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ABSTRACT

We review the literature on sustainable investing, focusing on financial effects. First, we examine the effects of investor tastes on portfolio tilts and asset prices in a simple equilibrium setting. We establish novel connections, including a direct relation between the green portfolio tilt and the greenium. We also relate our framework to prior modeling of divestment. Finally, we review evidence related to the main concepts from our theoretical analysis, including the greenium, green tilts, climate risk, and investor tastes.

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1 INTRODUCTION

Sustainable investing considers not only financial but also non-financial criteria, such as environmental, social, and governance (ESG) metrics. This investment approach has grown in popularity in recent years. As of 2024, tens of trillions of dollars are managed by investment companies that have made various commitments to sustainability, such as signing the United Nations' Principles for Responsible Investment.

Sustainable investing can be pursued through a variety of strategies. In its early years, when it was known as socially responsible investing, sustainable investing involved mostly negative or exclusionary screening. Under this approach, investors avoid certain sectors or companies for moral, ethical, or religious reasons. Popular exclusions have included companies associated with gambling, alcohol, tobacco, weapons, human rights violations, and, more recently, fossil fuels. A closely related approach is divestment, which involves selling portfolio holdings that are no longer desired. While exclusionary screening is proactive, occurring before an investment is made, divestment is reactive, representing a corrective action after the investment is made.

Other sustainable investment strategies have emerged more recently. Positive or best-in-class screening involves investing in companies that perform well relative to their peers on ESG criteria. ESG integration incorporates ESG criteria in the investment process in a flexible way, aiming to enhance returns and manage risks. Thematic investing targets specific themes or sectors with positive environmental or social impacts, such as clean energy, sustainable agriculture, and healthcare. Impact investing seeks to generate measurable positive social or environmental impact alongside financial returns. This approach is implemented by investing in, and often actively guiding, projects or companies that are expected to have a positive social or environmental impact, such as affordable housing projects and renewable energy startups.[1] Last but not least, engagement is an active involvement of investors with their portfolio companies, with the goal of improving the companies' ESG practices and managing the related risks. For example, investors can engage in a dialogue with the company's management, vote on shareholder proposals, file their own proposals, and participate in proxy contests.

Investors have two types of motivations for using ESG information: value and values (Starks, 2023). The value motivation is financial—ESG metrics could in principle help in-

[1] The term "impact investing" is occasionally misused in the literature. For example, this term features in the titles of both Berk and van Binsbergen (2024) and Lo and Zhang (2024), but neither study is about impact investing; the former study is about divestment and the latter equates impact investing with sustainable investing more broadly.

vestors improve their portfolio performance. The values motivation is non-financial. Values-motivated investors are generally willing to sacrifice some financial value to accommodate their personal values. The non-pecuniary preferences of values-motivated investors are of two types: consequentialist or non-consequentialist. Investors with consequentialist preferences care about outcomes and real effects of their investments, such as a reduction in a company's carbon footprint. Investors with non-consequentialist preferences aim to align their investment choices with their own moral values or ethical principles, regardless of the real-world impact of those choices. For example, investors may have tastes for green assets, preferring to hold "green" assets over "brown."

The distinction between consequentialist and non-consequentialist preferences helps us understand the popularity of sustainable investment strategies that have limited ability to bring about real change. For example, divestment is expected to affect corporate behavior by raising the cost of capital due to limited risk sharing (e.g., Heinkel, Kraus, and Zechner, 2001). The resulting change in the cost of capital can be small, limiting the effectiveness of divestment and thus also its appeal to investors with consequentialist preferences (e.g., Teoh, Welch, and Wazzan, 1999; Berk and van Binsbergen, 2024). Nonetheless, despite its limited ability to trigger real change, divestment could be appealing to investors with non-consequentialist preferences. By divesting, such investors do not make the world a better place for others, but they make it better for themselves, as they eliminate their own disutility from divested holdings.

In this paper, we provide a targeted review of the fast-growing literature on sustainable investing.[2] We focus on sustainable investing's financial effects, omitting its real effects. Real effects, such as the impact on corporate investment and pollution, are of particular interest to investors with consequentialist preferences. We emphasize non-consequentialist preferences instead, consistent with the evidence that investors' moral preferences are largely of such nature (e.g., Bonnefon, Landier, Sastry, and Thesmar, 2025). Given our prioritization of non-consequentialist preferences, we discuss divestment but not shareholder engagement, which may be more effective than divestment in causing real change (e.g., Berk and van Binsbergen, 2024; Broccardo, Hart, and Zingales, 2022; Krueger, Sautner, and Starks, 2020). We highlight the effects of investor tastes on asset prices, portfolio tilts, and the amount of ESG investing. We also review the literature on climate risk, whose financial relevance for investors has been growing.

[2]Other reviews on related topics, each with a somewhat different focus, include Baker, Bergstresser, Serafeim, and Wurgler (2022a), Giglio, Kelly, and Stroebel (2021a), Gillan, Koch, and Starks (2021), and Hong and Shore (2023).

An advantage of a focused review is that we can go deeper and establish novel connections. In Section 2, for example, we provide a simple expression for the "greenium," the difference between the expected returns of brown and green assets. We then derive a theoretical relation between the greenium and the green tilt and connect it to a setting of total divestment. In Section 3, we discuss the evidence pertaining to the key concepts analyzed in Section 2, such as investor tastes, the greenium, green tilts, divestment, and climate risk.

2 THEORETICAL PERSPECTIVES

2.1 Investors with ESG tastes

A prominent dimension of sustainable investing arises from the presence of investors with ESG tastes, who derive non-pecuniary "warm-glow" utility by favoring green assets over brown in their portfolios. Investors with such tastes can affect asset prices in equilibrium (e.g., Fama and French, 2007). To review the effects of these tastes on the composition of investment portfolios and equilibrium expected returns, we consider a simplified version of the model in Pástor, Stambaugh, and Taylor (2021), hereafter PST21. In that model, each investor i maximizes a standard single-period exponential utility function that depends on final wealth plus a term reflecting tastes, $d_i w_i' g$.[3] The parameter d_i (≥ 0) represents the degree to which the investor cares about ESG (i.e., the strength of the investor's tastes), w_i is the vector of the investor's portfolio weights, and g contains each asset's greenness measure. We refer to investors with $d_i > 0$ as ESG investors and those with $d_i = 0$ as non-ESG investors. A non-ESG investor is simply a mean-variance maximizer who selects a portfolio with the highest Sharpe ratio. Pedersen, Fitzgibbons, and Pomorski (2021) show that, in such a setting, an ESG investor trades off their portfolio's Sharpe ratio with their portfolio's average greenness measure. PST21 define greenness relative to the market portfolio, so that $w_m' g = 0$, where w_m contains market weights. They show that the N-vector of assets' excess returns in equilibrium obeys a two-factor model,

$$\tilde{r} = \beta_m \tilde{r}_m + g \tilde{f}_g + \tilde{\nu}\,, \tag{1}$$

where the excess market return, $\tilde{r}_m$, is uncorrelated with $\tilde{f}_g$, denoted as the ESG factor or simply the "green factor."

