Sustainable Investing with ESG Rating Uncertainty[*]

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This Version: 26th July 2021

Abstract

This paper analyzes the asset pricing and portfolio implications of an important barrier to sustainable investing—uncertainty about the corporate ESG profile. In equilibrium, the market premium increases and demand for stocks declines under ESG uncertainty. In addition, the CAPM alpha and effective beta both rise with ESG uncertainty and the negative ESG-alpha relation weakens. Employing the standard deviation of ESG ratings from six major providers as a proxy for ESG uncertainty, we provide supporting evidence for the model predictions. Our findings help reconcile the mixed evidence on the cross-sectional ESG-alpha relation and suggest that ESG uncertainty affects the risk-return trade-off, social impact, and economic welfare.

Keywords: ESG, Rating Uncertainty, Portfolio Choice, Capital Asset Pricing Model
JEL: G11, G12, G24, M14, Q01

[*]We especially thank an anonymous referee for insightful comments and suggestions. We also thank Bill Schwert (the editor), Yakov Amihud, Marcin Kacperczyk, Lubos Pastor, Lasse Heje Pedersen, Luke Taylor, seminar participants at Catholic University of Milan, Ben-Gurion University of the Negev, Bar-Ilan University, Bocconi University, and EDHEC Business School, and conference participants at the 2021 North American Summer Meeting of the Econometric Society for useful comments and discussions. We are solely responsible for any remaining errors.

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1 Introduction

The global financial market has experienced exponential growth in sustainable investing, an investment approach that considers environmental, social, and governance (ESG) factors in portfolio selection and management. Since the launch of United Nations Principles for Responsible Investment (PRI) in 2006, the number of signatories has grown from 734 in 2010 to 1,384 in 2015 and 3,038 in 2020, with total assets under management of US$21 trillion in 2010, US$59 trillion in 2015, and US$103 trillion in 2020.[1] In line with the increasing concerns about global warming, BlackRock CEO Larry Fink wrote in a recent annual letter that climate change will force businesses and investors to shift their strategies, leading to a "fundamental reshaping of finance" and "significant reallocation of capital".[2]

As the ESG objective is becoming a primary focus in asset management, the reallocation of capital has major implications for portfolio decisions and asset pricing. However, ESG investors often confront a substantial amount of uncertainty about the true ESG profile of a firm. In the absence of a reliable measure of the true ESG performance, any attempt to quantify it needs to cope with incomplete and opaque ESG data and nonstructured methodologies. A meaningful illustration of uncertainty about the ESG score is the pronounced divergence across ESG rating agencies.[3] While such uncertainty could be an important barrier to sustainable investing, to date, little attention has been devoted to the role of ESG uncertainty in portfolio decisions and asset pricing.

This paper aims to fill this gap by analyzing the equilibrium implications of ESG uncertainty for both the aggregate market and the cross section. To pursue this task, we consider brown-averse agents who extract nonpecuniary benefits from holding green stocks, following Pástor, Stambaugh, and Taylor (2021a). We first study the aggregate market through a mean-variance setup that consists of the market portfolio and a riskless asset. Due to uncertainty about the ESG profile, equities are perceived to be riskier. In addition, the demand for equities consists of two components: (1) the usual demand when ESG preferences are muted and (2) a demand for a pseudo-asset with a positive payoff for a green market and a negative payoff for a brown market as well as volatility that evolves from uncertainty about the market ESG score. Aggregating these components, we show that the overall demand for equities falls due to ESG uncertainty, even when the market is green.

We then formulate the market premium in equilibrium. While the higher risk due to

[1] See, `https://www.unpri.org/pri`.

[2] See, `https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter`.

[3] Berg et al. (2020) document that the average correlation among six major rating providers is only 0.54. They also find that, even when the categories of attributes considered for the evaluation of a firm's ESG profile are fixed, raters largely disagree on the measurement of these granular characteristics.

ESG uncertainty essentially commands a higher market premium, there is an offsetting force when the market is green because ESG investors extract nonpecuniary benefits from holding green stocks. The ultimate implications of ESG preferences with uncertainty for the market premium are thus inconclusive. When the market is green neutral, however, the equity premium rises with ESG uncertainty. For perspective, when ESG uncertainty is not accounted for and the market is green (green neutral), the market risk does not change, the demand for risky assets rises (does not change), and the market premium drops (does not change) relative to ESG indifference.

We further derive a CAPM representation where both alpha and the effective beta vary with firm-level ESG uncertainty. The effective beta differs from the CAPM beta in the following way. While the CAPM beta is based on the covariance and variance of actual returns, the effective beta reflects the notion that both the market and individual stock returns are augmented by a random ESG-based component, which is positive for a green asset and negative otherwise. Thus, the effective beta is based on the covariance and variance of ESG-adjusted returns. Regarding alpha, when ESG uncertainty is not accounted for, the CAPM alpha exclusively reflects the willingness to hold green stocks due to nonpecuniary benefits, and the ESG-alpha relation is, hence, negative.[4] Accounting for ESG uncertainty, the equilibrium alpha increases with ESG uncertainty and the ESG-alpha relation weakens.

We move on to empirically test the model implications using U.S. common stocks from 2002 to 2019. We collect ESG ratings from six major rating agencies, namely, Asset4 (Refinitiv), MSCI KLD, MSCI IVA, Bloomberg, Sustainalytics, and RobecoSAM. We employ the average (standard deviation of) ESG ratings across rating agencies to proxy for the firm-level ESG rating (ESG uncertainty). Consistent with existing studies, we confirm that there are substantial variations across different rating providers, while the average rating correlation is 0.48. The variations are quite persistent throughout the entire sample period.

We first examine how the ESG rating and uncertainty affect investor demand. To better capture the demand from ESG-sensitive investors, we consider three distinct types of institutions: norm-constrained institutions, hedge funds, and other institutions. Norm-constrained institutions, such as pension funds as well as university and foundation endowments, are more likely to make socially responsible investments compared to hedge funds or mutual funds that are natural arbitrageurs (Hong and Kacperczyk (2009)). We first confirm that norm-constrained institutions display preferences for greener firms. Consistent with the model prediction, we find that in the presence of uncertainty about the ESG profile, ESG-sensitive investors lower their demand for risky assets. For instance, among the high-ESG-rating portfolios, norm-constrained institutions hold 22.8% of the low-uncertainty stocks while only

[4] See, e.g., Heinkel et al. (2001) and Pástor, Stambaugh, and Taylor (2021a).

18.1% of the high-uncertainty stocks, indicating a 21% decline. The results are particularly strong among high-ESG stocks, suggesting that rating uncertainty matters the most for ESG-sensitive investors in their ESG investment. Notably, even with the growing ESG awareness, their demand for green assets continues to diminish with rating uncertainty in the recent decade. In addition, while hedge funds invest more in low-ESG stocks, rating uncertainty plays a similar role in discouraging stock investment.

We next examine the cross-sectional implications of ESG uncertainty. We first sort stocks into quintile portfolios based on their ESG uncertainty. Within each uncertainty group, we further sort stocks into quintile portfolios according to their ESG ratings. We find that the ESG rating is negatively associated with future performance among stocks with low ESG uncertainty, providing empirical support for the predictions of Pástor, Stambaugh, and Taylor (2021a), who rely on deterministic ESG scores. For instance, brown stocks outperform green stocks by 0.59% per month in raw return and 0.40% per month in CAPM-adjusted return. However, in the presence of ESG uncertainty, our model shows that the ESG-alpha relation can be nonlinear and ambiguous. Indeed, we demonstrate empirically that the negative return predictability of ESG ratings does not hold for the remaining firms. The results are robust to adjusting returns for alternative risk factors and controlling for firm characteristics in Fama and MacBeth (1973) regressions.

Finally, we calibrate the model for plausible values of market volatility and risk aversion. The investment universe consists of a riskless asset and the market portfolio. Our calibration considers two types of agents who observe the returns on investable assets. One type of agents accounts for ESG preferences with uncertainty in assessing the risk-return profile of the optimal portfolio, while the other type is ESG indifferent. Accounting for ESG uncertainty significantly reduces the demand for the market portfolio and the certainty equivalent rate of return of ESG-sensitive agents. The calibration results reinforce the notion that ESG uncertainty could negatively, and significantly so, affect the risk-return trade-off, social impact, and economic welfare.

This paper contributes to several strands of the literature. First, we explicitly account for uncertainty about the ESG profile in equilibrium asset pricing for both the aggregate market and the cross section. Prior work has focused on investors' ESG preferences (e.g., Heinkel et al. (2001) and Pástor, Stambaugh, and Taylor (2021a)), while our model predictions and calibration results highlight the importance of considering ESG uncertainty when analyzing sustainable investing. Specifically, the perceived equity risk increases with ESG uncertainty, while the demand for equity falls. ESG uncertainty also affects the market premium in aggregate, as well as the CAPM alpha and effective beta in the cross section.

Second, we contribute to the growing literature on the cross-sectional return predictability of the ESG profile. Prior studies document weak return predictability of the overall ESG rating (e.g., Pedersen et al. (2021)) and mixed evidence based on different ESG proxies (e.g., Gompers et al. (2003); Hong and Kacperczyk (2009); Edmans (2011); Bolton and Kacperczyk (2020)). Our contribution is to propose that ESG uncertainty could tilt the ESG-performance relationship and serve as a potential mechanism to explain the opposing findings. We show that ESG ratings are negatively associated with future performance when there is little uncertainty and that the ESG-performance relationship could be insignificant or positive when uncertainty increases. Thus, the sin premium (Hong and Kacperczyk (2009)) and carbon premium (Bolton and Kacperczyk (2020)) could be attributed to the notion that sin stocks (i.e., companies involved in producing alcohol, tobacco, and gaming) and carbon emissions are clearly defined and thus subject to minimal uncertainty among investors. On the other hand, other ESG profiles could be more challenging to measure or rely on non-standardized information and methodologies, thereby displaying more uncertainty and mixed evidence on return predictability. A recent work by Pástor, Stambaugh, and Taylor (2021b) further highlights the distinction between ex ante *expected* returns and ex post *realized* returns, and shows that U.S. green stocks outperformed brown stocks during the last decade, due to unexpectedly strong increases in environmental concerns. While our model is static in nature and formulates *expected* returns, we also confirm that our findings are stronger in the pre-2011 period. This suggests that the equilibrium outcome over longer horizons could be even stronger than the full sample evidence we document, due to the *unexpected* outcomes realized over the last decade.

To the extent that ESG uncertainty will decrease with a better understanding of a firm's true ESG profile, our work enriches academic and policy discussions in that context. Despite the rapid growth in the sustainable investing and ESG data markets,[5] the comparability of ESG information remains a critical issue. Due to the lack of standards governing the reporting of ESG information, it is not a trivial task to compare the ESG data of two different companies (Amel-Zadeh and Serafeim (2018)). In addition, the construction of ESG ratings is nonregulated, and methodologies can be opaque and proprietary, leading to substantial divergence across data providers (e.g., Mackintosh (2018); Berg et al. (2020)). Our findings imply that the lack of consistency across ESG rating agencies makes sustainable investing riskier and hence reduces investor participation and potentially hurts economic welfare. This has important normative implications. For instance, it would be useful for policymakers to establish a clear taxonomy of ESG performance and unified disclosure standards for sustainability reporting. It would be especially instructive to identify which investments are *really*

[5]The estimated spending on ESG data was US$617 million in 2019 and could approach US$1 billion by 2021. See, `http://www.opimas.com/research/547/detail/`.

green. Doing so could mitigate ESG uncertainty, thus reducing the cost of equity capital for green firms, leading to higher social impact.

Our study of the equilibrium implications of ESG uncertainty owes a debt to the innovative setup developed by Pástor, Stambaugh, and Taylor (2021a), although our focus is different. Pástor, Stambaugh, and Taylor (2021a) comprehensively analyze the equilibrium implications of sustainable investing and conduct an analysis of welfare and social impact. They also account for the possibility that ESG investors can disagree about a firm's ESG profile and analyze cases where the market is green neutral or green. Notably, in their setup, the ESG score is *certain* because investors are dogmatic about their ESG perceptions and can observe each other's perceived ESG values. Relative to their important work, we study the implications of *uncertainty* about the corporate ESG profile. In particular, the investors in our model agree that the ESG scores are uncertain and they also agree on the underlying distribution of the uncertain scores. The empirical proxy for uncertainty is the dispersion, or disagreement, across raters. We show that ESG uncertainty affects the equity premium, investor's demand for risky assets, economic welfare, and the alpha and beta components of stock returns.

The remainder of this paper is organized as follows. Section 2 presents the model. Section 3 describes the data and the main variables used. Section 4 empirically examines how ESG ratings and uncertainty affect investor demand and cross-sectional return predictability. Section 5 calibrates the model and explores its quantitative implications. The conclusion follows in Section 6.

2 ESG and Market Equilibrium

The theory section develops the economic setup. We start with a single risky asset, i.e., the market portfolio, and a riskless asset. We derive the optimal portfolio and discuss the implications of uncertainty about the ESG profile for the market premium and welfare. The single-asset setup is then extended to consider multiple risky assets. We analyze the implications of ESG uncertainty for the demand of individual stocks, derive an asset pricing model for the cross section of stock returns, and discuss incremental effects of ESG uncertainty on the alpha and beta components of returns.

2.1 One Risky Asset

Consider a single-period economy in which an optimizing agent trades at time 0 and liquidates the position at time 1. Let $\tilde{r}_M$ denote the random rate of return on the market portfolio in excess of the riskless rate, r_f, and let $\tilde{g}_M$ denote the *true*, but unobservable, ESG score of the market portfolio.[6] We model the excess market return and the ESG score as

$$\tilde{r}_M = \mu_M + \tilde{\epsilon}_M, \tag{1}$$

$$\tilde{g}_M = \mu_{g,M} + \tilde{\epsilon}_{g,M}, \tag{2}$$

where $E(\tilde{r}_M) = \mu_M$ is the expected market excess return, $E(\tilde{g}_M) = \mu_{g,M}$ is the expected value of the market ESG score, and $\tilde{\epsilon}_M$ and $\tilde{\epsilon}_{g,M}$ are zero-mean residuals. We assume that the residuals obey a bivariate normal distribution with σ_M, $\sigma_{g,M}$, and $\rho_{g,M}$ denoting the standard deviation of return, the standard deviation of ESG score, and the correlation between residuals, respectively.

It is assumed that the agent knows the joint distribution of return and the ESG score as well as the underlying parameters. In the empirical analysis that follows, $\mu_{g,M}$ and $\sigma_{g,M}$ are proxied by the average and standard deviation of ESG ratings across six major data vendors, respectively. From an investor's perspective, a higher $\sigma_{g,M}$ indicates more disagreement among ESG raters and hence more uncertainty about the true ESG profile of the market.

