concerns.[7]

A portfolio that is market- and sustainability-neutral allows to study this effect explicitly.

[6] This has been done for example in Hsu et al. (2020) and Yang (2022).
[7] See footnote 3.

Consider a portfolio investing \$ 1 in the $S$ portfolio, shorting $\mathrm{ESG}^S/\mathrm{ESG}^{NS}$ of the $NS$ portfolio, funding this position shorting $1-\mathrm{ESG}^S/\mathrm{ESG}^{NS}$ of a risk-free asset and hedging it shorting \$ $\beta^S-\mathrm{ESG}^S/\mathrm{ESG}^{NS}\beta^{NS}$ of the market. The expected returns of this 'Betting Against Sustainability' (BAS) portfolio is

$$\mathbb{E}_t\left[r^{BAS}_{t+1}\right]=\mathbb{E}_t\left[r^S\right]-\frac{\mathrm{ESG}^S}{\mathrm{ESG}^{NS}}\mathbb{E}_t\left[r^{NS}\right]-(\beta^S-\frac{\mathrm{ESG}^S}{\mathrm{ESG}^{NS}}\beta^{NS})\mathbb{E}_t\left[r^M\right] \tag{14}$$

$$=\tilde{\lambda}_t\left(\beta^{NS}_t-\beta^S_t\right) \tag{15}$$

Then, the contemporaneous relation between BAS' returns and sustainability concerns shocks is naturally

$$\frac{\partial(r^{BAS}_t-\mathbb{E}_{t-1}\left[r^{BAS}_t\right])}{\partial\left(\tilde{\lambda}_t-\mathbb{E}_{t-1}[\tilde{\lambda}_t]\right)}\propto(\beta^S-\beta^{NS}). \tag{16}$$

This is helpful in identifying the impact that risk has on sustainability spreads.

# 3 A more realistic model

## 3.1 Factor-zoo world

Given the remarkable amount of evidence in favour of multi-factor models, it is useful to consider the case in which the marginal utility is affected by risks other than undiversifiable variance. Rearranging (5) and (6), one can obtain a broader formulation of the pricing condition that any asset has to abide by:

$$\mathbb{E}_t\left[r^i_{t+1}\right]=\tilde{\lambda}_t\left(\frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^M_t}-\frac{\mathrm{Cov}_t\left[u'(W_{t+1}),r^i_{t+1}\right]}{\mathrm{Cov}_t\left[u'(W_{t+1}),r^M_{t+1}\right]}\right)+\frac{\mathrm{Cov}_t\left[u'(W_{t+1}),r^i_{t+1}\right]}{\mathrm{Cov}_t\left[u'(W_{t+1}),r^M_{t+1}\right]}\mathbb{E}_t\left[r^M_{t+1}\right], \tag{17}$$

or, more simply,

$$\mathbb{E}_t\left[r^i_{t+1}\right]=\tilde{\lambda}_t\left(\frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^M_t}-\gamma^i_t\right)+\gamma^i_t\cdot\mathbb{E}_t\left[r^M_{t+1}\right]. \tag{18}$$

This follows closely what was previously derived, just with a broader measure of risk, $\gamma^i_t=\frac{\mathrm{Cov}_t[u'(W_{t+1}),r^i_{t+1}]}{\mathrm{Cov}_t[u'(W_{t+1}),r^M_{t+1}]}$. While $u'(W_{t+1})$ is empirically not easy to identify, all of the asset pricing literature provides alternatives, one of which is its projection on the returns, as in the similar application in Franceschini (2023).

This implies

$$\mathbb{E}\left[r^{SUS}\right]=\tilde{\lambda}\left[\left(\frac{\mathrm{ESG}^S_t}{\mathrm{ESG}^M_t}-\frac{\mathrm{ESG}^{NS}_t}{\mathrm{ESG}^M_t}\right)-(\gamma^S-\gamma^{NS})\right] \tag{19}$$

and

$$\mathbb{E}\left[r^{BAS}\right] = \tilde{\lambda}(\gamma^{NS} - \gamma^{S}). \tag{20}$$

It also naturally extends to the case where sustainable bonds are available, simply plugging $r_t^{f,GB}\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}$ for $\tilde{\lambda}_t$.