We maintain the simplifying assumptions PST21 make in their quantitative illustrations: ESG investors have an aggregate wealth share of λ (> 0), and each of them has $d_i = d$ (> 0).

[3] Specifically, the utility function PST21 use is $V(\tilde{W}_{1i}, w_i) = -e^{-A_i \tilde{W}_{1i} - d_i w_i' g}$, where A_i is the agent's absolute risk aversion and $\tilde{W}_{1i}$ is the agent's financial wealth in the next period.

The remaining (non-ESG) investors have $d_i = 0$. In addition, $w_m = (1/N)\iota_N$, $\beta_m' g = 0$, the elements of ν are mutually uncorrelated with equal variances, and, without loss of generality, $(g'g)/N = 1$. (The N-vector of 1's is denoted by ι_N.)

To simplify further, we assume there are just two ESG classifications of risky assets: green and brown. Specifically, each asset n has a greenness measure g_n that takes one of two values, with green assets having $g_n = g^+$ and brown assets having $g_n = g^-$. Denote the fraction of assets that are brown as τ $(0 < \tau < 1)$. It is readily verified that $g^+ = \sqrt{\frac{\tau}{1-\tau}}$, $g^- = -\sqrt{\frac{1-\tau}{\tau}}$, and τ is also the fraction of total market wealth represented by brown assets. In essence, the smaller is the presence of brown assets (the lower is τ), the browner those assets must be for the market to be green-neutral.

2.2 Equilibrium expected returns—the greenium

In equilibrium, PST21 show that the vector of expected excess returns is given by

$$\mu = \mu_m \beta_m - \frac{\lambda d}{a} g\,, \tag{2}$$

where a is relative risk aversion, assumed to be identical across all investors. Baker et al. (2022a) obtain a similar result, with $(d/a)g$ replaced by a vector of greenness scores that the ESG investors treat as additions to assets' expected returns in a mean-variance optimization. Applying Equation 2 to the simple green/brown setting here gives the difference in expected returns between brown and green assets having equal market betas, sometimes termed the greenium:

$$\begin{aligned} \mathrm{E}(r_B - r_G) &= -\left(\frac{\lambda d}{a}\right)\left(g^- - g^+\right) = \left(\frac{\lambda d}{a}\right)\left(\sqrt{\frac{1-\tau}{\tau}} + \sqrt{\frac{\tau}{1-\tau}}\right) \\ &= \frac{\lambda d}{a\sqrt{\tau(1-\tau)}} > 0\,. \end{aligned} \tag{3}$$

The greenium is positive because λ, d, a, and τ are all positive.

From Equation 3, the greenium is larger when the wealth share of ESG investors is larger (higher λ), when these investors have a stronger taste for green assets (higher d), and when investors are less risk-averse (lower a). In addition, the greenium is smallest when the market is evenly divided between green and brown assets ($\tau = 1/2$). As brown assets become scarce ($\tau \to 0$), they offer increasingly higher expected return, while the plentiful green assets earn an aggregate return approaching the market return. In contrast, as green assets become scarce ($\tau \to 1$), they offer increasingly lower expected return, while the return on brown assets then approaches the market's.

2.3 Portfolio weights—the green tilt

An ESG investor's vectors of portfolio weights on individual green assets (w_G) and brown assets (w_B) are given by

$$\begin{bmatrix} w_G \\ w_B \end{bmatrix} = \left(\frac{1}{N}\right) \begin{bmatrix} (1+hg^+)\iota_{(1-\tau)N} \\ (1+hg^-)\iota_{\tau N} \end{bmatrix} = \left(\frac{1}{N}\right) \begin{bmatrix} \left(1+h\sqrt{\frac{\tau}{1-\tau}}\right)\iota_{(1-\tau)N} \\ \left(1-h\sqrt{\frac{1-\tau}{\tau}}\right)\iota_{\tau N} \end{bmatrix}, \tag{4}$$

obtained by applying PST21's equation (A27) in our simplified setting. For large N, h is given by PST21's equation (A29),

$$h = \frac{(1-\lambda)d}{a^2\sigma_f^2}, \tag{5}$$

where σ_f^2 is the variance of the green factor, $\tilde{f}_g$, in Equation 1. From Equation 4, an ESG investor's total weights on green and brown assets, $x_G = w_G'\iota_{(1-\tau)N}$ and $x_B = w_B'\iota_{\tau N}$, are

$$x_G = (1-\tau) + t_G \tag{6}$$

$$x_B = \tau - t_G, \tag{7}$$

where t_G, the "green tilt," is given by

$$t_G = h\sqrt{\tau(1-\tau)}. \tag{8}$$

The green tilt is the deviation of an ESG investor's weights on green and brown assets from the market's weights on those assets, $1-\tau$ and τ. Equation 5 shows that the factor h in the green tilt is larger the stronger is the ESG taste, d, and the smaller is the presence of ESG investors, λ. The latter negative effect of λ on the green tilt goes in the opposite direction to the effect of λ on the greenium in Equation 3. This counteraction is sensible: as expected returns and thus prices are affected more by ESG investors' increased presence (greater λ), those investors' desire to favor green assets in their portfolios is increasingly met via greater weights on green assets in the market portfolio, due to the price effects. Therefore, there is less desire to tilt green beyond what the market already reflects.

The presence of the green factor's risk, σ_f^2, in the denominator of h implies a lower green tilt when σ_f^2 is higher. Green tilts by ESG investors must be offset with brown tilts by non-ESG investors. Tilting away from the market in a green or brown direction exposes an investor to the green factor's risk. All investors are thus less inclined to tilt green or brown when σ_f^2 is higher. In essence, the higher is σ_f^2, the less green and brown assets' returns are substitutes for each other. For the same reason, t_G is smaller when investors are more risk-averse (note that σ_f^2 is multiplied by a^2 in Equation 5).

2.4 Relating the greenium to the green tilt

We see above how investors' ESG tastes affect both expected returns and portfolio tilts. We next relate the greenium directly to the green tilt. First, rewrite h in Equation 5 as

$$h = \frac{1-\lambda}{(\mu_m/\sigma_m^2)\lambda\sigma_f^2}\left(\frac{\lambda d}{a}\right), \tag{9}$$

obtained by substituting PST21's assumption that $a = \mu_m/\sigma_m^2$, where μ_m and σ_m^2 are the mean and variance of $\tilde{r}_m$. From Equation 3, $\lambda d/a = \sqrt{\tau(1-\tau)}\,\mathrm{E}(r_B - r_G)$. Substituting for $\lambda d/a$ in Equation 9 and then for h in Equation 8, after rearranging, gives

$$\mathrm{E}(r_B - r_G) = \mu_m\left(\frac{\lambda}{1-\lambda}\right)\left(\frac{1}{\tau(1-\tau)}\right)\left(\frac{\sigma_f^2}{\sigma_m^2}\right)t_G\,. \tag{10}$$

Equation 10 relates the greenium, $\mathrm{E}(r_B - r_G)$, to the green tilt, t_G, for $t_G > 0$. (The latter condition requires $0 < \lambda < 1$, from Equations 8 and 9.) For a given tilt, the greenium is larger when there are more ESG investors (higher λ), when either brown or green assets are more scarce (τ farther from 1/2), and when the green factor is riskier (higher σ_f^2).