Following Pástor, Stambaugh, and Taylor (2021a), we consider an optimizing agent who derives nonpecuniary benefits from holding stocks based on their ESG characteristics. Moreover, preferences are formulated through the exponential utility (CARA) function

$$V\left(\tilde{W}_1, x\right) = -e^{-A\tilde{W}_1 - BW_0 x \tilde{g}_M}, \tag{3}$$

where $\tilde{W}_1 = W_0(1 + r_f + x\tilde{r}_M)$ is the terminal wealth, W_0 is the initial wealth, x is the fraction of wealth invested in the risky asset, A stands for the agent's absolute risk aversion, and B characterizes the nonpecuniary benefits that the agent derives from stock holdings. Positive (negative) B indicates that the agent extracts benefits from holding green (brown) stocks. Hence, B can be interpreted as the absolute brown aversion. In the following, we make the sensible assumption of a nonnegative brown aversion ($B \geq 0$). Slightly departing from Pástor, Stambaugh, and Taylor (2021a), we formulate preferences for ESG to be wealth-dependent. Then, the expression BW_0 represents the relative brown aversion.

In the presence of brown aversion, the correlation between residuals in equations (1) and (2), $\rho_{g,M}$, is assumed to be positive. In particular, if the agent learns that the market ESG score is higher than previously thought (i.e., $\tilde{\epsilon}_{g,M}$ is positive), the price that he would be willing to pay for the market will be revised upward (positive $\tilde{\epsilon}_M$), while a downward price

[6] Consistent with static setups, we do not formulate intertemporal preferences; hence, the riskless rate is exogenously specified.

revision applies for a score lower than previously thought.[7]

Observe from equation (3) that the investment in the riskless asset does not contribute to the portfolio's ESG profile, as perceived by the agent. This is because the riskless asset is implicitly assumed to be green neutral. As ESG scores are ordinal in nature, the choice of considering the riskless asset as a reference level does not imply loss of generality. In addition, to capture the ESG benefits and costs from investing in the market, we allow the market portfolio to depart from green neutrality.

The agent picks x attempting to maximize the expected value of preferences in equation (3). The first-order condition suggests that the optimal portfolio in the presence of ESG uncertainty is given by

$$x^* = \frac{1}{\gamma}\frac{\mu_M + b\mu_{g,M}}{\sigma^2_{M,U}}, \tag{4}$$

where $b = \frac{B}{A}$, $\gamma = AW_0$ stands for the relative risk aversion, and $\sigma^2_{M,U} = \sigma^2_M + b^2\sigma^2_{g,M} + 2b\sigma_M\sigma_{g,M}\rho_{g,M}$ is the variance of return, as *perceived* by the agent. Henceforth, b is referred as brown aversion for brevity. The ex-ante market variance, $\sigma^2_{M,U}$, is no longer equal to σ^2_M because, with ESG uncertainty, the risky asset is perceived to be a package of two distinct securities. The first delivers the market excess return $\tilde{r}_M$, while the second reflects exposure to ESG uncertainty and yields $b\tilde{g}_M$. The latter component can be interpreted as investing b units in a pseudo-asset that pays $\tilde{g}_M$ per unit. As b increases, i.e., when the ratio between brown aversion and risk aversion increases, the ESG component becomes more meaningful in investment decisions. A sufficient condition for $\sigma^2_{M,U} \geq \sigma^2_M$ is that the brown aversion and the correlation between market return and ESG score are nonnegative (i.e., $b \geq 0$ and $\rho_{g,M} \geq 0$). As noted earlier, these conditions are likely to be satisfied.

In what follows, we consider a positive market premium (i.e., $\mu_M > 0$), which is plausible in the presence of risk aversion. The brown-aversion assumption is sensible for ESG-perceptive investors. Additionally, to distill the incremental effects of ESG uncertainty, we consider two benchmark cases. In the first, the agent is ESG indifferent, and in the second, preference for ESG is accounted for, while the ESG profile is known for certain. The latter case is studied by Pástor, Stambaugh, and Taylor (2021a) in a multiple-security setup.

Equation (4) presents the optimal stock position in the presence of uncertainty about the ESG profile. Stock investment is thus driven by the relative risk aversion, γ, and the price of risk of the portfolio that yields $\tilde{r}_M + b\tilde{g}_M$. To give perspective on the optimal equity demand, consider the case that incorporates ESG preferences but excludes uncertainty. Then, the perceived volatility of the stock return is still σ_M. Conforming to intuition, the demand for stocks rises as b rises and the market is green. Essentially, stocks are more attractive to

[7]We thank the referee for suggesting this avenue.

a green-loving agent.

When ESG uncertainty is accounted for, however, this intuition is no longer binding. To illustrate, consider two limiting cases. In the first, b grows with no bound. The investor then avoids equities, i.e., $\lim_{b\to\infty} \frac{1}{\gamma}\frac{\mu_M + b\mu_{g,M}}{\sigma^2_{M,U}} = 0$. Similarly, when ESG uncertainty rises with no bound, the demand for stocks evaporates. Thus, both increasing brown aversion and increasing uncertainty translate into increasing equity risk. In the presence of ESG uncertainty, a brown-averse agent could substantially reduce stock investing, even when the market is green, on average.

Moving beyond the two limiting cases, we further examine portfolio tilts in the presence of ESG uncertainty. For that purpose, we rewrite the optimal portfolio as

$$x^* = \frac{1}{\gamma}\frac{\mu_M}{\sigma^2_M} + \frac{1}{\gamma}b\frac{\mu_{g,M}}{\sigma^2_M} - \frac{1}{\gamma}\frac{\mu_M + b\mu_{g,M}}{\sigma^2_M}\left(b^2\frac{\sigma^2_{g,M}}{\sigma^2_{M,U}} + 2b\frac{\sigma_M\sigma_{g,M}\rho_{g,M}}{\sigma^2_{M,U}}\right). \tag{5}$$

The first term on the right-hand side of equation (5) describes the benchmark case of ESG indifference. Preferences for ESG generate the second and third terms. The term $\frac{1}{\gamma}\frac{b\mu_{g,M}}{\sigma^2_M}$ corresponds to the second benchmark case with ESG preferences when the ESG profile is known for certain. It suggests that as b rises, the demand for risky asset rises and portfolio tilt intensifies. The third term purely reflects the incremental effect of ESG uncertainty. The ratio $\frac{\sigma^2_{g,M}}{\sigma^2_{M,U}}$ stands for the contribution of ESG uncertainty to the total, *ex ante*, market variance. Additionally, in the presence of a positive correlation between market return and the ESG profile, the agent employs the market portfolio to hedge against risk evolving from ESG uncertainty, as captured by the hedge ratio $\frac{\sigma_M\sigma_{g,M}\rho_{g,M}}{\sigma^2_{M,U}}$. Hence, the incremental effect of ESG uncertainty on stock investing (captured by the third term) is negative.[8]

In addition, when the market is green neutral (i.e., $\mu_{g,M} = 0$) and when the ESG profile is known for certain, stock investing is unaffected relative to ESG indifference. In contrast, when the market is green neutral and ESG uncertainty is accounted for, participation in the equity market is discouraged, relative to both benchmark cases.

We now turn to analyzing the equilibrium implications of ESG preferences with uncertainty. It is assumed that, in equilibrium, the representative agent's wealth is fully invested in the market portfolio. Thus, equalizing the optimal stock allocation in equation (4) to 1 yields the market premium. The market premiums for the cases of ESG indifference (I), ESG preference with no uncertainty (N), and ESG preference with uncertainty (U) are given

[8] In the case where $\mu_M + b\mu_{g,M}$ is negative, the ESG uncertainty effect on stock investing goes the opposite way. This requires the interaction of extreme brown aversion along with an extreme brown market.

by

$$\mu_M^I = \gamma\sigma_M^2, \tag{6}$$
$$\mu_M^N = \gamma\sigma_M^2 - b\mu_{g,M}, \tag{7}$$
$$\mu_M^U = \gamma\sigma_M^2 - b\mu_{g,M} + \gamma(\sigma_{M,U}^2 - \sigma_M^2). \tag{8}$$

Retaining the assumptions of a green market and a brown-averse agent, the market premium diminishes relative to equation (6), as captured by the second term in equation (7). This is because, as implied by Pástor, Stambaugh, and Taylor (2021a) in a multi-asset context, an agent who extracts nonpecuniary benefits from holding green stocks is willing to compromise on a lower risk premium relative to an ESG-indifferent agent. If the market is green neutral, the second term disappears; hence, the equity premium is unchanged even when ESG preferences are accounted for.

Further accounting for uncertainty in equation (8), there are two conflicting forces. On the one hand, the agent extracts nonpecuniary benefits from holding the green market, a force leading to diminished market premium. On the other hand, the market is perceived to be riskier; thus, it commands a higher market premium, as formulated in the third term of equation (8). The overall effect is inconclusive. If the market is green neutral, the equity premium increases relative to both benchmark cases due to the increasing risk channel.

The same conflicting forces apply to the equilibrium Sharpe ratio (the slope of the capital allocation line) when accounting for ESG uncertainty, SR^U, relative to ESG indifference, SR^I. Given market return volatility, σ_M, it follows that $\frac{SR^U}{SR^I} = \frac{\sigma_{M,U}^2}{\sigma_M^2} - \frac{b\mu_{g,M}}{\gamma\sigma_M^2}$. The first term is greater than one and reflects the increase in perceived equity risk. The second captures the decrease in the market premium due to the nonpecuniary benefits from ESG investing.

In the presence of ESG preferences, the market risk premium thus incorporates an ESG incremental premium that can be defined as

$$\mu_M^N - \mu_M^I = -b\mu_{g,M}, \tag{9}$$
$$\mu_M^U - \mu_M^I = \gamma\left(\sigma_{M,U}^2 - \sigma_M^2\right) - b\mu_{g,M}. \tag{10}$$

The no-uncertainty case is associated with a negative ESG incremental premium when the market is green and the agent is brown-averse, while the incremental premium is zero when the market is green neutral. In addition, it is evident from equation (10) that the market premium increases with ESG uncertainty. Collectively, with ESG uncertainty, the incremental premium is positive when the market is green neutral. Otherwise, with a green market and a brown-averse agent, the sign of the incremental premium is inconclusive due to the conflicting forces.

The single-security economy establishes a solid benchmark in which to comprehend the more complex multi-asset setup to be developed later in the text. While the cross-sectional ESG-alpha relation is negative when ESG uncertainty is not accounted for, the single-security case provides the first clue that (1) the risk premium increases with ESG uncertainty, and (2) the risk premium of a green stock could exceed that of a brown stock in the presence of ESG uncertainty. Taking together, the ESG-alpha relation in the cross section can be subject to conflicting forces.

Up to this point, we have considered a single-agent economy for ease of exposition. In what follows, to assess the welfare implications of ESG uncertainty in the aggregate and to study the multi-asset economy, we extend the framework to account for multiple heterogeneous agents. Thus, consider I agents indexed by $i = 1, \ldots, I$, who differ in their initial wealth $W_{i,0}$, absolute risk aversion A_i, and absolute brown aversion B_i. Market clearing requires that $\sum_{i=1}^{I} w_i x_i^* = 1$, where $w_i = \frac{W_{i,0}}{W_0}$ is the fraction of agent i's initial wealth relative to aggregate wealth. With heterogeneous agents, the market premium equivalent to equation (8) is given by

$$\mu_M^U = \gamma_M \sigma_{M,U}^2 - b_M \mu_{g,M,U}, \tag{11}$$

where $\gamma_M = \frac{1}{\sum_{i=1}^{I} w_i \gamma_i^{-1}}$ is the aggregate risk aversion, $b_M = \frac{\sum_{i=1}^{I} w_i \gamma_i^{-1} b_i}{\gamma_M^{-1}}$ is the aggregate brown aversion, $\sigma_{M,U}^2 = \frac{\gamma_M^{-1}}{\sum_{i=1}^{I} w_i \gamma_i^{-1} \sigma_{i,U}^{-2}}$ is the perceived aggregate variance, and $\mu_{g,M,U} = \frac{\sum_{i=1}^{I} w_i b_i \gamma_i^{-1} \sigma_{i,U}^{-2}}{b_M \gamma_M^{-1} \sigma_{M,U}^{-2}} \mu_{g,M}$ is the perceived aggregate ESG score. Online Appendix A.1 provides details.

The changing cost of equity capital due to ESG preferences has implications for economic welfare and social impact. For instance, Pástor, Stambaugh, and Taylor (2021a) show that when the market is green, the lower cost of equity capital could trigger increasing capital investment and social impact. In our setup, a green representative firm would be harmed by the higher cost of equity capital induced by ESG uncertainty, which could trigger adverse effects on capital investment and social impact. In the calibration experiment described in Section 5.1, we comprehensively analyze the utility loss attributable to ESG uncertainty. We also calibrate the market premium, as well as equity demand and welfare for two types of agents: the first is indifferent to ESG, while the other is ESG perceptive and recognizes the uncertainty about the sustainability profile.

2.2 A Multi-Asset Economy

We move on to formulate an economy populated with I optimizing agents, N risky assets, and a riskless asset. We aim to derive an asset pricing model for the cross section of equity returns in the presence of ESG uncertainty, while we also extend the analysis of portfolio selection.

We model the excess returns and ESG scores on N assets as

$$\tilde{\boldsymbol{r}} = \boldsymbol{\mu}_r + \tilde{\boldsymbol{\epsilon}}_r, \tag{12}$$

$$\tilde{\boldsymbol{g}} = \boldsymbol{\mu}_g + \tilde{\boldsymbol{\epsilon}}_g, \tag{13}$$

where $\boldsymbol{\mu}_r$ is an N-vector of expected excess returns and $\boldsymbol{\mu}_g$ is an N-vector of expected ESG scores. The residuals from both equations are assumed to obey a $2N$-variate normal distribution. The $N \times N$ covariance matrices of returns and ESG ratings are denoted by $\boldsymbol{\Sigma}_r$ and $\boldsymbol{\Sigma}_g$, respectively, while $\boldsymbol{\Sigma}_{rg}$ is the $N \times N$ cross-covariance matrix between $\tilde{\boldsymbol{r}}$ and $\tilde{\boldsymbol{g}}$ with diagonal elements that are assumed to be positive.

Similar to equation (3), the agent maximizes an exponential utility function, $V\left(\tilde{W}_{i,1}, \boldsymbol{X}_i\right) = -e^{-A_i \tilde{W}_{i,1} - B_i W_{i,0} \boldsymbol{X}_i' \tilde{\boldsymbol{g}}}$, where $\tilde{W}_{i,1} = W_{i,0}\left(1 + r_f + \boldsymbol{X}_i' \tilde{\boldsymbol{r}}\right)$ is the terminal wealth and $\boldsymbol{X}_i$ is the N-vector of portfolio weights per investor i.