## 3.2 With sustainable bonds

Consider the presence of a bond that contributes to the required sustainability of the portfolio, such as green bonds contribute to environmental sustainability, which is indexed as $i = GB$. Then,

$$W_t = \sum_{i=1}^{I} x_t P_t^i + x_t^0 + x_t^{GB} \tag{21}$$

$$W_{t+1} = \sum_{i=1}^{I} x_t (P_{t+1}^i + D_{t+1}^i) + x_t^0 R_t^f + x_t^{GB} R_t^{f,GB}, \tag{22}$$

while the sustainability requirement becomes

$$\sum_{i=1}^{I} (x_t^i P_t^i) \cdot \mathrm{ESG}_t^i + x_t^{GB} \cdot \mathrm{ESG}_t^{GB} > q_t \cdot W_t. \tag{23}$$

The first-order condition related to the holdings of the sustainable risk-free asset, which can be obtained from a Lagrangian formed in a similar way to the previous section, implies the spread on the sustainable bond being determined as

$$R_t^{f,GB} - R_t^f = -\frac{\lambda_t \mathrm{ESG}_t^{GB}}{\mathbb{E}_t\left[u'(W_{t+1})\right]}, \tag{24}$$

which is non-positive. The optimality condition for the risky asset $i$, combined with the previous condition, results in a more explicit pricing condition:

$$\mathbb{E}_t\left[r_{t+1}^i\right] = \frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^{GB}} \cdot r_t^{f,GB} - \mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t\left[u'(W_{t+1})\right]}, r_{t+1}^i\right], \tag{25}$$

where $r_{t+1}^i$ is the excess return $R_{t+1}^i - R_t^f$. This essentially deviates from a standard formulation for the term multiplying the sustainable bond rate.

In a CAPM world, this translates to

$$\mathbb{E}_t\left[r_{t+1}^i\right] = r_t^{f,GB}\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}\left(\frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^M} - \beta^i\right) + \beta^i \mathbb{E}_t\left[r_{t+1}^M\right], \tag{26}$$

where $r_t^{f,GB}\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}$ essentially provides a proxy of $\tilde{\lambda}_t$. 'Sustainable' bonds are essentially available for environmental sustainability, but it still useful as it allows an easier empirical test. It follows that the expected returns of a plain high-minus-low sustainability portfolio, previously addressed as 'SUS' and determined by (11), is now

$$\mathbb{E}\left[r^{SUS}\right] = r_t^{f,GB}\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}\left[\left(\frac{\mathrm{ESG}_t^S}{\mathrm{ESG}_t^M} - \frac{\mathrm{ESG}_t^{NS}}{\mathrm{ESG}_t^M}\right) - (\beta^S - \beta^{NS})\right] \tag{27}$$

and the returns of the sustainability- and market-neutral BAS portfolio, previously defined by (14), amounts now to

$$\mathbb{E}\left[r^{BAS}\right] = r_t^{f,GB}\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}(\beta^{NS} - \beta^S). \tag{28}$$

# 4 A look at ESG constraints

## 4.1 Test assets

The analysis focuses on the US stock market; monthly data on stocks is provided by CRSP. The time span of the analysis is ultimately determined by the yearly ESG data, which is from Refinitiv. The series starts in 2002, but it had a remarkable increase in coverage in 2003, which is when the analysis starts from, ending in 2021. Table 3 displays the fraction of the US stock market coverage by the ESG measure. By no means the analysis has to be confined to this measure, indeed it will not be, moving on, as many more sustainability measures can be associated to constraints in portfolio formation.

The test assets pool is formed by portfolios of stocks sorted by characteristics that are known to generate dispersion in average returns and are widely used in the literature. Three of these are based on market capitalization (size), three on book-to-market (B/M) equity ratio, three on the cumulated return over the 11 months ending a month before (mom), and three portfolios based on the ESG score. Finally, the SUS portfolio and the market are added, for a total of 14 test assets. The number of portfolios per characteristic is chosen to ensure a minimum of approximately 60 firms per portfolio, given the limited number of firms covered by the ESG measure. Size and B/M portfolios are formed based on NYSE capitalization quantiles. All of the portfolios are value-weighted to obtain the portfolios' returns and portfolios' ESG score at every date. Statistics of the portfolios are in table 1.