When just a small fraction of investors have ESG tastes, there are likely not significant pricing effects, as noted earlier. Suppose, for example, just 5% of investors are ESG-conscious ($\lambda = 0.05$), green assets represent 60% of the market ($\tau = 0.4$), the equity premium is 8% per year ($\mu_m = 0.08$), and the green factor's variance is 5% as large as the market's ($\sigma_f^2/\sigma_m^2 = 0.05$). Then even in an equilibrium where ESG investors tilt toward green assets by, say, 20% ($t_G = 0.20$), the greenium is just 1.8 basis points (bps).

When more investors have ESG tastes, the pricing effects can be substantial. For example, in a setting otherwise identical to the above, suppose half of investors are ESG-conscious ($\lambda = 0.50$). Then the same 20% green tilt is accompanied by a greenium of 33 bps. If three-fourths of investors are ESG-conscious ($\lambda = 0.75$), the greenium is 100 bps.

2.5 Amount of ESG investing

We define the total amount of ESG-driven investing as the sum across all ESG investors of the dollar amounts of their green tilts. Dividing that sum by total market value delivers the aggregate ESG tilt defined by PST21, which characterizes the relative size of the ESG investment industry. Applying that definition here gives the aggregate green tilt as

$$T = \lambda t_G = \frac{d}{a^2\sigma_f^2}\lambda(1-\lambda)\sqrt{\tau(1-\tau)}\,, \tag{11}$$

with the second equality obtained using Equations 5 and 8.

Equation 11 shows that T is highest when $\lambda = 1/2$, as PST21 also note. In essence, the ESG investment industry is largest when there is the greatest divergence in ESG tastes. When there are no ESG investors ($\lambda \approx 0$), then of course there is no ESG investment industry, as all investors hold the market portfolio. On the other hand, when all investors are the ESG type ($\lambda = 1$), there is again no ESG investment industry, because all investors then hold the market, which in that case has weights that fully reflect the investors' ESG tastes. The dependence of T on d, a, σ_f^2, and τ inherits the properties of green tilts, which are larger when d is larger, a is smaller, σ_f^2 is smaller, and τ is closer to $1/2$, as discussed earlier (Equation 8).

Even though there is no ESG investment industry when all investors are the ESG type ($\lambda = 1$), the strength of investors' ESG tastes can produce a substantial greenium, via the taste parameter d in Equation 3. PST21 show how ESG tastes can translate to large differences between expected returns on green and brown assets, and moreover this effect is strongest when $\lambda = 1$, which is also evident from Equation 3.

2.6 Divesting from brown assets

Suppose ESG investors choose a zero weight on brown assets, representing full divestment. This case is analyzed in the models of Berk and van Binsbergen (2024), Heinkel et al. (2001), Luo and Balvers (2017), and Zerbib (2022), all of which show that divestment produces higher expected returns for the divested assets, but to a degree that can be modest.

Important to realize first is that investors' ESG tastes can produce a substantial greenium in the absence of any divestment, or indeed any ESG investment, as noted above. The presence of full divestment by some investors requires disparity in ESG tastes, meaning $0 < \lambda < 1$ in the current setting.

To analyze divestment in this setting, observe from Equation 7 that $x_B = 0$ implies $t_G = \tau$, which when substituted into Equation 10 makes the greenium

$$\mathrm{E}(r_B - r_G) = \mu_m \left(\frac{\lambda}{1-\lambda}\right)\left(\frac{1}{1-\tau}\right)\left(\frac{\sigma_f^2}{\sigma_m^2}\right) . \tag{12}$$

For two assets with the same beta, one of which (brown) is divested by ESG investors and the other (green) is not, Equation 12 shows that the difference in expected returns is increasing in each of four quantities: μ_m, λ, τ, and σ_f^2/σ_m^2.

Berk and van Binsbergen (2024), hereafter BB, derive an approximation for the effect of divestment that depends on μ_m, λ, and τ as well, plus a fourth parameter, ρ_{GB}, the correlation between the aggregate green and brown portfolio returns. Equation 12 instead contains σ_f^2/σ_m^2 as its fourth quantity, but it is straightforward to show that[4]

$$\rho_{GB} = \left(1 - \frac{\sigma_f^2}{\sigma_m^2}\right)\left(\left[1 + \left(\frac{1-\tau}{\tau}\right)\frac{\sigma_f^2}{\sigma_m^2}\right]\left[1 + \left(\frac{\tau}{1-\tau}\right)\frac{\sigma_f^2}{\sigma_m^2}\right]\right)^{-\frac{1}{2}}. \tag{13}$$

BB's favored calibration sets $\mu_m = 6\%$, $\lambda = 0.02$, $\tau = 0.27$, and $\rho_{BG} = 0.93$. Solving Equation 13 using those values of τ and ρ_{BG} gives $\sigma_f/\sigma_m = 0.17$. Substituting into Equation 12 gives $\mathrm{E}(r_B - r_G)$ equal to 0.49 bps, close to the 0.44 bps from the BB approximation. The BB framework thus delivers essentially the same implication as the simplified version of the PST21 framework. When ESG-conscious investors represent a small fraction of the total ($\lambda = 0.02$), they have little effect on prices.

One should not infer from BB that divestment, or ESG investing more broadly, is ineffective in general. The pricing effects can be much larger when ESG investors have a greater presence, consistent with the role of λ shown by PST21 and discussed following Equation 10. In fact, BB themselves show that λ plays a key role in the effect of divestment. To illustrate here, suppose the value of λ is 0.50 instead of 0.02, with μ_m, τ, and ρ_{GB} (and thus σ_f^2/σ_m^2) maintained at their values above. Then the pricing effect is nearly 50 times greater than before, with $\mathrm{E}(r_B - r_G)$ equal to 24 bps. One could also make the case for larger values of μ_m, τ, and σ_f^2/σ_m^2, all of which would further increase the greenium. Moreover, divestment need not stop at a zero portfolio weight. In principle, ESG investors could short brown assets (i.e., $x_B < 0$ in Equation 7), which would produce an even larger greenium. Shorting corresponds to increasing the value of t_G beyond τ, and larger values of t_G push up the greenium, according to Equation 10.

There are two scenarios for considering divestment. One scenario shifts an asset from non-divested to divested (i.e., green to brown). Another scenario shifts some investors to being divestors (i.e., $\lambda = 0$ to $\lambda > 0$). The equal-beta comparison in Equation 12 reflects the first scenario, because the beta on a newly divested asset is essentially unchanged, given the asset is infinitesimal relative to the total market. In the second scenario, considered by BB, betas shift because all brown assets become newly divested, but BB conclude the beta shift plays only a second-order role in the expected-return impact. Equation 12 thus reasonably represents the effect of divestment in either scenario.