Proposition 1 describes the optimal portfolio in the presence of multiple risky assets. The proof is in Online Appendix A.2.

Proposition 1. *The optimal portfolio strategy of investor i is given by*

$$\boldsymbol{X}_i^* = \frac{1}{\gamma_i} \boldsymbol{\Sigma}_{i,U}^{-1} \left(\boldsymbol{\mu}_r + b_i \boldsymbol{\mu}_g\right), \tag{14}$$

where $\boldsymbol{\Sigma}_{i,U} = \boldsymbol{\Sigma}_r + b_i^2 \boldsymbol{\Sigma}_g + 2b_i \boldsymbol{\Sigma}_{rg}$ is the covariance matrix of $\tilde{\boldsymbol{r}} + b_i \tilde{\boldsymbol{g}}$.

This portfolio strategy is the multi-asset version of equation (4). It suggests that in the presence of ESG preferences, investors perceive asset excess returns to be the sum of (1) N stock excess returns $\tilde{\boldsymbol{r}}$ and (2) N returns on pseudo-assets yielding $b_i \tilde{\boldsymbol{g}}$. Several implications are in order. First, infinitely brown-averse agents act as if they were infinitely risk averse, as, in the presence of ESG uncertainty, $\lim_{b_i \to \infty} \boldsymbol{X}_i^* = \boldsymbol{0}$. Second, in another extreme case when ESG uncertainty grows with no bound for all stocks, economic agents avoid stocks altogether. Third, in intermediate cases, uncertainty about ESG profiles nonlinearly intervenes in formulating the optimal portfolio, through the inverse of $\boldsymbol{\Sigma}_{i,U}$, and tends to reduce the demand for both green and brown stocks.

To highlight the incremental implications of ESG uncertainty for portfolio selection, we rewrite equation (14) as

$$\boldsymbol{X}_i^* = \frac{1}{\gamma_i}\boldsymbol{\Sigma}_r^{-1}\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right) + \frac{1}{\gamma_i}\boldsymbol{\Psi}_i\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right), \tag{15}$$

where $\boldsymbol{\Psi}_i = -\boldsymbol{\Sigma}_r^{-1}\left(b_i^2\boldsymbol{\Sigma}_g + 2b_i\boldsymbol{\Sigma}_{rg}\right)\boldsymbol{\Sigma}_r^{-1}\left(\mathbf{I}_N + \left(b_i^2\boldsymbol{\Sigma}_g + 2b_i\boldsymbol{\Sigma}_{rg}\right)\boldsymbol{\Sigma}_r^{-1}\right)^{-1}$ and $\mathbf{I}_N$ stands for the $N \times N$ identity matrix.

The first term of the optimal portfolio coincides with the strategy in Pástor, Stambaugh, and Taylor (2021a) (equation (4)). The second term is exclusively attributable to ESG preferences with uncertainty about the sustainability profile. Interestingly, in the presence of heterogeneous agents, the ESG uncertainty term precludes fund separation because the incremental portfolio, evolving from ESG uncertainty, is agent specific.

In particular, consider the alternative decomposition of the optimal portfolio:

$$\boldsymbol{X}_i^* = \frac{\lambda^r}{\gamma_i}\boldsymbol{\Gamma}_i^{-1}\frac{\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\mu}_r}{\mathbf{1}'\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\mu}_r} + \frac{\lambda^g}{\gamma_i}b_i\boldsymbol{\Gamma}_i^{-1}\frac{\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\mu}_g}{\mathbf{1}'\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\mu}_g}, \tag{16}$$

where $\lambda^r = \mathbf{1}'\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\mu}_r$, $\lambda^g = \mathbf{1}'\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\mu}_g$, and $\boldsymbol{\Gamma}_i = \mathbf{I}_N + b_i^2\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\Sigma}_g + 2b_i\boldsymbol{\Sigma}_r^{-1}\boldsymbol{\Sigma}_{rg}$.

The decomposition shows that each optimizing agent holds three portfolios: (1) a riskless asset, (2) the maximum Sharpe ratio portfolio in the risk-return space, and (3) the maximum Sharpe ratio portfolio in the risk-ESG space. Note that ESG uncertainty affects the demand for risky assets through the $N \times N$ matrix $\boldsymbol{\Gamma}_i$, which enters both risky asset portfolios. If all agents have the same b_i, then the matrix $\boldsymbol{\Gamma}_i$ is common to all agents and, therefore, a three-fund separation results. Otherwise, the two risky portfolios are agent specific and, hence, fund separation does not apply in the setup of heterogeneous agents with ESG uncertainty.

2.3 CAPM with ESG Uncertainty

The next two propositions illustrate the cross-sectional asset pricing implications of ESG preferences, first excluding and then accounting for ESG uncertainty. The proofs are in Online Appendix A.3 and A.4.

Proposition 2. *Excluding ESG uncertainty, the equilibrium expected excess returns of the risky assets are given by*

$$\boldsymbol{\mu}_r = \boldsymbol{\beta}\mu_M - b_M\left(\boldsymbol{\mu}_g - \boldsymbol{\beta}\mu_{g,M}\right), \tag{17}$$

where $\mu_M = \gamma_M\sigma_M^2 - b_M\mu_{g,M}$ is the equilibrium market premium, $\sigma_M^2 = \boldsymbol{X}_M'\boldsymbol{\Sigma}_r\boldsymbol{X}_M$ is the market return variance, $\boldsymbol{\beta} = \frac{\boldsymbol{\Sigma}_r\boldsymbol{X}_M}{\sigma_M^2}$ is the N-vector of market beta, $\mu_{g,M} = \boldsymbol{X}_M'\boldsymbol{\mu}_g$ is the *aggregate market greenness, $\boldsymbol{X}_M = \sum_{i=1}^{I} w_i \boldsymbol{X}_i$ is the N-vector of aggregate market positions in risky assets, γ_M is the aggregate risk aversion, and b_M is the aggregate brown aversion.*

In the absence of ESG uncertainty, the expected excess return expression in equation (17) is identical to that derived by Pástor, Stambaugh, and Taylor (2021a), with a slight modification that the market can depart from green neutrality. Expected returns are affected by ESG preferences through (1) the modified market premium and (2) the alpha component that stands for excess return unexplained by $\boldsymbol{\beta}\mu_M$. Alpha depends on the effective ESG score, i.e., the difference between the firm's own ESG score and the market ESG score multiplied by the stock's beta. A numerical example is useful to illustrate. Assume a stock with $\beta = 1.2$ and $\mu_{g,M} = 2$. As long as the ESG score is below 2.4, the stock has a positive alpha even when the stock is green. The threshold value 2.4 reflects zero alpha, while alpha turns negative if the ESG score goes above the threshold. For instance, if the ESG score is 3 (2), the effective ESG score is 0.6 (-0.4), and alpha is negative (positive). Altogether, as long as the market is not green neutral, it is not the firm's own ESG score that dictates the sign and magnitude of alpha. Instead, it is the effective ESG score.

In the presence of ESG preferences and certainty about the ESG profile, the beta measuring exposure to total market risk, $\boldsymbol{\beta}$, coincides with the CAPM beta. This is because, as noted earlier, the perceived return on any security is equal to the sum of (1) the actual return and (2) the pseudo-asset return that is proportional to the ESG score, while the ESG score is nonrandom. Thus, in the absence of ESG uncertainty, the covariance and variance terms used to define beta are unchanged. With uncertainty, the ESG score is random; hence, the resulting beta is no longer identical to the standard CAPM beta.

As proposed by Pástor, Stambaugh, and Taylor (2021a), in the absence of ESG uncertainty, equilibrium expected returns compensate for exposure to (1) the market risk factor and (2) an ESG-based factor. When ESG uncertainty is in play, fund separation no longer results; thus, expected returns cannot be represented through a multifactor model. Instead, we propose a CAPM-type representation, where expected excess returns are expressed as the sum of two components: the first reflects the exposure to the market factor, while the second is a nonzero alpha that stands for (1) nonpecuniary benefits from ESG investing and (2) an additional risk premium attributable to ESG uncertainty. The following proposition explains the equilibrium expected returns with ESG uncertainty, which is the core of our analysis.

Proposition 3. *With ESG uncertainty, the equilibrium expected excess returns of the risky assets are formulated as*

$$\boldsymbol{\mu}_r = \boldsymbol{\beta}\mu_M + \left(\boldsymbol{\beta}_{\mathit{eff}} - \boldsymbol{\beta}\right)\mu_M - b_M\left(\boldsymbol{\mu}_{g,U} - \boldsymbol{\beta}_{\mathit{eff}}\,\mu_{g,M,U}\right), \tag{18}$$

where $\mu_M = \gamma_M \sigma^2_{M,U} - b_M \mu_{g,M,U}$ *is the equilibrium market premium,* $\boldsymbol{\beta} = \frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma^2_M}$ *the* N*-vector of the equilibrium CAPM beta,* $\boldsymbol{\beta}_{\mathit{eff}} = \frac{\boldsymbol{\Sigma}_{M,U} \boldsymbol{X}_M}{\sigma^2_{M,U}}$ *the* N*-vector of effective beta,* $\boldsymbol{\Sigma}^{-1}_{M,U} = \frac{\sum_{i=1}^I w_i \gamma_i^{-1} \boldsymbol{\Sigma}^{-1}_{i,U}}{\sum_{i=1}^I w_i \gamma_i^{-1}}$ *the inverse of the covariance matrix of ESG-adjusted perceived asset returns.* $\boldsymbol{\mu}_{g,U} = \frac{\mathbf{B}_M \boldsymbol{\mu}_g}{b_M}$ *is the perceived aggregate ESG scores of individual assets, where* $\mathbf{B}_M = (\sum_{i=1}^I w_i \gamma_i^{-1} \boldsymbol{\Sigma}^{-1}_{i,U})^{-1} \sum_{i=1}^I w_i \gamma_i^{-1} b_i \boldsymbol{\Sigma}^{-1}_{i,U}$*, and* $\mu_{g,M,U} = \boldsymbol{X}'_M \boldsymbol{\mu}_{g,U}$ *is the perceived aggregate market ESG score. Online Appendix A.4 displays simplified expressions for asset pricing with ESG uncertainty assuming homogeneous agents.*

The expected excess return expression in equation (18) modifies the no-uncertainty case in equation (17) by replacing the market beta with the effective beta. Thus, it is the effective beta that is priced in the cross section of equity returns. To give perspective on the notion of effective beta, note that the perceived return on an arbitrary asset still consists of two components: (1) the actual return and (2) b times the ESG score of that asset. Because ESG scores for the market and individual assets are random, both the covariance and variance terms, used to define beta, depart from the standard return-based counterparts. The effective beta is based on ESG-adjusted returns. Collectively, expected excess returns on N risky assets are formulated as the sum of three terms. The first term reflects exposure to market risk, as in the standard CAPM. Then, the difference between the effective beta and the market beta gives rise to the second term. The third term accounts for the uncertainty-adjusted effective ESG scores, analogously to equation (17) but using the effective beta instead.

To provide further intuition on the beta-pricing specification, we consider a simplified case in which agents have homogeneous preferences (γ and b are equal across agents). The effective beta can then be represented as

$$\boldsymbol{\beta}_{\mathit{eff}} = \frac{\sigma^2_M}{\sigma^2_{M,U}} \boldsymbol{\beta} + \frac{b^2 \sigma^2_{g,M}}{\sigma^2_{M,U}} \boldsymbol{\beta}_g + \frac{2b\sigma_{rg,M}}{\sigma^2_{M,U}} \boldsymbol{\beta}_{rg}, \tag{19}$$

where $\boldsymbol{\beta}_g = \frac{\boldsymbol{\Sigma}_g \boldsymbol{X}_M}{\sigma^2_{g,M}}$, $\boldsymbol{\beta}_{rg} = \frac{\boldsymbol{\Sigma}_{rg} \boldsymbol{X}_M}{\sigma_{rg,M}}$, and $\sigma^2_{M,U} = \sigma^2_M + b^2 \sigma^2_{g,M} + 2b\sigma_{rg,M}$. The effective beta is a weighted average of (1) the CAPM beta, $\boldsymbol{\beta}$, (2) the ESG uncertainty beta, $\boldsymbol{\beta}_g$, and (3) the ESG-return cross-covariance beta, $\boldsymbol{\beta}_{rg}$. The ESG uncertainty beta represents the co-movement between the asset's own ESG uncertainty and the market ESG uncertainty. The cross-covariance beta represents the asset's contribution to the aggregate ESG-return cross covariance, $\sigma_{rg,M}$. The weights in equation (19) reflect the relative contributions to the perceived market return variance, i.e., the actual return, the ESG component, and the cross-covariance component.

The asset's effective beta coincides with its market beta if preferences for ESG are muted

($b = 0$) or if the market is not subject to ESG uncertainty ($\sigma_{g,M} = \sigma_{rg,M} = 0$). To provide more intuition about the dependence of the effective beta on ESG uncertainty, consider the case where the covariance matrix of ESG uncertainty, $\mathbf{\Sigma}_g$, is diagonal with elements $\sigma^2_{g,j}$ ($j = 1, \ldots, N$), while $\mathbf{\Sigma}_{rg}$ is diagonal with elements $\sigma_{rg,j}$. The effective beta of asset j can be written as

$$\beta_{\mathit{eff},j} = \frac{\sigma^2_M}{\sigma^2_{M,U}}\beta_j + \frac{b^2\sigma^2_{g,M}}{\sigma^2_{M,U}}\frac{X_j\sigma^2_{g,j}}{\sigma^2_{g,M}} + \frac{2b\sigma_{rg,M}}{\sigma^2_{M,U}}\frac{X_j\sigma_{rg,j}}{\sigma_{rg,M}}. \tag{20}$$

Given positive market weights in equilibrium, $X_j > 0$, the effective beta increases with the asset's own ESG uncertainty, $\sigma^2_{g,j}$, and with the covariance between firm's ESG and return, $\sigma_{rg,j}$, while it does not depend on the mean ESG score. Interestingly, as long as the aggregate ESG uncertainty is nonzero, a positive market beta asset with certain ESG profile ($\sigma_{g,j} = \sigma_{rg,j} = 0$) has an effective beta equal to $\frac{\sigma^2_M}{\sigma^2_{M,U}}\beta_j$, which is lower than the market beta β_j. This is because the asset contributes to the aggregate return-based risk, but not to the aggregate ESG uncertainty.