A clear pattern, obviously, emerges in the esg-sorted portfolio as well as in the size portfolios as well as in the B/M, where ESG scores increase with size and decrease with B/M. Momentum portfolios instead appears to have no meaningful relation to esg scores. Returns mostly conform with the literature, with returns being lower for greater size portfolios and lower B/M ratios. Momentum portfolios show a more bizarre behaviour, with worse performing assets having higher returns, although the unexplained returns by CAPM increase with momentum as expected. More sustainable assets, as expected from theory have lower returns, reflected in the negative average return of the SUS portfolio. To have a first sight of the relation between sustainability and risk, figure 1 charts the relative ESG scores and

4-year rolling window of the high- and low-sustainability portfolios. Most of the variation comes from the beta of the least portfolio, ‘non-sus’, but the difference in risk reached at most half the difference in relative ESG scores, up to 2022.

Table 1: Test assets statistics. In parenthesis the HAC standard errors, computed following Lazarus et al. (2018). Monthly returns annualized, sample from Jul 2004 to Dec 2021.

| Stat | size.1 | size.2 | size.3 | BM.1 | BM.2 | BM.3 | mom.1 | mom.2 | mom.3 | sus.1 | sus.2 | sus.3 | sus.hml | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r. ESG (%) | 43.030 | 56.621 | 102.267 | 103.449 | 100.233 | 88.766 | 99.209 | 100.736 | 96.885 | 36.046 | 67.859 | 121.551 | 85.505 | 84.781 |
| | (7.204) | (1.460) | (0.827) | (1.785) | (1.814) | (3.451) | (1.422) | (0.567) | (1.440) | (1.881) | (6.531) | (4.708) | (1.693) | |
| Avg. ret (%) | 40.100 | 17.176 | 10.366 | 11.245 | 8.495 | 13.126 | 10.045 | 10.525 | 9.745 | 12.809 | 11.033 | 9.952 | -4.003 | 12.355 |
| SD (%) | 282.196 | 89.919 | 55.454 | 50.995 | 55.476 | 87.238 | 77.914 | 50.700 | 52.918 | 67.499 | 62.668 | 56.340 | 37.412 | 78.979 |
| CAPM $\alpha$ (%) | 17.820 | 2.937 | 0.305 | 2.151 | -1.438 | 0.521 | -2.824 | 1.438 | 0.582 | 1.280 | -0.068 | 0.070 | -2.385 | 1.568 |
| | (17.497) | (4.096 ) | (1.073 ) | (1.510 ) | (0.989 ) | (3.010 ) | (2.034 ) | (1.401 ) | (1.091 ) | (1.860 ) | (1.459 ) | (1.105 ) | (1.463 ) | |
| CAPM $\beta$ | 2.275 | 1.454 | 1.027 | 0.928 | 1.014 | 1.287 | 1.314 | 0.928 | 0.936 | 1.177 | 1.134 | 1.009 | -0.165 | 1.101 |
| | (0.536) | (0.103) | (0.038) | (0.018) | (0.020) | (0.132) | (0.100) | (0.027) | (0.042) | (0.063) | (0.038) | (0.037) | (0.050) | |