[4]The assumptions $w_m' g = 0$ and $\beta_m' g = 0$ imply market betas of 1 for both the aggregate green and brown portfolios, so from Equation 1 those portfolios' returns as $N \to \infty$ are given by $r_G = \tilde{r}_m + \sqrt{\frac{\tau}{1-\tau}}\tilde{f}_g$ and $r_B = \tilde{r}_m - \sqrt{\frac{1-\tau}{\tau}}\tilde{f}_g$, and recall $\tilde{r}_m$ and $\tilde{f}_g$ are uncorrelated.

2.7 ESG-related market inefficiency

Thus far we have assumed that whether or not an investor has ESG tastes, all investors condition correctly on whatever information greenness measures convey about firms' future profits. Suppose some investors ignore that information, a case of market inefficiency. The model of Pedersen et al. (2021) includes such investors, who are assumed also to have no ESG tastes ($d_i = 0$). These uninformed investors represent a third type, in addition to the two types of informed investors considered thus far, with $d_i = 0$ or $d_i = d > 0$.

Uninformed investors, if they have a substantial presence, can strengthen or weaken the relation between μ and g in Equation 2. The direction depends on how greenness relates to assets' future profits. Suppose green firms are likely to experience lower profits due, for example, to future costs of adopting green technologies. Because the uninformed investors ignore that information, green assets get overpriced relative to brown in equilibrium, thereby strengthening the negative relation between μ and g. Suppose instead that green assets are likely to earn higher profits, due, say, to increased demands for greener products. With that information ignored by the uninformed investors, green assets get underpriced, thereby weakening or even reversing the negative relation between μ and g.

2.8 Ex-ante versus ex-post greenness

In the models discussed above, asset greenness enters investors' utility as a characteristic assessed ex ante, treated as known by investors when they make portfolio choices. Avramov, Cheng, and Tarelli (2021) consider an alternative specification in which greenness is stochastic, entering utility as an ex-post quantity. An ESG investor derives utility from a portfolio's actual green tilt, which the investor observes only after choosing their portfolio. In that respect, an asset's greenness enters utility in the same manner as the asset's realized return.

In that model, ESG investors base their portfolio choices on the joint distribution of returns and greenness. Assets' ESG ratings provide *expected* greenness, denoted by the N-vector μ_g. In this setting, μ_g does not simply replace g in Equation 2, even though μ_g and g are both ex-ante quantities. Uncertainty about ex-post greenness generally weakens the role of ex-ante greenness in portfolio choice and asset pricing. In particular, Avramov et al. (2021) show that the expected brown-green return difference in Equation 3 still contains g^- and g^+ as ex ante quantities, the ESG ratings, but unless λ equals 0 or 1, the coefficient multiplying $(g^- - g^+)$ gets shrunk toward zero.

2.9 Climate risk

Many experts predict that climate change will lower the quality of life, aside from reducing wealth, but the severity of the effect is uncertain. A simple modeling of this risk introduces a stochastic climate outcome, $\tilde{C}$, that enters investor i's realized utility as $c_i\tilde{C}$, where c_i represents the investor's sensitivity to climate. A positive value for $\bar{c}$, the wealth-weighted average c_i across investors, means that the typical investor dislikes low realizations of $\tilde{C}$. PST21 show that when the model discussed above is extended to include this climate component of utility, the vector of equilibrium expected returns in Equation 2 expands to include a third term involving "climate betas." That is,

$$\mu = \mu_m\beta_m - \frac{\lambda d}{a}g + \bar{c}\left(1 - \rho_{mC}^2\right)\psi\,, \tag{14}$$

where ψ contains assets' climate betas and ρ_{mC} is the correlation between $\tilde{C}$ and $\tilde{r}_m$. Specifically, asset n's climate beta, ψ_n, is the slope coefficient on $\tilde{C}$ when regressing the asset's return on $\tilde{C}$ and $\tilde{r}_m$.

It seems reasonable to assume $\bar{c} > 0$, meaning the typical investor dislikes low realizations of $\tilde{C}$. When those low realizations occur, an asset with a higher ψ_n tends to perform worse than one having a lower ψ_n. Therefore, other things equal, the former asset is less desirable to the typical investor, so it has a higher expected return in equilibrium. In other words, the typical investor is willing to pay more for better climate "hedges," i.e., assets less exposed to bad climate outcomes. PST21 also show that the investors more sensitive to climate, with $c_i > \bar{c}$, tilt their portfolios toward better climate hedges, while the investors with $c_i < \bar{c}$ tilt in the other direction.

2.10 The greenium with climate risk

How does climate risk affect the greenium? The answer depends on how green assets differ from brown as climate hedges. To see this in our simple setting, suppose each green asset (with $g_n = g^+$) has $\psi_n = \psi^G$, and each brown asset (with $g_n = g^-$) has $\psi_n = \psi^B$. Then Equation 14 implies that the greenium in Equation 3 is augmented as

$$\mathrm{E}(r_B - r_G) = \frac{\lambda d}{a\sqrt{\tau(1-\tau)}} + \bar{c}\left(1 - \rho_{mC}^2\right)\left(\psi^B - \psi^G\right). \tag{15}$$

If green assets hedge climate better than brown ones, meaning $\psi^B > \psi^G$, then climate risk raises the greenium, because the second term in Equation 15 is then positive. If brown assets hedge better, then that term is negative, and the greenium is reduced.

Which assets are better climate hedges, green or brown? Theory can argue either way. As PST21 explain, green assets can be better hedges through either a firm-earnings or investor-demand channel. A bad realization of $\tilde{C}$ can induce stronger consumer demands for products of green firms relative to brown, and it can also induce regulations less friendly to brown firms. The latter effect is modeled by Hsu, Li, and Tsou (2023). Both effects impair expected future earnings of brown firms relative to green. Through this firm-earnings channel, an adverse $\tilde{C}$ is accompanied by lower realized returns on brown assets versus green. An adverse $\tilde{C}$ can also operate via the investor-demand channel by strengthening investors' ESG tastes (i.e., raising λ or d). Green assets then experience an upward shift in demand and thus higher realized returns relative to brown.

One can argue instead that brown assets are better climate hedges. In the models of Brav and Heaton (2021) and Baker, Hollifield, and Osambela (2022b), an adverse realization of $\tilde{C}$ results from unexpectedly high carbon emissions. Because brown firms account for a larger share of emissions, positive shocks to emissions are likely to accompany positive shocks to brown firms' output, earnings, and stock returns. This positive correlation between emissions and brown stocks' returns make those stocks a better climate hedge than green stocks.

Empirical evidence indicates that green assets are better climate hedges, as we explain below in Section 3.4. If so, climate risk increases the greenium, due to a positive value of $\psi^B - \psi^G$ in the second right-hand term in Equation 15. That term also includes $\bar{c}$, which reflects both the fraction of wealth held by investors affected by climate risk and the strength of those investors' climate sensitivities. Suppose, for simplicity, the fraction affected is λ^C, and all those affected have sensitivities $c_i = c$, so then $\bar{c} = \lambda^C c$. Important to realize is that λ^C can be high while λ is low. That is, many investors can see adverse climate outcomes as detrimental to their welfare, even if few also derive warm-glow utility from holding green assets. In the limiting case where $\lambda^C = 1$, climate risk could increase the greenium substantially, even if no investor had warm-glow preferences. Put differently, a large greenium does not necessarily imply strong warm-glow preferences among investors. If $\lambda^C = 1$, no investor would tilt away from the market portfolio to hedge climate risk. The unequal hedging abilities of green and brown assets would simply affect the assets' weights in the market portfolio, via equilibrium pricing.