We next analyze alpha variation with ESG uncertainty in the case of homogeneous agents. Combining equations (18) and (19), we show in Online Appendix A.4 that the CAPM alpha can be expressed as

$$\boldsymbol{\alpha} = \left(\frac{b^2\sigma^2_{g,M}}{\sigma^2_{M,U}}\left(\boldsymbol{\beta}_g - \boldsymbol{\beta}\right) + \frac{2b\sigma_{rg,M}}{\sigma^2_{M,U}}\left(\boldsymbol{\beta}_{rg} - \boldsymbol{\beta}\right)\right)\left(\mu_M + b_M\mu_{g,M}\right) - b_M\left(\boldsymbol{\mu}_g - \boldsymbol{\beta}\mu_{g,M}\right). \tag{21}$$

The second term on the right-hand side of equation (21) is identical to that in equation (17) when ESG uncertainty is excluded. The first term represents the incremental effect of ESG uncertainty and is further analyzed below. For ease of interpretation, we assume again that $\mathbf{\Sigma}_g$ and $\mathbf{\Sigma}_{rg}$ are diagonal. Then, it follows that

$$\begin{aligned} \alpha_j = {} & \left(\frac{b^2\sigma^2_{g,M}}{\sigma^2_{M,U}}\left(\frac{X_j\sigma^2_{g,j}}{\sigma^2_{g,M}} - \beta_j\right) + \frac{2b\sigma_{rg,M}}{\sigma^2_{M,U}}\left(\frac{X_j\sigma_{rg,j}}{\sigma_{rg,M}} - \beta_j\right)\right)\left(\mu_M + b_M\mu_{g,M}\right) \\ & - b_M\left(\mu_{g,j} - \beta_j\mu_{g,M}\right). \end{aligned} \tag{22}$$

Given positive market portfolio weights in equilibrium, $X_j > 0$, the asset alpha increases with ESG uncertainty, $\sigma^2_{g,j}$. Likewise, alpha increases with the asset ESG-return cross covariance, $\sigma_{rg,j}$. Additionally, in the presence of aggregate ESG uncertainty, a positive market beta asset with zero effective ESG score ($\mu_{g,j} - \beta_j\mu_{g,M} = 0$) and with certain ESG profile has a negative alpha, because its effective beta in equation (20) is smaller than its market beta, as noted earlier.

We have shown that both alpha and the effective beta rise with ESG uncertainty. The analysis is based on the simplifying assumption of homogeneous brown-averse agents. Relaxing the homogeneity assumption, alpha and beta variations with ESG uncertainty appear quite complex to analyze analytically. However, in the calibration developed in Section 5.2, we consider heterogeneous agents in a two-asset economy (both brown and green) and show that, even then, alpha and the effective beta do increase with ESG uncertainty. Below, we provide further analytical results for the two-asset economy for ease of interpretation.

2.4 Demand and Expected Return in a Two-Asset Economy

In particular, to gain additional intuition about the demand for multiple risky assets and their equilibrium expected returns, it is useful to consider a simplified economy consisting of two risky assets (along with a riskless asset), both green and brown. In that economy, expected excess returns are denoted by $\mu_{r,green}$ for the green stock and $\mu_{r,brown}$ for the brown, the corresponding ESG scores are $\mu_g > 0$ and $-\mu_g$, the variances of the ESG scores are $\sigma^2_{g,green}$ and $\sigma^2_{g,brown}$, and the correlation between the scores is assumed to be zero. Asset returns are assumed to be uncorrelated with identical variance denoted by σ_r^2. Finally, ESG scores are assumed to be positively correlated with returns of the same asset, with covariances denoted by $\sigma_{rg,green}$ and $\sigma_{rg,brown}$. The expressions below follow from Propositions 1 and 3. Online Appendix A.5 provides further details.

The two-asset optimal strategy is formulated as

$$X^*_{i,green} = \frac{1}{\gamma_i}\frac{\mu_{r,green} + b_i\mu_g}{\sigma_r^2 + b_i^2\sigma^2_{g,green} + 2b_i\sigma_{rg,green}}, \tag{23}$$

$$X^*_{i,brown} = \frac{1}{\gamma_i}\frac{\mu_{r,brown} - b_i\mu_g}{\sigma_r^2 + b_i^2\sigma^2_{g,brown} + 2b_i\sigma_{rg,brown}}. \tag{24}$$

The optimal portfolio illustrates that, for ESG-sensitive agents ($b_i > 0$), demand falls with higher ESG uncertainty but rises with higher ESG scores. The notion is that when targeting an ESG level, uncertainty about the precise ESG profile should be accounted for. As in the single-asset setup, the effect of ESG uncertainty is amplified by the positive correlation between return and the ESG score. For ESG-indifferent agents ($b_i = 0$), the demand for green and brown stocks is equal to the mean-variance demand when ESG preferences are excluded.

We next formulate expected excess returns in equilibrium. We denote the fraction and brown aversion of ESG-sensitive investors by w_{ESG} and $b_{ESG} > 0$, while the corresponding parameters of ESG-indifferent agents are $w_{IND} = 1 - w_{ESG}$ and $b_{IND} = 0$. Assuming that all agents have the same relative risk aversion γ, expected excess returns on the green and brown assets are formulated as

$$\mu_{r,green} = \frac{\beta_{green}\gamma\sigma_M^2\left(1 + b_{ESG}^2\frac{\sigma_{g,green}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,green}}{\sigma_r^2}\right) - w_{ESG}b_{ESG}\mu_g}{1 + (1 - w_{ESG})\left(b_{ESG}^2\frac{\sigma_{g,green}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,green}}{\sigma_r^2}\right)}, \tag{25}$$

$$\mu_{r,brown} = \frac{\beta_{brown}\gamma\sigma_M^2\left(1 + b_{ESG}^2\frac{\sigma_{g,brown}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,brown}}{\sigma_r^2}\right) + w_{ESG}b_{ESG}\mu_g}{1 + (1 - w_{ESG})\left(b_{ESG}^2\frac{\sigma_{g,brown}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,brown}}{\sigma_r^2}\right)}, \tag{26}$$

where β_{green} and β_{brown} are the equilibrium CAPM betas. In the limiting case where $w_{ESG} = 0$ or $b_{ESG} = 0$, all agents are ESG indifferent and equilibrium expected excess returns boil down to $\beta_{green}\gamma\sigma_M^2$ and $\beta_{brown}\gamma\sigma_M^2$. In the opposite extreme, where $w_{ESG} = 1$, expected return diminishes with the ESG score and rises with ESG uncertainty. The latter force can magnify the required return to the extent that a green asset could, possibly, deliver higher return than a brown asset.

Otherwise, in the intermediate case where both ESG-sensitive and ESG-indifferent agents populate the economy, the expected return difference between the brown and the green assets diminishes with ESG uncertainty. To see why, consider two assets with identical beta ($\beta_{green} = \beta_{brown} = \beta$) and ESG uncertainty ($\sigma_{g,green} = \sigma_{g,brown} = \sigma_g$ and $\sigma_{rg,green} = \sigma_{rg,brown} = \sigma_{rg}$). The expected return gap (also the alpha gap) is given by

$$\mu_{r,brown} - \mu_{r,green} = \frac{2w_{ESG}b_{ESG}\mu_g}{1 + (1 - w_{ESG})\left(b_{ESG}^2\frac{\sigma_g^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg}}{\sigma_r^2}\right)}. \tag{27}$$

When all agents are ESG sensitive ($w_{ESG} = 1$ and $b_{ESG} > 0$), the difference in expected returns is independent of ESG uncertainty and equal to $2b_{ESG}\mu_g$. Put another way, controlling for ESG uncertainty and beta, the expected return gap between the brown and the green assets is fixed, reflecting the nonpecuniary benefits from holding green assets. The return gap is nonexistent when either $b_{ESG} = 0$ or $w_{ESG} = 0$, as all agents are ESG indifferent.

Otherwise, when ESG preferences are heterogeneous, the expected return gap monotonically decreases with σ_g^2 and σ_{rg}.[9] This suggests that ESG uncertainty could weaken the negative ESG-performance relation, as the asset demand of ESG-sensitive agents diminishes, which, in turn, implies lower aggregate nonpecuniary benefits from ESG investing. In the limit, when ESG uncertainty grows with no bound, the expected return gap between green and brown assets is approaching zero.

[9] The no-uncertainty case leads to $\mu_{r,brown} - \mu_{r,green} = 2b_M\mu_g$, where $b_M = w_{ESG}b_{ESG}$.

3 Data

3.1 Data Sources

Our sample consists of all NYSE/AMEX/Nasdaq common stocks with share codes 10 or 11; daily and monthly stock data are obtained from the Center for Research in Security Prices (CRSP). We collect ESG rating data from six data vendors, including Asset4 (Refinitiv), MSCI KLD, MSCI IVA, Bloomberg, Sustainalytics, and RobecoSAM. These data providers represent the major players in the ESG rating market, and their ratings are widely used by practitioners as well as a growing number of academic studies (e.g., Eccles and Stroehle (2018); Berg et al. (2020); Gibson et al. (2020)).

Quarterly and annual financial statement data come from the COMPUSTAT database. Analyst forecast data come from the Institutional Brokers' Estimate System (I/B/E/S). We also acquire quarterly institutional equity holdings from the Thomson-Reuters Institutional Holdings (13F) database.[10] The full sample period ranges from 2002 to 2019. Our sample begins in 2002, as we require ESG ratings from at least two data vendors.

3.2 Main Variables

We focus on the overall ESG rating from each data provider, i.e., "ESG Combined Score" from Asset4, "ESG Rating" from MSCI IVA, "ESG Disclosure Score" from Bloomberg, "Sustainalytics Rank" from Sustainalytics, and "RobecoSAM Total Sustainability Rank" from RobecoSAM.[11] For MSCI KLD data, we construct an aggregate ESG rating by summing all strengths and subtracting all concerns (e.g., Lins et al. (2017); Berg et al. (2020)).

ESG rating agencies may differ in sample coverage and rating scale. In the Online Appendix, we report the number of U.S. common stocks covered by each data vendor over time. In addition, Asset4, Bloomberg, Sustainalytics, and RobecoSAM apply a scale from 0 to 100, MSCI IVA uses a seven-tier rating scale from the best (AAA) to the worst (CCC), and the MSCI KLD rating ranges from -11 to $+19$ in our sample. Panel B further demonstrates that requiring a common sample covered by all data vendors could significantly reduce the sample size and shorten the sample period. Therefore, we focus on pairwise ESG rating disagreement and then average across all rater pairs. Note that the ESG uncertainty in our

[10] The institutional ownership data come from money managers' quarterly 13F filings with the U.S. Securities and Exchange (SEC). The database contains the positions of all institutional investment managers with more than \$100 million U.S. dollars under discretionary management. All holdings worth more than \$200,000 U.S. dollars or 10,000 shares are reported in the database.

[11] Although the Bloomberg ESG disclosure score measures the extent of disclosure of ESG-related data by a company, it is positively associated with ESG quality due to the largely voluntary nature of ESG disclosure requirements (López-de-Silanes et al. (2020)).

model is motivated by the fundamental difficulty and lack of consensus in measuring and interpreting the *true* ESG profile. The disagreement among ESG raters is largely due to the lack of consensus on the scope and measurement of ESG performance (Berg et al. (2020)), and as a result, investors cannot reliably observe the firm's *true* ESG profile and are exposed to uncertainty in their sustainable investment. Hence, we employ the disagreement among ESG raters as a proxy for uncertainty about a firm's ESG profile and label such disagreement ESG uncertainty to be consistent with the model terminology.

Specifically, we obtain 14 rater pairs from the six data providers.[12] To achieve comparability across rating agencies, we proceed as follows. For each rater pair-year, we sort all stocks covered by both raters according to the original rating scale of the respective data provider and calculate the percentile rank (normalized between 0 and 1) for each stock-rater pair. Then, for each stock, we compute the pairwise rating uncertainty as the sample standard deviation of the ranks provided by the two raters in the pair. Specifically, let $g_{j,t,A}$ and $g_{j,t,B}$ denote the ESG rank for stock j in year t from raters A and B, respectively. The pairwise rating uncertainty is calculated as $\frac{|g_{j,t,A}-g_{j,t,B}|}{\sqrt{2}}$.[13] For perspective, a company that is ranked by two data providers at the 33rd and 59th percentiles would generate a rating uncertainty of 0.18.

Finally, we compute the firm-level ESG rating uncertainty as the average pairwise rating uncertainty across all rater pairs. Similarly, we compute the pairwise average rank and then average across all rater pairs to obtain the firm-level ESG rating. Notably, the pairwise measure has the advantage of maximizing the use of available rating information while still preserving comparability across raters, despite the difference in their sample coverage.[14] In addition, investors may not have access to all six data vendors, therefore the average pairwise rating level and rating uncertainty provide an approximate assessment for the perceived ESG profile and rating uncertainty among investors. As a robustness check, we also consider

[12]There are 14 (instead of 15) rater pairs because MSCI KLD data are only available until 2015, while RobecoSAM data start in 2016, as shown in the Online Appendix.

[13]To illustrate, consider two ratings g_1 and g_2. The pairwise rating uncertainty is given by $\sqrt{\frac{\left(g_1-\frac{g_1+g_2}{2}\right)^2+\left(g_2-\frac{g_1+g_2}{2}\right)^2}{2-1}}=\frac{|g_1-g_2|}{\sqrt{2}}$.

[14]Relative to standard economic measures that are cardinal and can be directly compared, ESG scores are ordinal in nature. Thus, ESG scores are sensitive to the sample coverage considered by the particular data vendor. As shown in the Online Appendix, ESG rating agencies differ in their sample coverage, the stand-alone rank (e.g., 90th percentile) provided by one rater may not be directly comparable with the corresponding figure from another rater, if, for instance, one rater covers, on average, more green firms. To ensure comparability across all vendors covering a stock, a proper experiment for determining the stock-level average ESG rating and rating uncertainty is to narrow down the focus to only those stocks jointly covered by all vendors. This experiment, however, could considerably shrink the sample, which reflects the coverage intersection of all vendors providing a rating for the stock. In contrast, the pairwise measure requires only a minimal set of restrictions on common coverage, and, hence, allows us to explore the richness in ESG ratings provided by each data vendor, while still preserving comparability across vendors.

alternative proxies for ESG rating (ESG^{ALL}) and rating uncertainty ($ESG\ Uncertainty^{ALL}$) using *all* ESG ratings from all raters (instead of rater pairs), without requiring common coverage, at a given point in time. Online Appendix provides detailed definitions for each variable.

In the Online Appendix, we present the pairwise ESG uncertainty and correlation of ESG ratings. The average correlation across all rater pairs is 0.48 and ranges from 0.25 to 0.71. MSCI KLD and MSCI IVA exhibit the lowest correlation and the highest rating disagreement with other raters, and the average correlation is 0.38 and 0.34, respectively. On the other hand, ratings provided by Sustainalytics and RobecoSAM are more correlated with those of other raters, and the average correlation is 0.59 and 0.56, respectively. Our findings are largely consistent with the existing literature and echo the growing concerns related to the lack of agreement across ESG rating agencies (e.g., Chatterji et al. (2016); Amel-Zadeh and Serafeim (2018); Berg et al. (2020); Gibson et al. (2020)).