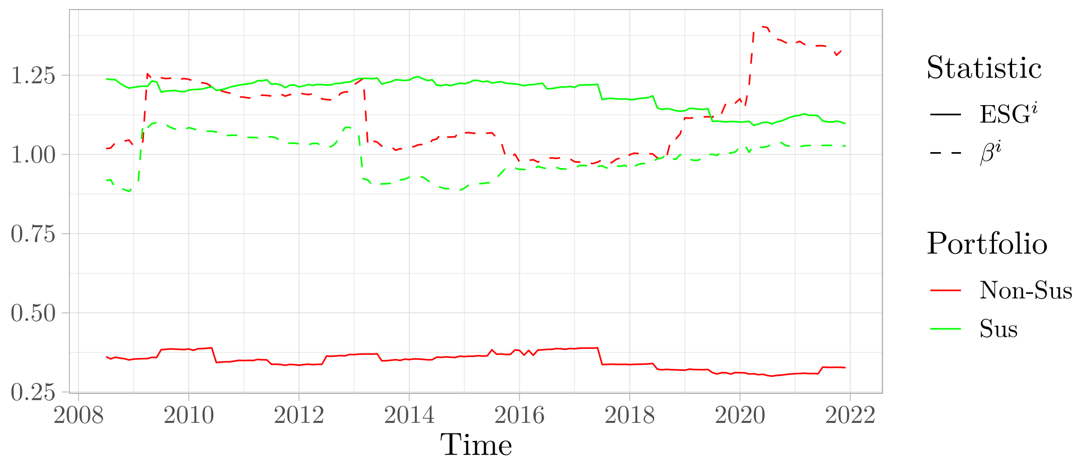


Figure 1: ESG$^i$ is actually ESG intensity, i.e. $\frac{\text{ESG}^i}{\text{ESG}^M}$ and 4-year rolling window of high- and low-sustainability portfolios, both reported on the vertical axis.

### 4.2 Risk factors

The scaled marginal utility is assumed to be linear in a set of risk factors $\mathbf{f}$, i.e. $\frac{u'(W_{t+1})}{\mathbb{E}[u'(W_{t+1})]} = 1 - \mathbf{f}_t'\mathbf{b}$. Three sets of factors are used: (1) market factor only; (2) the three factors of Fama and French (1993), which include the market, named 'FF3'; (3) the market and the first two principal components of the test assets, orthogonalized with respect to the market to avoid redundant information, named 'F(3)'. The number of agnostic factors matches the size of FF3 for comparison and is right before an 'elbow' in the scree plot of the Principal component analysis, as shown in figure 2.

### 4.3 Pricing results

The main condition of interest is (5), which traslates into the moment condition

$$\mathbb{E}\left[r_t^i\right] - a \cdot \text{ESG}_{t-1}^i - \mathbb{E}\left[(\mathbf{f}_t'\mathbf{b})(r_t^i - \mathbb{E}\left[r_t^i\right])\right] = 0, \tag{29}$$

where $a$ return the unconditional expectations of $\tilde{\lambda}$ and $\mathbf{f}$ are the factors spanning the scaled marginal utility with loadings $\mathbf{b}$, which are to be estimated together with $a$. The covariances are then estimated contemporaneously exploiting the moment

$$s_i + \mathbb{E}\left[(\mathbf{f}_t'\mathbf{b})(r_t^i - \mathbb{E}\left[r_t^i\right])\right] = 0, \tag{30}$$

where $s_i$ is the empirical counterpart of Cov $\left[\frac{u'(W_{t+1})}{\mathbb{E}[u'(W_{t+1})]}, r_{t+1}^i\right]$, employed to obtain estimates of the $\gamma$s. The estimation results are in table 2.

The unconditional sustainability spread $\mathbb{E}\left[\tilde{\lambda}\right] = a \cdot \mathbb{E}\left[\text{ESG}_t^M\right]$ is always negative and slightly significant for multifactor models, not for the market-only model. The loading on the market factor is significant and positive in all estimations. Adding factors beyond the market does not appear to improve the pricing performance, as highlighted by the fact that