Our modeling of climate risk, with a stochastic climate outcome, $\tilde{C}$, is very simple. A large literature, mostly outside finance, integrates climate risk with macroeconomic dynamics. For a review of the climate finance literature, see Giglio et al. (2021a).

3 EMPIRICAL PERSPECTIVES

Sustainable investing has become popular. For example, after Morningstar published its first mutual fund sustainability ratings in 2016, investors reallocated billions of dollars to highly-rated funds (Hartzmark and Sussman, 2019). Similarly, after Morningstar published its first carbon risk metrics in 2018, funds labeled as “low carbon” received disproportionate inflows (Ceccarelli, Ramelli, and Wagner, 2024b). Edmans, Gosling, and Jenter (2024) survey managers of both traditional and sustainable equity funds and find that sustainability influences portfolio choices and engagement for over three quarters of investors. In Europe, the launch of the Sustainable Finance Disclosure Regulation in 2021 was followed by strong inflows into funds newly categorized as green (Emiris, Harris, and Koulischer, 2024). European investors favor sustainable investing even if they expect lower returns as a result (e.g., Riedl and Smeets, 2017; Bauer, Ruof, and Smeets, 2021). Investors’ appetite for sustainability continued during the 2020 COVID-19 crisis (e.g., Pástor and Vorsatz, 2020), but it has cooled off since 2022, especially in the U.S. (Baker, Egan, and Sarkar, 2024).

In this section, we review evidence related to the key concepts introduced in Section 2, namely, investor tastes, the greenium, green tilts, and climate risk.

3.1 Investor tastes

Investors’ preferences for sustainability can be consequentialist or non-consequentialist, as explained in the introduction. In Section 2.1, we mention only non-consequentialist preferences. Our theoretical analysis actually allows investors to have both types of preferences, but only non-consequentialist preferences matter, because we assume that investors are atomistic. Given their infinitesimal size, investors’ preference for social impact does not affect portfolio choice or asset prices. In the model of Oehmke and Opp (2024), investors’ preference for social impact does matter because investors are assumed to coordinate, which is not the case here. See Section 6.3 of PST21 for a related discussion.

For more intuition, consider why people vote in elections. Many people vote because they derive utility directly from the act of voting (non-consequentialist preferences)—they might enjoy participating in a democracy or feel good about voting for their favorite candidate. People may also care about the election outcome (consequentialist preferences), but that by itself cannot explain why people vote, because with a large number of voters, the likelihood of any individual vote being pivotal is negligible. Non-consequentialist preferences seem essential to understanding why people vote. We argue that these preferences, in the form of tastes for green assets, also help us understand why investors pursue some of the leading sustainable investment strategies.

A prime example of non-consequentialist preferences are warm-glow preferences, which refer to the personal satisfaction from altruistic behavior, independent of its impact (Andreoni, 1990). For example, a donation to charity can make one feel good, regardless of its effectiveness. Strong support for the relevance of non-consequentialist preferences comes from the experimental evidence of Heeb, Kölbel, Paetzold, and Zeisberger (2023) and Bonnefon et al. (2025) who find that investors derive non-pecuniary utility from their portfolio holdings. In their field experiment, Heeb et al. (2023) find that experienced investors are willing to pay more for sustainable investments. Investors are not willing to pay for more impact, though, even when this impact is represented by a ten-times-larger carbon emission reduction. Surprisingly, this is true even for dedicated high-net-worth impact investors. Bonnefon et al. (2025) implement an experiment in which they auction off stocks of hypothetical corporations that donate parts of their profits to charity. They find strong evidence that investors seek to align their investments with their personal values, but no evidence for seeking social impact. Their investors are willing to pay more for stocks with higher greenness, but this willingness does not change when the greenness is made contingent on investors buying the stock. Overall, both studies find strong evidence that investors' moral preferences are non-consequentialist, and neither finds evidence of consequentialist preferences.

Humphrey, Kogan, Sagi, and Starks (2021) also find experimental evidence of investor tastes in their sample of subjects from the University of Texas. They additionally find that investors care more about negative externalities than about positive ones. Green and Roth (2024) conduct an online experiment to elicit U.S. stock market investors' social preferences. They find that investors' social investing preferences are quite heterogeneous, but even investors with consequentialist preferences often invest like non-consequentialists.

3.2 The greenium

In Section 2.2, we show that green assets have lower expected returns than brown in equilibrium. This hypothesis has been tested by numerous studies, too many to list here.[5] While most studies indeed find lower expected returns for green assets, some report the opposite.[6]

[5]See, for example, Table 1 in Hong and Shore (2023). Prominent recent examples include Bolton and Kacperczyk (2021) and Bolton and Kacperczyk (2023).

[6]Studies that report higher expected returns on green assets include, for example, Kempf and Osthoff (2007); Edmans (2011); Khan, Serafeim, and Yoon (2016), Nagy, Kassam, and Lee (2016); In, Park, and Monk (2017).

The main challenge in testing the hypothesis is the measurement of expected return.

3.2.1 Measurement: Ex post versus ex ante

The traditional approach is to use the average realized return as an unbiased proxy for expected return. This approach is reasonable as long as the time period over which the average return is calculated is long enough for the average unexpected return to be approximately zero. Unfortunately, time periods over which average returns are computed in sustainability studies tend to be short, because sustainable investing became popular only recently.[7] Over short periods, the average realized return on a long-green-short-brown portfolio (GMB, for green-minus-brown) can be dominated by GMB's unexpected return.

In particular, green assets can have higher realized returns than brown while agents' demands are shifting unexpectedly in the green direction. In their Section 3, PST21 discuss two ways green demands can shift. First, investors' demand for green assets can increase, directly driving up green asset prices. Second, consumers' demand for green products can strengthen, boosting green firms' profits and thus also their stock prices. The resulting wedge between expected and realized returns is the main subject of Pástor, Stambaugh, and Taylor (2022), hereafter PST22.

PST22 compute each U.S. stock's greenness from the firm's environmental rating from MSCI. They show that green stocks outperformed brown over the 2012-2020 period (i.e., GMB's average realized return is significantly positive).[8] Nonetheless, PST22 conclude that green stocks have lower expected returns than brown. The reason is that concerns about climate change strengthened unexpectedly over this time period, as PST22 show based on the media index of climate concerns constructed by Ardia, Bluteau, Boudt, and Inghelbrecht (2023). Importantly, shocks to climate concerns are positively related to the GMB portfolio's returns, indicating that GMB's unexpected returns have benefitted from unexpected increases in climate concerns. After PST22 purge unanticipated shocks from GMB's average realized return, the outperformance of green stocks vanishes, and in fact turns slightly negative.