The Online Appendix also reports the summary statistics for the stock-level data used in the paper. We report the mean, standard deviation, median, and quantile distribution of the annual ESG rating and ESG rating uncertainty and other stock characteristics. The average ESG rating is 0.46, and the ESG rating uncertainty is 0.18. In addition, to study the demand for risky assets and the cross section of equity returns, we construct 25 equity portfolios independently sorted on the ESG rating and rating uncertainty, and report the average ESG rating, ESG rating uncertainty, and monthly return.

In addition, we examine the market ESG uncertainty throughout the sample period, as well as the time trend in ESG uncertainty at the market and individual stock level. While ESG data vendors do not provide a direct assessment for the market ESG profile, we evaluate the value-weighted ESG score of the U.S. market by using firm-level ratings per the different vendors. To preserve comparability across data vendors, we rely on the same pairwise measures used at the single-stock level.[15] For each stock-rater-year, we average the percentile ranks corresponding to the specific rater across all rater pairs covering this stock. For each rater-year, we then value-weight firms' ESG average percentile ranks to obtain a rater-specific market-level ESG rating. Finally, for each year, using all rater-specific market ESG ratings, we evaluate the aggregate market-level ESG rating and rating uncertainty as the pairwise mean and standard deviation across raters.

In Figure 1, the top graph plots the time-series of the market ESG ratings corresponding to each data vendor, and we observe a significant dispersion across vendors. The bottom graph shows the time-series of market ESG uncertainty, as well as equal- and value-weighted

[15] In unreported analysis, we confirm that the alternative measurement method described above (ESG^{ALL} and $ESG\ Uncertainty^{ALL}$) provides similar results.

average of stock-level ESG uncertainty. Stock-level ESG uncertainty, on average, diminishes during the first half of the sample, as the number of raters increases and their coverage widens. Stock-level uncertainty remains stable in the second subperiod. Focusing on the market, as ESG ratings are correlated across firms and vendors, the evidence indicates that the market ESG uncertainty does consistently prevail throughout the entire sample period. This further supports our intuition that ESG uncertainty could play an important role in asset pricing.

4 Investor Demand, Stock Return, and Alpha

4.1 Investor Demand

We start with the first testable hypothesis generated from the model, i.e., investor demand for risky assets increases with the ESG score, consistent with Pástor, Stambaugh, and Taylor (2021a), while it diminishes with ESG rating uncertainty, as formulated in Proposition 1 and equations (23) and (24). We rely on institutional ownership as a proxy for the demand for ESG investment, as Krueger et al. (2020) document that institutional investors incorporate ESG when forming their portfolios. While retail investors could still have ESG preference, it is highly costly to obtain and analyze the ESG information, especially when even the most specialized raters do not agree, on average, on the firm ESG profile. Due to the complex nature of ESG investment, retail investors often rely on financial institutions to achieve their ESG target, thereby making institutional ownership a reasonable source to investigate the ESG demand. For instance, Hartzmark and Sussman (2019) show that once Morningstar published sustainability ratings for mutual funds, there was a massive shift of fund flows from low-sustainability funds to high-sustainability ones. A recent study on Robinhood investors also documents that retail investors do not respond to ESG disclosures (Moss et al. (2020)).

To test the model predictions based on ESG-sensitive investors, it is also critical to account for the heterogeneity among institutions, as they are subject to different social norm pressures and apply various strategies to make socially responsible investments. For instance, pension funds, universities, religious organizations, banks, and insurance companies are more norm-constrained than hedge funds or mutual funds that are natural arbitrageurs (Hong and Kacperczyk (2009)). We therefore consider three distinct groups: norm-constrained institutions, hedge funds, and other institutions. Specifically, we disaggregate the 13F institutional holdings based on institution type, including bank trust (type 1), insurance company (type 2), investment company (type 3), independent investment advisor (which includes hedge funds, type 4), and others (including corporate/private pension funds, public pension funds, university and foundation endowments, and miscellaneous, type 5), following Abarbanell et al. (2003).[16] We follow Hong and Kacperczyk (2009) to consider types 1, 2, and 5 as norm-constrained institutions. Our data on hedge fund holdings are constructed by matching the 13F institutional holdings with a manually collected list of the names of hedge fund companies.[17] The remaining institutions are mostly mutual funds.[18]

The analysis proceeds as follows. At the end of each year t, we independently sort stocks into quintile portfolios based on their ESG rating and rating uncertainty to generate 25 (5×5) portfolios. The low- (high-) ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each type of institution, we compute the average institutional ownership in each quarter in year $t+1$ for each of the 25 portfolios, and rebalance the portfolios at the end of year $t+1$. We report the time-series averages of quarterly institutional ownership for each of the 25 portfolios and the average difference in institutional ownership between high- and low-ESG-rating portfolios ("HML-R") as well as between high- and low-ESG-rating-uncertainty portfolios ("HML-U"). The standard errors in all estimations are corrected for autocorrelation using the Newey and West (1987) method.

We tabulate the results in Table 1, with Panel A for the stock ownership from norm-constrained institutions, Panel B for hedge funds, and Panel C for other institutions. Several findings are worth noting in Panel A. First, as expected, norm-constrained institutions are in favor of greener firms. For instance, they hold 17.7% of the brown stocks (i.e., stocks in the bottom ESG rating quintile) while they hold 23.0% of the green stocks (i.e., stocks in the top ESG rating quintile), indicating a 30% increase. Second, the ownership gap between low- and high-ESG-rating portfolios attenuates when rating uncertainty increases. When uncertainty is low, green stocks display 5.8% higher institutional ownership than brown stocks, while the ownership gap declines to an insignificant 0.2% when rating uncertainty is high. More importantly, this pattern is due to a decline in the demand for *green* firms when ESG uncertainty is high, and the difference is statistically significant and economically meaningful. For instance, among the high-ESG-rating portfolios, norm-constrained institutions hold 22.8% of the low-uncertainty stocks while only 18.1% of the high-uncertainty stocks, indicating a 21% decline. In line with our working hypothesis, demand for green firms from norm-constrained institutions diminishes with ESG rating uncertainty, suggesting that rat-

[16]We thank Brian Bushee for making the institutional investor classification data available via his website: `https://accounting-faculty.wharton.upenn.edu/bushee/`.

[17]We thank Vikas Agarwal for generously sharing the data. A detailed description of the hedge fund list is provided by Agarwal et al. (2013).

[18]While mutual funds and hedge funds are increasingly subject to social norm pressures as shown by the rapid growth of ESG investment, some may still prioritize financial returns at the cost of lower ESG standard. However, this remains an empirical question that we directly test.

ing uncertainty matters the most for ESG-sensitive investors in their ESG investment (i.e., green stocks).[19]

Panel B reports similar statistics for hedge fund ownership. Hedge funds invest more in brown stocks on average, e.g., they hold 15.7% of the brown stocks but hold 12.7% of the green stocks.[20] The ownership gap between low- and high-ESG rating portfolios tends to diminish as ESG rating uncertainty rises. For high-uncertainty stocks, the ownership gap is no longer significant. Unlike the case of norm-constrained institutions, rating uncertainty mostly affects hedge fund holdings for *brown* stocks. For instance, within the lowest rating group, hedge funds hold 15.7% of the low-uncertainty stocks but 13.0% of the high-uncertainty stocks, indicating a 17% decline. Despite the different incentives for hedge funds to implement sustainable investment, we continue to find that the rating uncertainty matters the most for investors in their preferred investment universe.

As shown in Panel C, we do not find strong ESG preference among other institutions. Conditional on the level of ESG rating, we find evidence that rating uncertainty reduces investor demand, while the economic magnitude is much smaller than in the previously discussed subsamples for norm-constrained institutions and hedge funds.

Overall, our findings support the model prediction that for ESG-sensitive investors, demand for risky assets increases with the ESG score but diminishes with ESG rating uncertainty. Our findings suggest that although institutional investors are likely to be more sophisticated and have access to privileged information, the uncertainty about corporate ESG profile remains an important barrier to their investment. This could further limit their capacity to engage in ESG issues and improve the ESG performance of the firm (e.g., Dimson et al. (2015); Dyck et al. (2019); Chen et al. (2020); Krueger et al. (2020)). As more institutions seek sustainable investing, it is likely that ESG-induced investor demand will play an even more prominent role in the future.

4.2 Cross-Sectional Return Predictability

In line with Pástor, Stambaugh, and Taylor (2021a), our model predicts a negative relationship between the ESG rating and CAPM alpha when there is no uncertainty in ESG ratings (Proposition 2). Negative return predictability stems from nonpecuniary benefits

[19] Perhaps not surprisingly, investor demand is less affected among other ESG rating groups, as such investment may not be entirely ESG-driven; hence, the rating uncertainty plays a lesser role in asset allocation decisions.

[20] Note that hedge funds can take both long and short positions, hence the long position per se may not fully reflect the ESG preference of hedge funds. Unreported results examine the net hedge fund ownership, defined as the hedge fund ownership minus the short interest, where the short interest is computed as the number of shares held short scaled by the number of shares outstanding (Jiao et al. (2016)). The net hedge fund ownership is 10.3% for brown stocks and 9.4% for green stocks.

from holding green stocks. However, the ESG-alpha relationship is less clear in the presence of ESG uncertainty due to the conflicting forces of the uncertainty-adjusted stock beta and ESG rating (Proposition 3).

We assess return predictability using a conventional portfolio sort. In particular, at the end of each year t, we sort stocks into quintile portfolios based on their ESG rating uncertainty. Within each rating uncertainty group, we further sort stocks into quintile portfolios according to their ESG ratings and generate 25 (5×5) portfolios.[21] The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the value-weighted return in each month in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Within each quintile of portfolios sorted by ESG rating uncertainty, we also implement the zero-cost trading strategy by taking long positions in the bottom quintile of stocks (lowest ESG rating) and selling short stocks in the top quintile (highest ESG rating). The payoff of the long-short investment strategy is computed as the low (bottom quintile) minus high (top quintile) portfolio return ("LMH-R"), indicating the return predictability of ESG ratings after controlling for rating uncertainty. We then report the time-series averages of monthly returns for each of the 25 portfolios and the long-short strategy.

In addition to raw portfolio returns, we report risk-adjusted returns from **(1)** the CAPM, i.e., only adjusting for the market factor (MKT, defined as the excess return on the value-weighted CRSP market index over the one-month Treasury bill rate); **(2)** the Fama-French-Carhart 4-factor model (FFC) consisting of the market factor (MKT), the size factor (SMB, defined as small minus big firm return premium), the book-to-market factor (HML, defined as the high book-to-market minus the low book-to-market return premium) (Fama and French (1993)), and Carhart (1997) the momentum factor (MOM, defined as the winner minus loser return premium); and **(3)** the Fama-French 6-factor model (FF6) consisting of the market factor (MKT), the size factor (SMB), the book-to-market factor (HML), the profitability factor (RMW, defined as the robust minus weak return premium), the investment factor (CMA, defined as the conservative minus aggressive return premium), and the momentum factor (MOM) (Fama and French (2018)).[22] The standard errors in all estimations are corrected for autocorrelation using the Newey and West (1987) method.

Table 2 reports the results, with Panel A for raw return and Panel B for CAPM-adjusted return. In the interest of brevity, we tabulate the results of FFC-adjusted return and FF6-

[21] We employ a conditional sort to better control for rating uncertainty, while an independent sort yields similar findings as shown in the Online Appendix.

[22] We thank Kenneth French for making the common factor returns available via his website: `https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`.

adjusted return in the Online Appendix and only discuss the main findings in this subsection. Several findings are worth noting. First, the ESG rating is negatively associated with future performance among stocks with low rating uncertainty, and the long-short portfolio return is significant at 0.59% per month. Brown stocks (i.e., stocks in the bottom ESG rating quintile) continue to outperform green stocks (i.e., stocks in the top ESG rating quintile) after adjusting for risk exposures, i.e., the long-short portfolio yields a CAPM-adjusted (FFC-adjusted, FF6-adjusted) return of 0.40% (0.46%, 0.50%) per month.[23]

Second, the negative return predictability of ESG ratings no longer holds for the remaining firms and even turns positive in some cases. For perspective, we also consider a univariate portfolio sort based on ESG ratings and report similar statistics in the column titled "All". The ESG rating does not predict stock returns for the full sample, which is consistent with the existing literature showing weak return predictability of the overall ESG rating (e.g., Pedersen et al. (2021)) and mixed evidence based on different ESG proxies (e.g., Gompers et al. (2003); Hong and Kacperczyk (2009); Edmans (2011); Bolton and Kacperczyk (2020)). The empirical evidence that ESG uncertainty can nontrivially interact with the ESG-performance relation is also consistent with equation (27). Our results further highlight the importance of rating uncertainty, as it not only affects investor demand but also has meaningful asset pricing implications, i.e., the negative ESG-alpha relation *only* exists among stocks with low rating uncertainty. The lack of consistency across ESG rating agencies could be a barrier for investors who have to balance information on ESG scores and uncertainty when making portfolio decisions.

Additionally, we consider a univariate portfolio sort based on ESG uncertainty and report the results in the row titled "All". Consistent with the model prediction, as shown in equation (22), we find that when ESG uncertainty is in play at the market level, stocks with low ESG uncertainty carry a negative and statistically significant CAPM alpha of -0.16% per month. As shown in the Online Appendix, the result is also robust to FFC-adjusted and FF6-adjusted returns. Furthermore, returns are increasing in ESG uncertainty, even though the patterns are not always monotonic. For instance, the high-minus-low ESG uncertainty portfolio ("HML-U") shows a monthly CAPM alpha of 0.23% that is statistically significant at the 10% level, supporting the model prediction that CAPM alpha increases with ESG rating uncertainty. Collectively, our findings support the prediction that brown stocks outperform green stocks *only* in the absence of rating uncertainty, and ESG uncertainty could tilt this relationship via conflicting forces, as illustrated in Proposition 3.

[23] As our model is derived in market equilibrium, it is based on one market factor. However, the economic magnitude and statistical significance in FFC-adjusted and FF6-adjusted returns reinforce our conclusion that accounting for rating uncertainty can be useful even for investors who use multiple investment factors in their portfolio decisions.