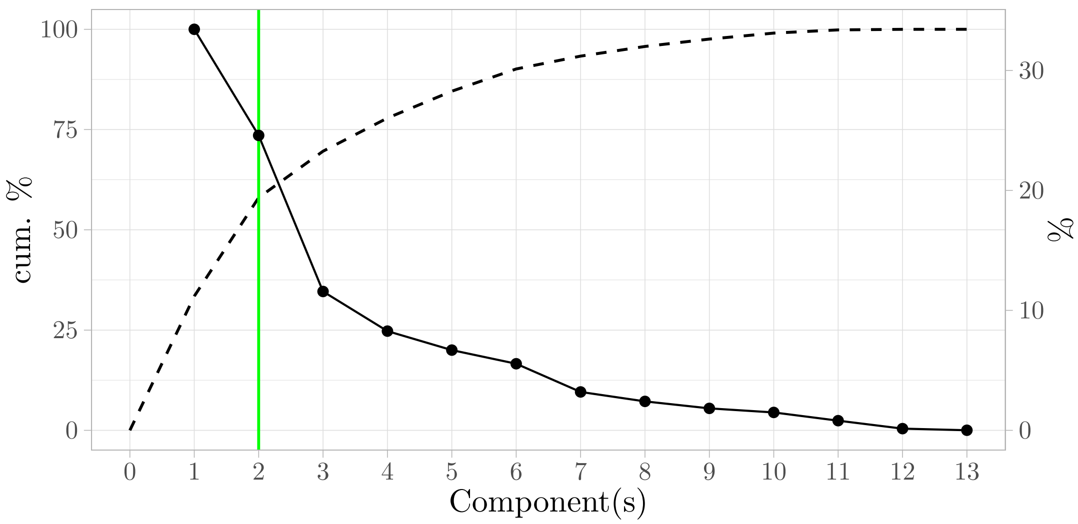


Figure 2: Scree plot of principal component analysis. On the horizontal axis the number of component considered, on the vertical axis the share of variance explained by the relative component (solid line) and the cumulative share of variance explained (dotted line). The green vertical line marks the $2^{\text{nd}}$ component.

Table 2: cross-sectional pricing estimation, HAC standard errors in parenthesis. Coverage 2004-2021.

| | Mkt only | FF3 | F(3) |
|---|---|---|---|
| $\mathbb{E}\left[\tilde{\lambda}\right]$ | $-5.753$ | $-8.844^{*}$ | $-5.146^{*}$ |
| | (4.023) | (4.810) | (3.053) |
| Market factors | $0.302^{**}$ | $0.514^{**}$ | $0.274^{**}$ |
| | (0.131) | (0.224) | (0.118) |
| J-test | $94.3^{***}$ | $105.5^{***}$ | $100.2^{***}$ |
| MAPE | 2.431 | 2.309 | 2.446 |
| SUS a.p.e. | $3.479^{**}$ | 1.864 | 2.187 |
| | (1.575) | (1.701) | (1.494) |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

all the models are formally rejected by the J-test. However, the multifactor models price the SUS portfolio better, whose average return in excess of the the models' fit is not significantly different from 0. This pattern contrast the pattern in the estimates of the unconditional sustainability spread, whose significance is exactly complementary to that of the SUS excess returns. This highlights how returns on the SUS portfolio does not provide a reliable measure of the sustainability spread.

To further assess the impact of risk on univariate sustainability portfolios such as SUS, the $\gamma$s implied by the previous estimation are computed and reported in table 3. Specifically, the differential in ESG intensity is

$$\Delta \mathrm{ESG}_t = \frac{\mathrm{ESG}_t^S}{\mathrm{ESG}_t^M} - \frac{\mathrm{ESG}_t^{NS}}{\mathrm{ESG}_t^M} \tag{31}$$

Table 3: $\Delta$ESG and $\Delta\gamma$. In parenthesis HAC standard errors. Standard errors of $\Delta\gamma$ are obtained via Delta method from the covariances estimates from the GMM step.

| $\Delta$ESG | $\Delta\gamma$ | | |
|---|---|---|---|
| | Market | FF3 | F(3) |
| $0.855^{***}$ | $-0.165^{**}$ | 0.094 | $-0.127$ |
| (0.017) | (0.067) | (0.135) | (0.165) |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

and the differential in risks is then defined as

$$\Delta\gamma = \gamma^S - \gamma^{NS}. \tag{32}$$

It can be seen that the estimates, in table 3, do not suggest risk affecting significantly how the spread $\tilde{\lambda}$ gets reflected into $\mathbb{E}\left[r^{SUS}\right]$, as $\Delta\gamma > \Delta\text{ESG}$ is clearly unlikely. Nonetheless, it can be seen that considering more risks results in higher $\Delta\gamma$. It should be noted that these are unconditional estimates, so an instability of portfolios sorted on sustainability, which is highly possible, will have to be taken in greater care in following analysis, with conditional estimates.