To explain this approach more formally, let r_t denote GMB's realized return in period

[7] A notable exception is Hong and Kacperczyk (2009) whose sample period is 42 years long, 1965–2006. Since this period is pre-ESG, they focus on "sin" stocks (i.e., stocks of firms producing alcohol, tobacco, and gaming). They find that sin stocks significantly outperform non-sin stocks, and they argue that social norms lead investors to demand compensation for holding sin stocks. Both their finding and their interpretation are consistent with the PST21 model.

[8] Karolyi, Wu, and Xiong (2023) report similar evidence in a global 2012–2021 sample.

t. The objective is to estimate GMB's expected return, $\mu = E\{r_t\}$, which is the negative of the greenium defined in our Equation 3. Instead of simply using GMB's sample average return, $\bar{r}$, PST22 exploit the additional information in the history of another variable, x_t, which represents an unanticipated change in climate concerns in period t. In the regression

$$r_t = a + bx_t + \epsilon_t \,, \tag{16}$$

$a = \mu$ because $E\{x_t\} = 0$. Therefore, one can estimate μ by the sample estimate of a. This estimate is given by the OLS intercept

$$\hat{a} = \bar{r} - \hat{b}\bar{x} \,, \tag{17}$$

where $\hat{b}$ is the OLS slope estimate and $\bar{x}$ is the sample average of x_t. PST22 estimate μ by $\hat{a}$. In their sample, $\hat{b} > 0$ (i.e., GMB tends to perform well when climate concerns strengthen unexpectedly) and $\bar{x} > 0$ (i.e., climate concerns strengthen unexpectedly over the sample period); as a result, $\bar{r}$ overstates μ by $\hat{b}\bar{x}$ on average. This overstatement is removed by $\hat{a}$, which reduces $\bar{r}$ by $\hat{b}\bar{x}$. Over their sample period, PST22 find $\bar{r} > 0$ (i.e., green stocks outperformed brown) but $\hat{a} < 0$ (i.e., green stocks would have underperformed brown had there been no surprises on average during the sample period). In other words, after purging climate-related shocks from the average realized return, PST22's estimate of μ is no longer significantly positive; in fact, it is slightly negative, consistent with the prediction of PST21 and our Equation 3.

In addition to this "ex post" approach to estimating μ, PST22 also use an "ex ante" approach, which estimates μ by the difference between the implied costs of capital of green and brown stocks. Their estimates of μ are consistently negative, fluctuating between 0.5% and 2.5% per year. The estimates grow steadily in the second half of their sample, consistent with strengthening investor demands for green assets since 2017 or so. Similarly, El Ghoul, Guedhami, Kwok, and Mishra (2011); Chava (2014), and Eskildsen, Ibert, Jensen, and Pedersen (2024) also find that greener firms tend to have lower implied costs of capital than brown.

The greenium is related to the value premium, in that green stocks tend to be growth stocks and brown stocks tend to be value stocks, as shown by PST22. In fact, that study finds the value-growth spread's worst-ever decade of underperformance, ending in 2020, can be largely explained by the outperformance during that period of green (environmentally friendly) stocks relative to brown. A similar connection between growth and greenness, with the latter broadly defined, arises for sustainable mutual funds, which in earlier years were known as socially responsible funds. For example, Geczy, Stambaugh, and Levin (2021) find that, in 2001, a tilt toward value is less achievable when restricted to socially responsible funds. Those authors also note that a similar situation exists decades later: in 2020, Morningstar classifies three times as many sustainable funds as being growth as compared to value.

In general, there is no single greenium value. While we do derive a formula for the greenium in our Equation 3, this formula pertains to our simple setting with only two levels of greenness. In this setting, the greenium is simply the corresponding difference in expected returns. In reality, though, greenness fills out a spectrum. Likewise, in the general version of the PST21 model, there is a continuum of g_n values. There is no obvious pair of greenness values to pick, so there is no single greenium, just as there is no single credit premium or value premium.

3.2.2 Evidence outside the equity market

The evidence discussed above pertains to the stock market. There is also a fair amount of evidence pointing to a greenium in the bond market. Some of the cleanest evidence comes from PST22's comparison of the yields on German "twin" bonds. Since September 2020, the German government has been issuing green bonds, along with virtually identical non-green twins. The two bonds have the same issuer, same maturity, same coupon rate, and the same coupon payment dates; the only notable difference is in their greenness. PST22 find that the green bond always trades at a lower yield, indicating a lower expected return. The yield spread between the 10-year green and non-green twins, or the greenium, widened about three-fold between September 2020 and November 2021, presumably due to growing climate concerns. As a result of this widening, the green bond outperformed its higher-yielding non-green twin over this period. However, this outperformance does not imply green outperformance going forward; in fact, the opposite is clearly true, given the wider greenium at the end of the sample. This evidence parallels PST22's equity-based evidence: the greener asset had a higher realized return than brown temporarily, but its expected return going forward is lower. The green bond's temporary outperformance came at the expense of its future return.

Studies that do not have access to twin bonds compare the yields of green bonds to the yields of similar non-green securities. Larcker and Watts (2020) compare green U.S. municipal bonds to nearly identical bonds issued for non-green purposes by the same issuers on the same day. They find essentially identical pricing, indicating a zero greenium. Flammer (2021) finds similar results in corporate green bonds. Baker et al. (2022a) analyze U.S.

municipal and corporate green bonds. They find that green bonds are issued at a premium of 5 to 9 bps over similar ordinary bonds. When green bonds are issued simultaneously with ordinary bonds from the same issuer, the initial pricing is the same, as in Larcker and Watts (2020), but even then a greenium emerges after the bonds begin trading in the secondary market. Caramichael and Rapp (2024) find that even at issuance, green corporate bonds yield 3 to 8 bps less than conventional bonds, but a significant greenium emerges only in 2019. After matching investment-grade green bonds to counterfactual non-green bonds, Zerbib (2019) finds that green bond yields are lower by about 2 bps, on average. Feldhütter, Halskov, and Krebbers (2024) find lower yields on sustainability-linked bonds.

Greeniums have also been found in the alternatives space. For example, Barber, Morse, and Yasuda (2021) find that dual-objective impact venture capital funds earn lower internal rates of return, by 4.7% per year, compared to traditional venture capital funds. Jeffers, Lyu, and Posenau (2024) find that impact funds have lower total returns than benchmark non-impact funds. Liang, Sun, and Teo (2022) find underperformance by UN PRI signatory hedge funds.

3.2.3 Agents' expectations

When asked, investors express a variety of views about the magnitude, and even the sign, of the greenium. Many investors expect green assets to outperform brown. For example, in the 2019 *ESG Global Survey* by BNP Paribas, 60% of respondents expect their ESG portfolios to outperform over the next five years. Other investors expect green assets to underperform brown, as predicted by our Equation 3. In Giglio, Maggiori, Stroebel, Tan, Utkus, and Xu (2024)'s large-scale survey of Vanguard's U.S. investors, the average investor expects ESG investments to underperform the market by 2.1% per year. The survey reveals large heterogeneity across investors (a standard deviation of 5%) in their return expectations, but ESG underperformance is expected by the average investor among both males and females, Democrats and Republicans, the young and the old, and the rich and the poor. The same survey also reveals heterogeneous motives for ESG investing: 48% of respondents see no reason to invest in ESG, 24% are motivated by ethical considerations, 22% have climate hedging motives, and 6% expect higher returns.