As a robustness check, we perform regression analysis to further control for other firm characteristics. Specifically, we estimate the following monthly Fama and MacBeth (1973) regression:

$$\begin{aligned} Perf_{i,m} = \alpha_0 + \beta_1 ESG_{i,m-1} + \beta_2 ESG_{i,m-1} \times Low\ ESG\ Uncertainty_{i,m-1} \\ + \beta_3 Low\ ESG\ Uncertainty_{i,m-1} + \boldsymbol{\beta}_4' \boldsymbol{M}_{i,m-1} + e_{i,m}, \end{aligned} \tag{28}$$

where $Perf_{i,m}$ refers to the excess return or CAPM-adjusted return of stock i in month m, $ESG_{i,m-1}$ refers to the ESG rating, and $Low\ ESG\ Uncertainty_{i,m-1}$ refers to a dummy variable that takes a value of 1 if the ESG rating uncertainty is in the bottom quintile across all stocks in that month and 0 otherwise. The vector $\boldsymbol{M}$ stacks all other control variables, including the *Log(Size)*, *Log(BM)*, *6M Momentum*, *Log(Illiquidity)*, *Gross Profitability*, *Corporate Investment*, *Leverage*, *Log(Analyst Coverage)* and *Analyst Dispersion*. The parameter of interest is β_2. Since the model predicts a negative ESG-performance relationship when there is no rating uncertainty, we should see a negative value of β_2. The Online Appendix provides detailed definitions for each variable. We also report Newey and West (1987) adjusted t-statistics.

We tabulate the results in Table 3, with models 1 to 4 for excess return and models 5 to 8 for CAPM-adjusted return. As expected, the ESG rating does not predict stock returns for the full sample. More importantly, the ESG rating is negatively associated with future stock performance when rating uncertainty is low. This relation is significant across all regression specifications after controlling for other potential sources of uncertainty about corporate ESG profiles and disagreement on firm fundamentals, such as analyst dispersion. Overall, we confirm the early results in the portfolio sort and provide supporting evidence for the ESG-augmented CAPM after considering rating uncertainty.

4.3 Additional Analysis and Robustness Checks

In the presence of a rapid growth in sustainable investing during the last decade (e.g., GSIA (2018); PRI (2020)), we next assess how our findings evolve over time. We then conduct robustness checks using alternative proxy for ESG rating and rating uncertainty.

We divide the full sample into two subperiods: 2003–2010 and 2011–2019, and repeat the main analysis. Table 4 has a similar layout as Table 1, where Panels A, B and C show the results for the norm-constrained institutions, hedge funds, and other institutions, respectively. First, we confirm that for all three types of institutions, their preference for green assets increases over time. Norm-constrained institutions hold 12.3% of the brown stocks (i.e., stocks in the bottom ESG rating quintile) while they hold 19.2% of the green stocks (i.e., stocks in the top ESG rating quintile) in the post-2011 period, indicating a 56% increase. For perspective, they hold 14% more green stocks than brown stocks in the pre-2011 period. While hedge funds invest more in brown stocks during both periods, they hold 33% less green stocks in the pre-2011 period and only 10% less green stocks in the post-2011 period. Interestingly, other institutions exhibit a shift in ESG preference over time, i.e., from brown-loving to green-loving. They hold 7% less green stocks in the pre-2011 period while 12% more green stocks in the post-2011 period.

Second, for norm-constrained institutions, demand for green firms diminishes with ESG rating uncertainty in both periods, while the effect is stronger in the pre-2011 period. Among the green stocks, norm-constrained institutions hold 27.1% (19.0%) of the low-uncertainty stocks while 19.5% (16.8%) of the high-uncertainty stocks in the pre-2011 (post-2011) period, indicating a 28% (12%) decline. It is possible that the rising popularity in sustainable investing also incentivizes institutional investors to invest in ESG research and even create internal ratings tools (e.g., Mooney (2019)), partially mitigating the negative effect of rating uncertainty. Overall, our findings confirm that even with the growing ESG awareness, demand for green assets diminishes with ESG rating uncertainty for ESG-sensitive investors.

When there is no uncertainty in ESG ratings, our model predicts a negative relationship between the ESG rating and *expected* CAPM alpha due to the nonpecuniary benefits from holding green stocks. However, Pástor, Stambaugh, and Taylor (2021a,b) document that green assets have higher *realized* alphas when investors' tastes for green holdings shift unexpectedly during the last decade. As a result, we expect our findings to be stronger in the pre-2011 period, which provides a cleaner setting to analyze the equilibrium expected returns of stocks.

Table 5 has a similar layout as Table 2, with Panel A for raw return and Panel B for CAPM-adjusted return. As expected, the ESG rating is negatively associated with future performance among stocks with low rating uncertainty in the pre-2011 period, yielding a significant long-short portfolio return ("LMH-R") of 1.12% (t-stat=3.06) per month and CAPM-adjusted return of 0.96% (t-stat=2.81) per month. Consistent with our model prediction, the negative ESG-CAPM alpha relationship does not hold for the remaining firms. A univariate portfolio sort based on ESG uncertainty further confirms that CAPM alpha increases with ESG rating uncertainty, i.e., the high-minus-low ESG uncertainty portfolio ("HML-U") shows a monthly CAPM alpha of 0.42% (t-stat=2.04) in the pre-2011 period.

In contrast, we do not find a negative return predictability of ESG ratings across all ESG-rating-uncertainty portfolios, nor a positive ESG uncertainty-CAPM alpha relationship in the post-2011 period. Our findings in both subperiods remain unchanged for FFC-adjusted return and FF6-adjusted return, as reported in the Online Appendix. Note that our results should not be interpreted as ESG rating uncertainty no longer matters in the future. Instead, the equilibrium outcome over longer horizons could be even stronger than the full sample evidence we document, due to the *unexpected* outcomes realized over the last decade.

Next, we conduct robustness checks by using alternative definition of ESG rating and rating uncertainty. Specifically, for each rater-year, we sort all stocks covered by this rater according to the original rating scale and calculate the percentile rank (normalized between 0 and 1) for each stock. The firm-level ESG rating is defined as the average rank across all raters (labelled as ESG^{ALL}), and the ESG rating uncertainty is defined as the standard deviation of the ranks provided by all raters (labelled as $ESG\ Uncertainty^{ALL}$). As noted earlier, this method can entail some bias due to the lack of comparability across vendors.

We repeat our main analysis using the alternative proxy for ESG rating and rating uncertainty, and present the results in the Online Appendix. First, we confirm that norm-constrained institutions have strong preference for green assets in general, while display lower demand for green firms when ESG uncertainty is high. For instance, among the high-ESG-rating portfolios, norm-constrained institutions hold 23.4% of the low-uncertainty stocks while only 15.5% of the high-uncertainty stocks, indicating a 33% decline. As a result, green stocks no longer attract more norm-constrained institutional investors than brown stocks when rating uncertainty is high.

Moving to cross-sectional stock returns, our findings are largely consistent with the model prediction that the ESG rating is negatively associated with future performance among stocks with low rating uncertainty. The long-short portfolio return (FFC-adjusted return, FF6-adjusted return) is significant at 0.52% (0.35%, 0.35%) per month. While the CAPM-adjusted return is not statistically significant, the magnitude is sizable at 0.31% per month. Unreported results show that the long-short portfolio yields a return of 1.05% per month and a CAPM-adjusted (FFC-adjusted, FF6-adjusted) return of 0.87% (0.75%, 0.73%) per month in the pre-2011 period, all statistically significant at the 5% or 1% level. We further confirm that ESG rating is negatively associated with CAPM-adjusted return when rating uncertainty is low, after controlling for other firm characteristics. In short, our main results are robust to the alternative definition of ESG rating and rating uncertainty.

5 Calibration

As final experiments, we calibrate the model to study the general equilibrium implications of ESG rating uncertainty for the market premium, the cross section of stock returns, economic welfare, and equity demand. Following Pástor, Stambaugh, and Taylor (2021a), we consider ESG-indifferent (*IND*) and ESG-sensitive (*ESG*) agents. The former group does not derive utility from ESG externalities (i.e., $b_{IND} = 0$), while the utility of the latter positively depends on the market ESG score and negatively depends on rating uncertainty, through $b_{ESG} > 0$. Specifically, we assume that 20% of the agents have ESG preferences, while the remaining fraction consists of ESG-indifferent agents. Hence, ESG-sensitive agents are not the vast majority in the economy, yet they account for a substantial fraction.[24]

The ESG parameters, b_{ESG}, $\mu_{g,M}$, $\sigma_{g,M}$, $\rho_{g,M}$, and the stock level counterparts of $\mu_{g,M}$, $\sigma_{g,M}$, and $\rho_{g,M}$ are unknown. In the data section above, we describe ways to map ESG ratings into scores for individual securities, and the market-level ESG rating follows through aggregation. The resulting quantities are not on the scale of equity returns and are ordinal in nature. In particular, a higher ESG rating indicates a greener stock, while a higher standard deviation among raters amounts to greater ESG uncertainty. Thus, stock-level and market-level ratings, as well as measures of rating uncertainty, can comfortably be used to assess the model implications through cross-sectional regressions and portfolio sorts. In the calibration experiments that follow, we choose ESG parameters that conform to payoffs on pseudo-assets, as formulated in the theory section.[25] Further details are provided below.

5.1 Market Premium, Welfare, and Equity Demand

The analysis for the aggregate market is based on an economy that consists of the market portfolio and a riskless asset (in zero net supply). The market volatility parameter employed in the calibration is $\sigma_M = 15.19\%$, which is the annual estimate from monthly U.S. market returns, spanning the period July 1963 through December 2019. Then, employing the sample estimate for the equity premium (6.5%), we obtain $\gamma = 2.81$, following equation (6). Two remarks are in order. First, while our sample for individual stocks starts in 2002, due to limited data for ESG ratings, the possibility to use longer return histories from the aggregate, to sharpen estimates, builds on Pástor and Stambaugh (2002). In addition, expected market return is endogenous in our setup, while the sample estimate is used to set the risk aversion parameter.

We evaluate the equilibrium market premium on the basis of equation (11) for the multiple-agent case. The market demand and the certainty equivalent return from investment differ across agent types. In particular, based on equation (4), the optimal market demand for agent i is $x_i^* = \frac{1}{\gamma_i}\frac{\mu_M + b_i\mu_{g,M}}{\sigma_{i,U}^2}$, where $\sigma_{i,U}^2 = \sigma_M^2 + b_i^2\sigma_{g,M}^2 + 2b_i\sigma_M\sigma_{g,M}\rho_{g,M}$. In addition, as derived in Online Appendix A.6, the certainty equivalent excess return for agent

[24]In unreported results, we confirm that an increasing fraction of ESG-sensitive investors leads to stronger implications of ESG uncertainty.

[25]In our model, the $g = 0$ case reflects green neutrality. Having this reference point, all the model implications are invariant to a multiplicative scaling of ESG ratings and rating uncertainty, as long as the brown aversion parameter is also scaled such that the pseudo return, bg, remains unchanged.

i is given by $CE_i = \frac{1}{2\gamma_i}\left(\frac{\mu_M + b_i \mu_{g,M}}{\sigma_{i,U}}\right)^2$. Both the market demand and the certainty equivalent return increase in the perceived market premium and diminish in the perceived market variance. For ESG-sensitive agents, the perceived certainty equivalent return increases with the market ESG score, while the perceived variance rises with ESG uncertainty and the correlation between the market ESG score and market return. The effect of ESG rating uncertainty is stronger for higher values of b_i and $\rho_{g,M}$.

To make the analysis sufficiently comprehensive, we run calibration experiments for multiple scenarios. First, we consider both green-neutral ($\mu_{g,M} = 0$) and green ($\mu_{g,M} = 0.01$) markets. The ESG implications of the former case are exclusively attributed to ESG uncertainty. The latter case involves the two conflicting forces noted earlier, i.e., the nonpecuniary benefits from holding the green market versus aversion to ESG uncertainty. For ESG-sensitive agents, we consider two values for brown aversion, namely, b_{ESG} is equal to 1 or 2. When the market is green, both cases generate ESG return of 1% and 2% per year, respectively. When the market is green neutral, brown aversion is not mapped into the incremental expected return. We also consider two values for the correlation between ESG and market return, $\rho_{g,M}$, namely, 0 and 0.5. The zero-correlation is a benchmark case that reflects the lower bound on the implications of ESG uncertainty. The positive correlation is sensible, as described in the theory section. Finally, the market ESG uncertainty, $\sigma_{g,M}$, ranges between 0 and 0.04.[26]

Panel A of Figure 2 describes the green-neutral market case, with solid lines representing the case $\rho_{g,M} = 0$ and dashed lines corresponding to $\rho_{g,M} = 0.5$. The limiting case of $b_{ESG} = 0$ represents the departure point, where all agents are indifferent to the market ESG profile. In that case, it follows that (i) the equilibrium market premium equals the ESG-indifference value, $\gamma\sigma_M^2 = 6.50\%$, regardless of the level of ESG uncertainty, (ii) both agent types hold the market portfolio ($x^*_{ESG} = x^*_{IND} = 1$), and (iii) the agents perceive the same certainty equivalent excess return ($CE_{ESG} = CE_{IND} = \gamma\frac{\sigma_M^2}{2} = 3.25\%$).

When $b_{ESG} > 0$, the *ESG* agents are sensitive to the market rating uncertainty. Then, the perceived market variance $\sigma^2_{M,U}$ is higher than σ^2_M.[27] This force leads to an increasing equilibrium market premium, and more so for higher values of b_{ESG}, $\sigma_{g,M}$, and $\rho_{g,M}$.

As a result, the two types of agents have different certainty equivalent return and demand

[26]Empirically, the magnitude of ESG uncertainty is comparable to the scale of differences in ESG scores. For instance, considering the summary statistics of our dataset from the Online Appendix, the quartile deviation of ESG ratings is 0.14. The values of ESG uncertainty are of the same order of magnitude of differences in ESG scores: the median ESG uncertainty is 0.16, while the 90$^{\text{th}}$ percentile is 0.33. Similarly, for calibration, we consider values of ESG uncertainty that conform to ESG levels: a green (brown) asset has a mean ESG score of 0.01 (-0.01), and ESG uncertainty is of the order of 0.01 and multiples.

[27]As we derive in Online Appendix A.1, the perceived aggregate market variance, $\sigma^2_{M,U}$, is a harmonic weighted average of the market variances perceived by the agents, which in our example are $\sigma^2_{M,IND} = \sigma^2_M$ and $\sigma^2_{M,ESG} = \sigma^2_M + b^2_{ESG}\sigma^2_{g,M} + 2b_{ESG}\sigma_M\sigma_{g,M}\rho_{g,M}$. It follows that $\sigma^2_{M,IND} < \sigma^2_{M,U} < \sigma^2_{M,ESG}$.

for the market portfolio. On the one hand, the *IND* agents are not sensitive to ESG uncertainty ($\sigma^2_{IND,U} = \sigma^2_M$). Thus, they benefit from the higher equilibrium market premium, which translates into a higher certainty equivalent return and a levered position in the market portfolio ($x^*_{IND} > 1$). On the other hand, the *ESG* agents are more sensitive to ESG uncertainty than the aggregate market ($\sigma^2_{ESG,U} > \sigma^2_{M,U}$). Thus, their certainty equivalent return and their demand for the market portfolio decline with increasing values of b_{ESG}, $\sigma_{g,M}$, and $\rho_{g,M}$.