## 5 Conclusion

Assessing how sustainability affects asset prices, and thus investors' welfare, is key to better address current generational challenges. It is shown that a constraint on the average score of the portfolio held by an agent that binds induces a negative spread on the risk premium of an asset that is proportional to the difference between its sustainability intensity and its risk. This affects the returns of naive high-minus-low portfolios based on univariate sustainability sorting, which have been proposed to capitalize and measure the spread, or to hedge shocks to the constraint, i.e. sustainability concerns. Empirical analysis conducted on an ESG measure covering US data is not conclusive regarding the existence of such a sustainability premium in the first place. Anyway, it is shown a detachment of the average excess returns of naive high-minus-low sustainable portfolios from the sustainability spread, as one is found to be significant only in specification where the other does not, and vice-versa.

## References


Ardia, David et al. (16, 2022). 'Climate Change Concerns and the Performance of Green vs. Brown Stocks'. In: *Management Science*.

Berg, Florian, Julian F Kölbel, and Roberto Rigobon (1, 2022). 'Aggregate Confusion: The Divergence of ESG Ratings*'. In: *Review of Finance* 26.6, pp. 1315–1344.

Campbell, John Y. (1996). 'Understanding Risk and Return'. In: *Journal of Political Economy* 104.2, pp. 298–345.

Fama, Eugene F. and Kenneth R. French (1993). 'Common risk factors in the returns on stocks and bonds'. In: *Journal of Financial Economics* 33.1, pp. 3–56.

Franceschini, Fabio (2023). 'Does CAPM overestimate more the risk or its price?'

Frazzini, Andrea and Lasse Heje Pedersen (2014). 'Betting against beta'. In: *Journal of Financial Economics* 111 (1), pp. 1–25.

Giglio, Stefano, Bryan Kelly, and Johannes Stroebel (2021). 'Climate Finance'. In.

Hsu, Po-Hsuan, Kai Li, and Chi-Yang Tsou (2020). 'The Pollution Premium'. In: *SSRN Electronic Journal*.

Lazarus, Eben et al. (2018). 'HAR Inference: Recommendations for Practice'. In: *Journal of Business and Economic Statistics* 36 (4), pp. 541–559.

Pástor, Ľuboš, Robert F. Stambaugh, and Lucian A. Taylor (1, 2021). 'Sustainable investing in equilibrium'. In: *Journal of Financial Economics* 142.2, pp. 550–571.

— (1, 2022). 'Dissecting green returns'. In: *Journal of Financial Economics* 146.2, pp. 403–424.

Pedersen, Lasse Heje, Shaun Fitzgibbons, and Lukasz Pomorski (1, 2021). 'Responsible investing: The ESG-efficient frontier'. In: *Journal of Financial Economics* 142.2, pp. 572–597.

Yang, Biao (2022). 'Explaining Greenium in a Macro-Finance Integrated Assessment Model'. In.

Zerbib, Olivier David (1, 2022). 'A Sustainable Capital Asset Pricing Model (S-CAPM): Evidence from Environmental Integration and Sin Stock Exclusion*'. In: *Review of Finance* 26.6, pp. 1345–1388.

# 6 Derivations

The Lagrangian related to the problem with sustainable bonds is

$$\begin{aligned}\mathcal{L}_t = \mathbb{E}_t &\left[ u\left( W_t R_t^f + \sum_{i=1}^{I} x_t (P_{t+1}^i + D_{t+1}^i - P_t^i R_t^f) + x_t^{GB}(R_t^{f,GB} - R_t^f) \right) \right] \\ &+ \lambda_t \left\{ \sum_{i=1}^{I} (x_t^i P_t^i) \cdot \mathrm{ESG}_t^i + x_t^{GB} \cdot \mathrm{ESG}_t^{GB} - q_t \cdot W_t \right\}\end{aligned}. \tag{33}$$

The resulting first order conditions are

$$\mathbb{E}_t \left[ u'(W_{t+1}) \right] (R_t^{f,GB} - R_t^f) + \lambda_t \mathrm{ESG}_t^{GB} = 0 \tag{34}$$

for the sustainable bond, and

$$\mathbb{E}_t \left[ u'(W_{t+1})(R_{t+1}^i - R_t^f) \right] + \lambda_t \mathrm{ESG}_t^i = 0 \tag{35}$$

for the risky asset $i$.