Riedl and Smeets (2017) survey a large group of individual Dutch investors. They find that socially responsible investors (defined as those who hold at least one socially responsible equity fund) expect to earn lower returns on socially responsible equity funds than on conventional funds. Specifically, 48.7% of socially responsible investors expect to earn lower returns on socially responsible funds, whereas only 16.5% of these investors expect higher returns (the remaining 34.8% expect the same returns).[9] Investors thus seem willing to forgo financial performance to invest in line with their social preferences.

A similar conclusion is reached by Bauer et al. (2021), who run a field survey in which a Dutch pension fund grants its members a vote on its sustainable-investment policy. When asked whether they favor expanding the fund's engagement to promote the sustainability of the fund's portfolio companies, 67.9% of participants agree and only 10.8% disagree. This choice seems driven by participants' strong social preferences rather than their financial beliefs. While most participants do not expect sustainability to hurt financial returns, even among those who do, the majority choose it. In contrast, Edmans et al. (2024) find that few equity fund managers are willing to sacrifice financial returns for environmental and social performance, primarily over concerns about fiduciary duty.

Not only investors but also corporate managers perceive differences between the expected returns of green and brown firms. Gormsen, Huber, and Oh (2024) analyze perceived costs of capital extracted from corporate conference calls. They find that green and brown firms (as judged by MSCI's environmental scores) perceived their own costs of capital to be about the same until 2016. Since 2016, however, the perceived cost of capital of green firms has declined by more than that of brown firms, with the gap growing to about 1.5% per year in 2023. This evidence is consistent with our Equation 3 and the strengthening of ESG preferences between 2016 and 2023. The authors also find that large energy and utility firms have applied lower costs of capital to their greener divisions since 2016.

3.3 Green tilts

In Section 2.3, we show theoretically that ESG investors' portfolio weights deviate from market weights. Specifically, ESG investors tilt their portfolios toward green assets and away from brown assets, as we show in Equations 6 through 8.

Prior studies document various institutional portfolio tilts with respect to stocks' ESG characteristics. For example, Starks (2023) shows that U.S. active mutual funds increased their ownership of high-ESG firms between 2013 and 2021. Institutions overweight firms with good governance (Ferreira and Matos, 2008) but underweight firms with negative environmental and social indicators (Nofsinger, Sulaeman, and Varma, 2019), including firms with high carbon emissions (Bolton and Kacperczyk, 2021; Bolton, Eskildsen, and Kacperczyk,

[9] Conventional investors are slightly more pessimistic, with 56.1% (14.5%) of them expecting lower (higher) returns from socially responsible funds.

2024). Institutions reduced the carbon exposures of their portfolios between 2001 and 2015 (Choi, Gao, and Jiang, 2020), in part because institutions that have joined climate-related initiatives have increased their holdings of firms with low carbon emissions (Atta-Darkua, Glossner, Krueger, and Matos, 2023), and in part because of the growing popularity of net-zero portfolios (e.g., Bolton, Kacperczyk, and Samama, 2022; Cenedese, Han, and Kacperczyk, 2024). Democratic-leaning fund managers allocate less to firms viewed as socially irresponsible (Hong and Kostovetsky, 2012). Institutions with longer investment horizons tilt their portfolios more towards firms with high ESG scores (Starks, Venkat, and Zhu, 2023).

Most of the above studies examine portfolio-level ESG characteristics. Those characteristics reflect also stocks' non-ESG characteristics such as size and book-to-market, which are correlated with ESG characteristics. For example, growth stocks tend to be greener than value stocks, as noted earlier. Therefore, a growth fund can score well on ESG metrics even without paying attention to ESG. To get around this problem, Pástor, Stambaugh, and Taylor (2024b), hereafter PST24, compute ESG-related portfolio tilts by controlling for non-ESG characteristics. Let $\mathcal{G}$ denote the set of all stocks' ESG characteristics and $\mathcal{G}_0$ denote their neutral (market-average) values. Let w_{in} denote investor i's portfolio weight on stock n. For any given investor-stock pair, PST24 define the ESG-related portfolio tilt as

$$\Delta_{in} = \mathrm{E}[w_{in}|\mathcal{G}, \mathcal{C}] - \mathrm{E}[w_{in}|\mathcal{G}_0, \mathcal{C}]\,, \tag{18}$$

where E denotes a conditional expectation and $\mathcal{C}$ is the set of stocks' non-ESG characteristics including size, book-to-market, and five others. Δ_{in} is the part of w_{in} attributable to the difference between $\mathcal{G}$ and $\mathcal{G}_0$, holding $\mathcal{C}$ constant. After aggregating the Δ_{in}'s across i and n, the authors analyze these portfolio tilts at the aggregate, institution, and stock levels. They find, for example, that the largest institutions tilt increasingly toward green stocks, whereas other institutions and households tilt increasingly brown.

In Section 2.5, we define the total amount of ESG investing as the sum across all ESG investors of the dollar amounts of their green tilts. Following a closely related approach, PST24 find that ESG-related tilts total 6% of the investment industry's assets in 2021. They also find that ESG tilts represent 22% of institutions' total portfolio tilts, where total tilt is measured by active share (Cremers and Petajisto, 2009). Therefore, while ESG-related tilts are modest relative to the industry's assets, they are substantial relative to total tilts. Moreover, while ESG tilts do not represent a growing fraction of assets, they do represent a growing fraction of overall portfolio tilts.

The literature on green portfolio tilts contains many open questions. We give three examples. First, do institutional investors who sign the United Nations Principles for Responsible Investment become greener after becoming signatories? PST24 find they do, but prior evidence is mixed (Gibson Brandon, Glossner, Krueger, Matos, and Steffen, 2022; Humphrey and Li, 2021; Kim and Yoon, 2023; Liang et al., 2022). Second, do individual investors pay as much attention as institutions to ESG? Choi et al. (2020) find that retail investors, but not institutions, respond to abnormally warm temperatures by selling stocks of carbon-intensive firms. Li, Watts, and Zhu (2024b) find that retail investors' trades respond to a broader set of ESG news events. Moss, Naughton, and Wang (2024) find that retail investors' buy and sell decisions do not respond to ESG disclosures. Focusing on ESG-related portfolio tilts, PST24 find that the portfolios of non-13F investors, most of whom are retail investors, tilt brown, and increasingly so. Third, what is the price impact of ESG-related asset demands? Early investigations include Koijen, Richmond, and Yogo (2024); Noh, Oh, and Song (2023), and Van der Beck (2024).

3.4 Climate risk

Investors are increasingly interested in managing their portfolios' exposures to climate risk. This risk falls into two main categories: physical risk and transition risk. Physical risks are direct consequences of climate change, including immediate damages from extreme weather events such as hurricanes, wildfires, and floods, as well as longer-term damages from sustained temperature increases, rising sea levels, and droughts. Transition risks, which arise from the global move toward a lower-carbon economy, include mostly policy risk, regulatory risk, and risks associated with technological innovation. In their survey of institutional investors, Krueger et al. (2020) find that investors consider climate risk to be an important investment risk. Half of the survey respondents state that climate risks, particularly those related to regulation, have already begun to materialize. Similarly, finance academics and professionals surveyed by Stroebel and Wurgler (2021) identify regulatory risk as the most important climate risk to investors over the next five years.