We next quantitatively assess the economic cost of ESG uncertainty, as perceived by *ESG* agents. The cost is represented by a diminishing certainty equivalent return relative to $\sigma_{g,M} = 0$. When $\rho_{g,M} = 0$ and ESG uncertainty $\sigma_{g,M}$ is set to 0.02 (0.04), the utility loss is 0.03% (0.13%) per year for $b_{ESG} = 1$ and 0.13% (0.47%) for $b_{ESG} = 2$. Considering $\rho_{g,M} = 0.5$ instead, the corresponding figures are 0.26% (0.55%) for $b_{ESG} = 1$ and 0.55% (1.08%) for $b_{ESG} = 2$. The calibrated utility loss accounts for a nontrivial proportion of the overall certainty equivalent excess return when compared to the benchmark case of no uncertainty, i.e., 3.25%. Therefore, from the perspective of *ESG* agents, ESG uncertainty leads to a significant utility loss.

When the market is green neutral, preferences for ESG essentially hurt welfare because the only effect that comes into play is aversion to ESG uncertainty. Departing from a green-neutral market, the nonpecuniary benefits from holding green stocks intervene, and more so for higher values of brown aversion and market ESG score.

Panel B of Figure 2 describes the green-market case, with solid lines corresponding to $\rho_{g,M} = 0$ and dashed lines to $\rho_{g,M} = 0.5$. In the absence of ESG uncertainty ($\sigma_{g,M} = 0$) and when $b_{ESG} > 0$, the equilibrium market premium diminishes with b_{ESG}. This translates into a lower certainty equivalent return and market demand for *IND* agents, who confront a lower market premium but do not extract nonpecuniary benefits from holding the green market. In contrast, *ESG* agents extract nonpecuniary benefits from the positive market ESG tilt, which leads to a higher certainty equivalent return and higher market demand for increasing values of b_{ESG}.

As the parameter $\sigma_{g,M}$ captures the trade-off between the two conflicting forces of ESG preferences, we derive a break-even value of $\sigma_{g,M}$ when the utility loss of ESG uncertainty entirely offsets the benefits from holding green stocks. When $\rho_{g,M} = 0$ and b_{ESG} is 1 (2), the welfare benefits of a green market perceived by *ESG* agents vanish, due to ESG uncertainty, for $\sigma_{g,M} = 9.9\%$ (7.2%), well above reasonable values. However, a positive correlation between market return and ESG rating amplifies the effects of ESG uncertainty. When $\rho_{g,M} = 0.5$ and b_{ESG} is 1 (2), the threshold $\sigma_{g,M}$ is much lower at 4.9% (4.3%).

The market premium is also subject to the two conflicting forces, i.e., the negative ESG premium due to the green market versus the positive contribution due to ESG uncertainty. When $\rho_{g,M} = 0$ and b_{ESG} is 1 (2), the two forces are equal for $\sigma_{g,M} = 6.0\%$ (4.2%), while if $\rho_{g,M} = 0.5$ and b_{ESG} is 1 (2), the threshold $\sigma_{g,M}$ is at 2.1% (1.9%).

Overall, we reinforce the notion that ESG uncertainty increases the market premium, as well as reduces the economic welfare for ESG-sensitive investors and discourages their participation in the stock market.

5.2 Cross Section of Expected Returns, Alpha, and Effective Beta

We next calibrate the cross section of expected return, the CAPM alpha, and the effective beta in equilibrium, all of which are formulated in Section 2.3.

To distill cross-sectional implications of ESG uncertainty, we focus on the green-neutral market described in Section 5.1. At the stock level, we consider green and brown assets, with mean ESG scores $\mu_{g,green} = 0.01$ and $\mu_{g,brown} = -0.01$. Thus, for the green asset, *ESG* agents perceive an incremental ESG return equal to 1% per year for $b_{ESG} = 1$ and 2% per year for $b_{ESG} = 2$. The corresponding return figures are negative for the brown asset. It is assumed that $\beta_{green} = \beta_{brown} = 1$, and the idiosyncratic annualized return volatility is 20% for both assets. As $\sigma_M = 15.19\%$, the total stock return volatility is 25.12%.[28] We consider a positive correlation between return and ESG score for each asset, setting $\rho_{g,M} = \rho_{rg,green} = \rho_{rg,brown} = 0.5$. The off-diagonal elements in $\mathbf{\Sigma}_g$ and $\mathbf{\Sigma}_{rg}$ are assumed to be zero.

Figure 3 illustrates how the expected excess return, the CAPM alpha, and the effective beta vary with ESG uncertainty for green and brown assets ($\sigma_{g,green}$ and $\sigma_{g,brown}$). The solid lines represent the green asset while dashed lines represent the brown asset. We consider a market-wide ESG uncertainty, $\sigma_{g,M}$, equal to 0.01 for the left graphs and 0.02 for the right graphs. Starting from the benchmark case of ESG indifference ($b_{ESG} = 0$), the expected excess return for both assets is equal to the market premium, 6.50%, while the alpha is zero and the effective beta coincides with the unit market beta.

Considering ESG-sensitive agents ($b_{ESG} > 0$), the positive ESG score of a green asset is associated with lower expected return and alpha in equilibrium, as in Pástor, Stambaugh, and Taylor (2021a). The effect is stronger for larger values of b_{ESG}. In addition, expected return rises with ESG uncertainty. Thus, in the presence of the conflicting forces of ESG score (negative effect on alpha) and ESG uncertainty (positive effect on alpha), a green asset

[28] The total return variance of the green asset, σ^2_{green}, is given by $\beta^2_{green}\sigma^2_M + \sigma^2_{id,green}$, where $\sigma_{id,green}$ is the idiosyncratic volatility. For $\beta_{green} = 1$, $\sigma_M = 15.19\%$, and $\sigma_{id,green} = 20\%$, it follows that $\sigma_{green} = 25.12\%$. The same applies to σ^2_{brown}. The covariance between returns is $\beta_{green}\beta_{brown}\sigma^2_M = (15.19\%)^2$, corresponding to a correlation $\rho_{green,brown} = 36.59\%$.

with high ESG uncertainty could have higher expected return and alpha than a brown asset with low ESG uncertainty. For instance, when $\sigma_{g,M} = 0.01$, $\sigma_{g,green} = 0.10$, and $b_{ESG} = 1$ ($b_{ESG} = 2$), the green asset displays an expected excess return of 6.78% (7.09%) and an alpha of 0.20% (0.42%). To compare, when the ESG profile of the brown asset is known for certain, its expected excess return is 6.70% (6.90%) and alpha is 0.11% (0.23%).

The $\sigma_{g,green} = 0$ case merits further analysis. The zero-uncertainty asset does not contribute to the aggregate ESG uncertainty; thus, its effective beta is lower than the unit market beta, per equation (19), and the effect is stronger when brown aversion and market-wide ESG uncertainty are higher. For instance, when $\sigma_{g,M} = 0.01$, the effective beta is 0.987 (0.974) for $b_{ESG} = 1$ ($b_{ESG} = 2$). When $\sigma_{g,M} = 0.02$, the effective beta is 0.974 (0.950) for $b_{ESG} = 1$ ($b_{ESG} = 2$). The diminished effective beta relative to the market beta induces a negative contribution to alpha and expected return.

As demonstrated in equation (20), the effective beta does not depend on the mean ESG score. Consequently, green and brown assets have the same effective beta for identical levels of ESG uncertainty. The effective beta increases with ESG uncertainty and can rise above the unit market beta, and the effect is stronger for higher values of brown aversion.

Finally, as long as the green and the brown assets have the same ESG uncertainty, the performance difference between brown and green assets (both expected return and alpha) diminishes with increasing ESG uncertainty. Consider, for instance, $\sigma_{g,M} = 0.01$. As the ESG uncertainty increases from 0 to 0.10, the difference in expected return ($\mu_{r,brown} - \mu_{r,green}$) decreases from 0.40% to 0.23% when $b_{ESG} = 1$, and from 0.80% to 0.29% when $b_{ESG} = 2$. Similar patterns apply to alpha. Such calibration results follow from equation (27).

The overall evidence from the calibration indicates that ESG uncertainty has meaningful implications for expected return, alpha, and effective beta. Notably, both alpha and the effective beta increase with ESG uncertainty. Moreover, the alpha gap between brown and green assets diminishes with ESG uncertainty.

6 Conclusion

We comprehensively analyze the equilibrium implications of ESG rating uncertainty for portfolio choice and asset pricing. Starting with the market portfolio as the single risky asset, we show that rating uncertainty leads to higher perceived market risk, higher market premium, and lower investor demand. Next, we consider multiple risky assets and heterogeneous economic agents and derive an ESG-augmented CAPM for the cross section of stock returns. In particular, we propose that ESG uncertainty could tilt the ESG-CAPM alpha relationship and serve as a potential channel to explain the mixed evidence in prior studies.

We empirically test the model implications and provide supporting evidence. First, ESG rating uncertainty reduces investor demand for stocks, especially for ESG-sensitive investors (i.e., norm-constrained institutions) in their ESG investment (i.e., green stocks). Second, brown stocks outperform green stocks *only* when rating uncertainty is low, and the negative return predictability of ESG ratings does not hold for the remaining firms. We then calibrate the model to assess its quantitative implications in the presence of rating uncertainty. The analysis reinforces the notion that ESG uncertainty could affect investors' demand, the risk-return trade-off, and reduce economic welfare for ESG-sensitive agents.

Our findings echo the growing concerns regarding the lack of consistency of ESG information disclosure and ratings provided by different rating agencies. In the presence of rating uncertainty, investors are less likely to make ESG investments and actively engage in corporate ESG issues. This could increase the cost of capital for green firms and further limit their capacity to make socially responsible investments and generate real social impact. As the amount of sustainable investing is expected to keep growing, the overall impact will become even more striking. Viewed from this perspective, our results provide a conservative assessment of rating uncertainty.

Our evidence suggests that it would be useful for policymakers to establish a clear taxonomy of ESG performance and unified disclosure standards for sustainability reporting. It would be especially instructive to identify which investments are *really* green. Doing so could mitigate ESG uncertainty, thus reducing the cost of equity capital for green firms, leading to higher social impact.

Our paper also suggests avenues for future research. While existing work studying equilibrium with ESG focuses on a single-period environment, it would be natural to extend ESG equilibrium to multiperiod dynamic setups. Then, the market ESG can display time variation, which would give rise to an incremental asset pricing factor. It would also be instructive to account for investors' learning about the ESG profile of a firm. These and other topics in dynamic asset pricing are left for future research.

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Table 1: Institutional Ownership of Portfolios Sorted by ESG Rating and Uncertainty

At the end of year t, stocks are independently sorted into quintiles according to their ESG ratings and ESG rating uncertainty to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the average institutional ownership in each quarter in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of quarterly institutional ownership of norm-constrained institutions for each of the 25 portfolios and the average difference in institutional ownership between high- and low-ESG-rating portfolios ("HML-R"), as well as between high- and low-ESG-rating-uncertainty portfolios ("HML-U"). Panels B and C report similar statistics for average ownership of hedge funds and other institutions, respectively. The Online Appendix provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Panel A: Norm-Constrained Institutions

ESG Rating	ESG Uncertainty							
	Low	2	3	4	High	HML-U	t-stat	All
Low	0.170	0.183	0.187	0.178	0.179	0.009	(0.80)	0.177
2	0.185	0.192	0.207	0.209	0.184	-0.001	(-0.23)	0.195
3	0.189	0.215	0.210	0.212	0.191	0.002	(0.40)	0.200
4	0.211	0.211	0.211	0.215	0.211	0.000	(0.04)	0.211
High	0.228	0.236	0.238	0.225	0.181	-0.047***	(-2.73)	0.230
HML-R	0.058***	0.053***	0.050***	0.047***	0.002			0.053***
	(10.21)	(12.00)	(8.33)	(8.51)	(0.08)			(11.39)

Panel B: Hedge Funds

ESG Rating	ESG Uncertainty							
	Low	2	3	4	High	HML-U	t-stat	All
Low	0.157	0.157	0.160	0.156	0.130	-0.027***	(-3.70)	0.157
2	0.143	0.147	0.155	0.153	0.149	0.006	(1.31)	0.149
3	0.153	0.144	0.144	0.149	0.153	-0.000	(-0.08)	0.150
4	0.148	0.144	0.140	0.142	0.141	-0.006*	(-1.96)	0.142
High	0.127	0.124	0.128	0.128	0.119	-0.008	(-1.33)	0.127
HML-R	-0.031***	-0.033***	-0.032***	-0.029***	-0.011			-0.030***
	(-6.14)	(-8.15)	(-6.30)	(-5.57)	(-1.25)			(-8.06)

Panel C: Other Institutions

ESG Rating	ESG Uncertainty							
	Low	2	3	4	High	HML-U	t-stat	All
Low	0.347	0.367	0.357	0.363	0.317	-0.030**	(-2.57)	0.356
2	0.343	0.374	0.387	0.390	0.354	0.010	(1.43)	0.370
3	0.370	0.373	0.371	0.384	0.360	-0.011	(-1.66)	0.368
4	0.382	0.375	0.378	0.369	0.360	-0.022***	(-3.25)	0.370
High	0.363	0.368	0.363	0.357	0.328	-0.035	(-1.63)	0.363
HML-R	0.016	0.001	0.006	-0.005	0.011			0.007
	(1.28)	(0.13)	(0.59)	(-0.37)	(0.35)			(0.71)

Table 2: Performance of Portfolios Sorted by ESG Rating and Uncertainty

At the end of year t, stocks are first sorted into quintiles according to their ESG rating uncertainty. Within each ESG rating uncertainty group, stocks are further sorted into quintiles according to their ESG ratings to generate 25 (5×5) portfolios. The low-(high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the value-weighted return in each month in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of monthly returns for each of the 25 portfolios, as well as for the investment strategy of going long (short) the low- (high)-ESG-rating stocks ("LMH-R"). The column "All" reports similar statistics for portfolios sorted by ESG ratings only. The row "All" reports returns for portfolios sorted by ESG uncertainty only, as well as the investment strategy of going long (short) the high (low) ESG-uncertainty stocks ("HML-U"). In Panel B, portfolio returns are further adjusted by the CAPM. The Online Appendix provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