Combining sustainable bond and common asset conditions:

$$\frac{\mathbb{E}_t\left[u'(W_{t+1})(R^i_{t+1}-R^f_t)\right]}{\mathrm{ESG}^i_t} = \frac{\mathbb{E}_t\left[u'(W_{t+1})\right](R^{f,GB}_t - R^f_t)}{\mathrm{ESG}^{GB}_t} \tag{36}$$

$$\mathbb{E}_t\left[u'(W_{t+1})(R^i_{t+1}-R^f_t)\right] = \frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^{GB}_t}\mathbb{E}_t\left[u'(W_{t+1})\right](R^{f,GB}_t - R^f_t). \tag{37}$$

So,

$$\mathbb{E}_t\left[r^i_{t+1}\right] = \frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t - \mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t\left[u'(W_{t+1})\right]}, r^i_{t+1}\right]. \tag{38}$$

Then, the market has expected excess return

$$\begin{aligned}
\mathbb{E}_t\left[r^M_{t+1}\right] &= \sum_{i=1}^{I}\omega^i_t\cdot\mathbb{E}_t\left[r^i_{t+1}\right] && (39)\\
&= \frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t - \mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t\left[u'(W_{t+1})\right]}, r^M_{t+1}\right]. && (40)
\end{aligned}$$

Assuming $\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]} = a_t - b_t\cdot r^M_{t+1}$,

$$\mathbb{E}_t\left[r^i_{t+1}\right] = \frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t + b_t\mathrm{Cov}_t\left[r^M_{t+1}, r^i_{t+1}\right] \tag{41}$$

$$\mathbb{E}_t\left[r^M_{t+1}\right] = \frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t + b_t\mathrm{Var}_t\left[r^M_{t+1}\right]. \tag{42}$$

Then, $b_t = \frac{\mathbb{E}_t[r^M_{t+1}] - \frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t}{\mathrm{Var}_t[r^M_{t+1}]}$ and

$$\begin{aligned}
\mathbb{E}_t\left[r^i_{t+1}\right] &= \frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t + \left(\frac{\mathbb{E}_t\left[r^M_{t+1}\right] - \frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t}{\mathrm{Var}_t\left[r^M_{t+1}\right]}\right)\mathrm{Cov}_t\left[r^M_{t+1}, r^i_{t+1}\right] && (43)\\
&= \frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t + \left(\mathbb{E}_t\left[r^M_{t+1}\right] - \frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}\cdot r^{f,GB}_t\right)\beta^i && (44)\\
&= \frac{r^{f,GB}_t}{\mathrm{ESG}^{GB}_t}\left(\mathrm{ESG}^i_t - \mathrm{ESG}^M_t\beta^i\right) + \beta^i\mathbb{E}_t\left[r^M_{t+1}\right] && (45)\\
&= r^{f,GB}_t\frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}\left(\frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^M_t} - \beta^i\right) + \beta^i\mathbb{E}_t\left[r^M_{t+1}\right] && (46)
\end{aligned}$$