In Section 2.10, we offer a theoretical discussion of how climate risk affects the greenium. This effect depends on whether green or brown assets are better hedges against climate risk (Equation 15). Evidence indicates that green assets are better hedges. Choi et al. (2020) show that green firms, identified by low carbon emissions, outperform brown during abnormally warm months, which might alert investors to climate change. Engle, Giglio, Kelly, Lee, and Stroebel (2020) report that green firms, identified by high environmental scores, outperform brown in periods with negative climate news, as measured by their textual analysis of news sources. Ardia et al. (2023) find that green stocks tend to outperform brown on days with unexpected increases in climate change concerns, as measured by their news index. Using the same index but monthly data and a different sample, PST22 arrive at the same conclusion. All of these studies indicate that green stocks are better hedges against climate shocks, which implies that climate risk widens the greenium.

To measure a company's exposure to climate risk, many studies use the company's carbon emissions. Emissions are a good candidate for this role, given their connection to climate change and the large magnitude of the carbon externality (Pástor, Stambaugh, and Taylor, 2024a). Large emitters are generally considered to be more exposed to climate risk, especially its transition dimension. Several studies find significant links between carbon emissions and the cross section of stock returns (e.g., Bolton and Kacperczyk, 2021, 2023; Aswani, Raghunandan, and Rajgopal, 2024; Atilgan, Demirtas, Edmans, and Gunaydin, 2024; Zhang, 2024) as well as the cross section of bond returns (e.g., Duan, Li, and Wen, 2021; Seltzer, Starks, and Zhu, 2022). Looking at option market data, Ilhan, Sautner, and Vilkov (2021) show that larger emitters exhibit more tail risk and more variance risk.

Besides carbon emissions, another popular measure of climate risk is exposure to sea level rise (SLR). This exposure is particularly relevant for the real estate market. Bernstein, Gustafson, and Lewis (2019) find that coastal homes facing the risk of SLR sell at a discount compared to otherwise identical homes that are not exposed to the same risk. The discount is larger for homes more exposed to SLR and communities more concerned about climate change. The average discount has grown over time, as one would expect given the growing awareness of climate risk. Baldauf, Garlappi, and Yannelis (2020) report similar evidence, finding that homes projected to be underwater sell at larger discounts in neighborhoods more concerned about climate change. The heterogeneity in beliefs about climate change features also in Bernstein, Billings, Gustafson, and Lewis (2022), who find that Republicans are increasingly moving into homes exposed to SLR while Democrats are moving out. Giglio, Maggiori, Rao, Stroebel, and Weber (2021b) also show that SLR risk is reflected in house prices. Nguyen, Ongena, Qi, and Sila (2022) show that SLR risk is priced in residential mortgage markets. Beyond real estate, SLR risk seems priced also in the municipal bond market. Painter (2020) shows that counties more likely to be affected by SLR issue long-term bonds at higher yields. Goldsmith-Pinkham, Gustafson, Lewis, and Schwert (2023) find that school districts exposed to SLR have higher municipal bond yields than similar non-exposed districts.

SLR is an example of long-term physical climate risk. Shorter-term risks include heat waves. Acharya, Johnson, Sundaresan, and Tomunen (2022) find higher expected returns on stocks and bonds more exposed to local heat stress, consistent with the pricing of physical climate risk. Even more short-term are immediate disasters such as hurricanes, tornadoes, and wildfires. Analyzing 16 types of such climatic disasters, Alok, Kumar, and Wermers (2020) find that mutual fund managers located near disaster zones underweight disaster-zone stocks compared to distant managers. They attribute this finding to overreaction by local managers. Similarly, Huynh and Xia (2023) argue that investors overreact to natural disasters because the prices of stocks and bonds of firms exposed to disasters tend to exhibit short-term declines followed by reversals. While investors seem to overreact to disasters, they underreact to long-term physical climate risks, according to Hong, Li, and Xu (2019), who find underreaction in the response of food producers' stock prices to long-term trends in droughts.

Several studies construct firm-level measures of exposure to climate risk by analyzing transcripts of earnings calls, finding these measures to be priced in various markets (Sautner, van lent, Vilkov, and Zhang, 2023; Li, Shan, Tang, and Yao, 2024a). Huynh and Xia (2021) find that climate change news risk is priced in corporate bonds. Of course, economic activity creates other environmental risks beyond climate change. For example, several papers study the pricing of biodiversity risk (e.g., Coqueret, Giroux, and Zerbib, 2025; Garel, Romec, Sautner, and Wagner, 2024; Giglio, Kuchler, Stroebel, and Zeng, 2023).

4 CONCLUSION

Our targeted review focuses on the financial effects of sustainable investing, with a spotlight on investor tastes and their effects on portfolio tilts and asset prices. We leave out the real effects as well as shareholder engagement, an important avenue through which real effects could be delivered. We do not view these topics as unimportant; on the contrary, we believe they are so important that they deserve their own separate review.

The literature on sustainable investing is young, offering plentiful opportunities for future contributions. For example, only a few studies have analyzed the interactions between sustainable investing and active investing. Cao, Titman, Zhan, and Zhang (2023) find that institutions with greener portfolios respond less to traditional quantitative signals of mispricing. This evidence is consistent with the model of Goldstein, Kopytov, Shen, and Xiang (2024), in which ESG investors trade differently from traditional investors based on the same signals. Avramov, Cheng, and Tarelli (2024) develop an information acquisition model to analyze active management with ESG investors. In all three studies, investors' tastes affect asset prices. The ability to predict shifts in those tastes should thus be valuable to active investors, as should be the ability to predict changes in asset greenness. Indeed, Ceccarelli, Evans, Glossner, Homanen, and Luu (2024a) show that some mutual fund managers trade skillfully ahead of changes in the ESG scores of their portfolio companies. Whether some investors are able to predict shifts in ESG tastes remains to be seen.

ESG is not a monolith. In our theory, a firm's greenness is a single number, but that number implicitly embeds a multitude of sustainability-related characteristics. Which of those characteristics matter most for investors' tastes, portfolio tilts, and the greenium? While some work in this direction has already been done, there is clearly room for more.

Future research can also shed more light on the magnitude of the greenium. The literature summarized in Section 3.2 reports a wide variety of estimates. For example, while the greenium estimates in the bond market rarely exceed a few bps, much larger estimates have been found in other markets and surveys. What explains these differences? Guided by our theory in Section 2.2, one can hypothesize that the bond market has few ESG investors, or that bond market investors have weaker tastes for green assets, or that they are more risk-averse, or that the differences in greenness between green and conventional bonds are relatively small. Additionally, our theory in Section 2.10 implies that the greenium's magnitude depends on the strength of both warm-glow preferences and climate-hedging demands. Decomposing the greenium into these components, and potentially others, is yet another worthy challenge for future research.

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