For a factor-zoo with a sustainable bond:

$$\frac{\mathbb{E}_t\left[r^i_{t+1}\right] - \frac{\mathrm{ESG}^i_t}{\mathrm{ESG}^{GB}_t}r^{f,GB}_t}{\mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]}, r^i_{t+1}\right]} = -1 = \frac{\mathbb{E}_t\left[r^M_{t+1}\right] - \frac{\mathrm{ESG}^M_t}{\mathrm{ESG}^{GB}_t}r^{f,GB}_t}{\mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]}, r^M_{t+1}\right]}, \tag{47}$$

so

$$\frac{\mathbb{E}_t\left[r_{t+1}^i\right]-\frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^{GB}}r_t^{f,GB}}{\mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]},r_{t+1}^i\right]}=\frac{\mathbb{E}_t\left[r_{t+1}^M\right]-\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}r_t^{f,GB}}{\mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]},r_{t+1}^M\right]} \tag{48}$$

$$\mathbb{E}_t\left[r_{t+1}^i\right]-\frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^{GB}}r_t^{f,GB}=\frac{\mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]},r_{t+1}^i\right]}{\mathrm{Cov}_t\left[\frac{u'(W_{t+1})}{\mathbb{E}_t[u'(W_{t+1})]},r_{t+1}^M\right]}\left(\mathbb{E}_t\left[r_{t+1}^M\right]-\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}r_t^{f,GB}\right) \tag{49}$$

$$\mathbb{E}_t\left[r_{t+1}^i\right]=\frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^{GB}}r_t^{f,GB}+\frac{\mathrm{Cov}_t\left[u'(W_{t+1}),r_{t+1}^i\right]}{\mathrm{Cov}_t\left[u'(W_{t+1}),r_{t+1}^M\right]}\left(\mathbb{E}_t\left[r_{t+1}^M\right]-\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}r_t^{f,GB}\right) \tag{50}$$

$$\mathbb{E}_t\left[r_{t+1}^i\right]=\frac{r_t^{f,GB}}{\mathrm{ESG}_t^{GB}}(\mathrm{ESG}_t^i-\mathrm{ESG}_t^M\gamma_t^i)+\gamma_t^i\mathbb{E}_t\left[r_{t+1}^M\right] \tag{51}$$

$$\mathbb{E}_t\left[r_{t+1}^i\right]=r_t^{f,GB}\frac{\mathrm{ESG}_t^M}{\mathrm{ESG}_t^{GB}}\left(\frac{\mathrm{ESG}_t^i}{\mathrm{ESG}_t^M}-\gamma_t^i\right)+\gamma_t^i\cdot\mathbb{E}_t\left[r_{t+1}^M\right]. \tag{52}$$

# 7 Additional tables and figures

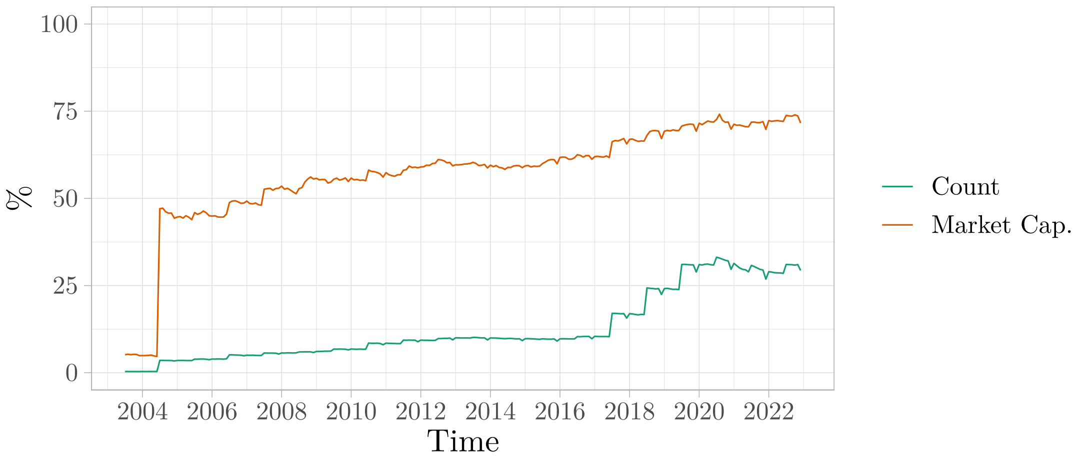


Figure 3: Refinitiv ESG scores coverage of the US market stocks in CRSP monthly file.