	Panel A: Return						**Panel B: CAPM-Adjusted Return**					
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	1.235***	1.113***	0.767**	0.875**	0.760**	0.923**	0.168	0.064	-0.311*	-0.141	-0.101	-0.101
	(2.95)	(2.99)	(1.98)	(2.30)	(2.32)	(2.58)	(0.93)	(0.40)	(-1.82)	(-0.89)	(-0.58)	(-0.84)
2	1.245***	1.026***	1.093***	1.043***	1.095***	0.963***	0.187	0.076	0.115	0.042	0.151	-0.008
	(3.36)	(2.84)	(3.30)	(2.74)	(2.91)	(2.85)	(1.16)	(0.38)	(0.77)	(0.29)	(0.77)	(-0.07)
3	1.096***	0.965***	1.050***	1.104***	0.949***	1.021***	0.040	-0.031	0.002	0.064	0.079	0.053
	(2.69)	(2.83)	(2.86)	(2.89)	(3.15)	(3.11)	(0.23)	(-0.20)	(0.02)	(0.46)	(0.42)	(0.64)
4	0.730**	0.695*	1.105***	1.019***	0.990***	1.017***	-0.192	-0.389***	0.108	0.040	0.006	0.095
	(2.09)	(1.81)	(2.90)	(2.96)	(2.68)	(3.42)	(-1.24)	(-3.28)	(0.55)	(0.34)	(0.03)	(1.32)
High	0.642*	0.842**	0.855***	1.184***	0.854***	0.805**	-0.230*	-0.063	-0.012	0.245*	-0.001	-0.095
	(1.97)	(2.53)	(3.06)	(3.62)	(2.81)	(2.57)	(-1.95)	(-0.55)	(-0.10)	(1.83)	(-0.01)	(-1.49)
LMH-R	0.594***	0.271	-0.088	-0.309	-0.094	0.118	0.398*	0.128	-0.299	-0.387*	-0.100	-0.006
	(2.72)	(1.30)	(-0.39)	(-1.43)	(-0.42)	(0.78)	(1.86)	(0.58)	(-1.25)	(-1.75)	(-0.42)	(-0.04)
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	0.753**	0.875***	0.935***	1.083***	0.940***	0.187	-0.155**	-0.090	-0.003	0.120*	0.071	0.226*
	(2.31)	(2.61)	(3.07)	(3.28)	(3.29)	(1.40)	(-1.98)	(-1.20)	(-0.04)	(1.72)	(0.84)	(1.67)

Table 3: ESG Rating, Uncertainty, and Stock Returns

This table presents the results of the following monthly Fama-MacBeth regressions, as well as their corresponding Newey-West adjusted t-statistics:

$$Perf_{i,m} = \alpha_0 + \beta_1 ESG_{i,m-1} + \beta_2 ESG_{i,m-1} \times Low\ ESG\ Uncertainty_{i,m-1} + \beta_3 Low\ ESG\ Uncertainty_{i,m-1} + \boldsymbol{\beta}_4' \boldsymbol{M}_{i,m-1} + e_{i,m},$$

where $Perf_{i,m}$ refers to the excess return (models 1 to 4) or CAPM-adjusted return (models 5 to 8) of stock i in month m, $ESG_{i,m-1}$ refers to the ESG rating, $Low\ ESG\ Uncertainty_{i,m-1}$ refers to a dummy variable that takes a value of 1 if the ESG rating uncertainty is in the bottom quintile across all stocks in that month and 0 otherwise. The vector $\boldsymbol{M}$ stacks all other control variables, including the Log(Size), Log(BM), 6M Momentum, Log(Illiquidity), Gross Profitability, Corporate Investment, Leverage, Log(Analyst Coverage) and Analyst Dispersion. The Online Appendix provides detailed definitions for each variable. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Stock Returns Regressed on Lagged ESG Rating and Uncertainty

	Excess Return				CAPM-Adjusted Return			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
ESG	0.002	0.098	0.062	0.199	0.042	0.139	0.162	0.301
	(0.01)	(0.65)	(0.33)	(1.03)	(0.23)	(0.91)	(0.77)	(1.65)
ESG × Low ESG Uncertainty			-0.163*	-0.223*			-0.254**	-0.312**
			(-1.91)	(-1.75)			(-2.26)	(-2.36)
Low ESG Uncertainty			0.114*	0.109			0.125**	0.114
			(1.86)	(1.38)			(2.20)	(1.61)
Log(Size)	-0.100	-0.036	-0.101	-0.038	-0.044	0.111	-0.044	0.111
	(-1.28)	(-0.27)	(-1.30)	(-0.29)	(-0.59)	(0.77)	(-0.60)	(0.77)
Log(BM)	0.001	0.009	-0.001	0.008	-0.021	0.019	-0.024	0.017
	(0.01)	(0.14)	(-0.01)	(0.12)	(-0.19)	(0.18)	(-0.21)	(0.17)
6M Momentum	0.336	0.188	0.335	0.194	0.275	0.105	0.276	0.111
	(0.70)	(0.40)	(0.69)	(0.42)	(0.50)	(0.20)	(0.50)	(0.21)
Log(Illiquidity)		0.056		0.056		0.103**		0.103**
		(1.00)		(1.03)		(2.17)		(2.15)
Gross Profitability		0.178		0.180		0.355*		0.359*
		(0.99)		(1.00)		(1.83)		(1.85)
Corporate Investment		0.037		0.037		-0.005		-0.007
		(0.49)		(0.50)		(-0.08)		(-0.09)
Leverage		-0.037		-0.037		-0.034		-0.034
		(-0.78)		(-0.79)		(-0.73)		(-0.73)
Log(Analyst Coverage)		-0.019		-0.019		-0.174		-0.175
		(-0.15)		(-0.14)		(-1.40)		(-1.41)
Analyst Dispersion		-0.536***		-0.539***		-0.828***		-0.831***
		(-2.67)		(-2.71)		(-4.37)		(-4.37)
Constant	2.309*	1.800	2.281*	1.775	0.591	-0.555	0.533	-0.614
	(1.71)	(1.09)	(1.70)	(1.09)	(0.46)	(-0.31)	(0.42)	(-0.34)
Obs	283,671	254,873	283,671	254,873	272,728	245,451	272,728	245,451
R-squared	0.045	0.080	0.048	0.082	0.043	0.076	0.045	0.078

Table 4: Institutional Ownership of Portfolios Sorted by ESG Rating and Uncertainty: Subsample Analysis

At the end of year t, stocks are independently sorted into quintiles according to their ESG ratings and ESG rating uncertainty to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the average institutional ownership in each quarter in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of quarterly institutional ownership of norm-constrained institutions for each of the 25 portfolios and the average difference in institutional ownership between high- and low-ESG-rating portfolios ("HML-R"), as well as between high- and low-ESG-rating-uncertainty portfolios ("HML-U"). We divide the full sample into two subperiods, and report results for 2003–2010 on the left and 2011–2019 on the right. Panels B and C report similar statistics for average ownership of hedge funds and other institutions, respectively. The Online Appendix provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Panel A: Norm-Constrained Institutions

	2003–2010								**2011–2019**							
ESG Rating	ESG Uncertainty								ESG Uncertainty							
	Low	2	3	4	High	HML-U	*t*-stat	All	Low	2	3	4	High	HML-U	*t*-stat	All
Low	0.234	0.239	0.243	0.238	0.262	0.028	(1.59)	0.239	0.114	0.133	0.137	0.124	0.105	-0.009*	(-1.77)	0.123
2	0.238	0.250	0.257	0.264	0.244	0.006	(0.76)	0.251	0.138	0.140	0.163	0.160	0.130	-0.008	(-0.93)	0.145
3	0.244	0.266	0.258	0.261	0.251	0.007	(1.09)	0.255	0.140	0.170	0.168	0.167	0.137	-0.003	(-0.54)	0.151
4	0.262	0.265	0.255	0.265	0.269	0.007	(1.06)	0.264	0.166	0.163	0.172	0.170	0.161	-0.006	(-0.71)	0.165
High	0.271	0.276	0.277	0.266	0.195	-0.076**	(-2.41)	0.273	0.190	0.200	0.203	0.188	0.168	-0.022***	(-3.65)	0.192
HML-R	0.037***	0.037***	0.034***	0.028***	-0.067			0.034***	0.076***	0.068***	0.065***	0.064***	0.063***			0.069***
	(8.58)	(8.60)	(6.87)	(7.18)	(-1.67)			(12.78)	(20.93)	(21.05)	(10.36)	(11.55)	(10.22)			(27.30)

Panel B: Hedge Funds

	2003–2010								**2011–2019**							
ESG Rating	ESG Uncertainty								ESG Uncertainty							
	Low	2	3	4	High	HML-U	*t*-stat	All	Low	2	3	4	High	HML-U	*t*-stat	All
Low	0.133	0.128	0.136	0.127	0.097	-0.036***	(-4.08)	0.129	0.179	0.183	0.181	0.182	0.160	-0.019*	(-1.97)	0.181
2	0.117	0.110	0.115	0.119	0.107	-0.010**	(-2.39)	0.113	0.166	0.180	0.189	0.184	0.187	0.021***	(5.08)	0.182
3	0.104	0.114	0.115	0.106	0.112	0.008	(1.55)	0.111	0.196	0.170	0.169	0.187	0.189	-0.008	(-1.65)	0.184
4	0.093	0.100	0.096	0.098	0.091	-0.002	(-1.00)	0.096	0.196	0.183	0.178	0.182	0.186	-0.009*	(-1.81)	0.183
High	0.086	0.087	0.090	0.088	0.066	-0.020**	(-2.13)	0.088	0.163	0.157	0.162	0.162	0.166	0.003	(0.78)	0.162
HML-R	-0.047***	-0.041***	-0.046***	-0.039***	-0.030***			-0.042***	-0.016***	-0.026***	-0.019***	-0.019**	0.006			-0.019***
	(-13.62)	(-7.73)	(-7.20)	(-13.21)	(-3.17)			(-12.15)	(-3.08)	(-6.31)	(-5.25)	(-2.56)	(0.51)			(-5.68)

Panel C: Other Institutions

	2003–2010								**2011–2019**							
ESG Rating	ESG Uncertainty								ESG Uncertainty							
	Low	2	3	4	High	HML-U	*t*-stat	All	Low	2	3	4	High	HML-U	*t*-stat	All
Low	0.385	0.389	0.384	0.414	0.356	-0.029	(-1.54)	0.390	0.314	0.347	0.333	0.317	0.283	-0.031**	(-2.42)	0.327
2	0.387	0.409	0.401	0.407	0.379	-0.008	(-0.97)	0.396	0.304	0.343	0.374	0.374	0.331	0.027***	(3.11)	0.347
3	0.394	0.385	0.377	0.384	0.363	-0.031***	(-6.31)	0.376	0.349	0.362	0.365	0.385	0.356	0.007	(1.02)	0.361
4	0.375	0.383	0.388	0.367	0.351	-0.024**	(-2.64)	0.370	0.388	0.369	0.368	0.372	0.369	-0.019**	(-2.19)	0.370
High	0.357	0.367	0.361	0.353	0.291	-0.066	(-1.57)	0.360	0.369	0.370	0.365	0.361	0.361	-0.008	(-1.09)	0.366
HML-R	-0.028**	-0.023	-0.023**	-0.061***	-0.065			-0.029***	0.055***	0.023***	0.032***	0.044***	0.078***			0.039***
	(-2.13)	(-1.67)	(-2.23)	(-5.46)	(-1.36)			(-3.34)	(10.32)	(3.35)	(3.62)	(4.56)	(5.44)			(9.84)

Table 5: Performance of Portfolios Sorted by ESG Rating and Uncertainty: Subsample Analysis

At the end of year t, stocks are first sorted into quintiles according to their ESG rating uncertainty. Within each ESG rating uncertainty group, stocks are further sorted into quintiles according to their ESG ratings to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the value-weighted return in each month in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of monthly returns for each of the 25 portfolios, as well as for the investment strategy of going long (short) the low- (high)-ESG-rating stocks ("LMH-R"). The column "All" reports similar statistics for portfolios sorted by ESG ratings only. The row "All" reports returns for portfolios sorted by ESG uncertainty only, as well as the investment strategy of going long (short) the high (low) ESG-uncertainty stocks ("HML-U"). We divide the full sample into two subperiods, and report results for 2003–2010 on the left and 2011–2019 on the right. In Panel B, portfolio returns are further adjusted by the CAPM. The Online Appendix provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Panel A: Return

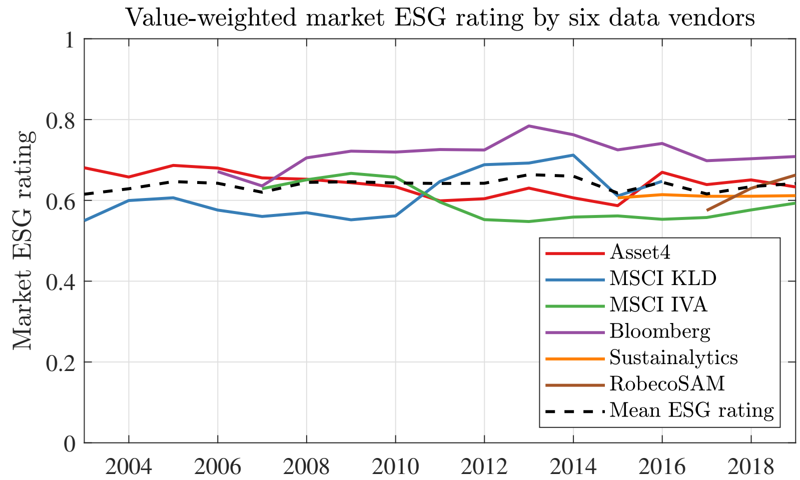
	2003–2010						**2011–2019**					
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	1.427*	0.845	0.528	0.949	0.667	0.773	1.065***	1.351***	0.980**	0.809**	0.842**	1.056***
	(1.86)	(1.35)	(0.77)	(1.43)	(1.23)	(1.23)	(2.93)	(3.25)	(2.52)	(2.00)	(2.26)	(2.92)
2	1.235*	0.973	0.955*	0.984	0.902	0.957	1.254***	1.073***	1.215***	1.096***	1.266***	0.968***
	(1.83)	(1.44)	(1.75)	(1.53)	(1.34)	(1.64)	(3.61)	(3.42)	(3.19)	(2.68)	(3.55)	(2.79)
3	0.944	1.014*	0.919	1.157*	0.879*	0.764	1.231***	0.921**	1.166***	1.057***	1.011***	1.249***
	(1.26)	(1.74)	(1.43)	(1.74)	(1.70)	(1.33)	(3.53)	(2.55)	(3.20)	(2.80)	(2.94)	(3.83)
4	0.497	0.502	0.928	0.763	1.108*	0.976*	0.937**	0.868**	1.262***	1.247***	0.884*	1.054***
	(0.86)	(0.73)	(1.29)	(1.22)	(1.91)	(1.87)	(2.52)	(2.40)	(4.15)	(4.43)	(1.92)	(3.62)
High	0.309	0.346	0.524	1.205**	0.619	0.420	0.937***	1.283***	1.150***	1.166***	1.062***	1.147***
	(0.52)	(0.57)	(1.08)	(2.05)	(1.18)	(0.75)	(3.36)	(5.14)	(3.98)	(3.78)	(3.38)	(4.26)
LMH-R	1.119***	0.499*	0.004	-0.256	0.048	0.353	0.127	0.068	-0.170	-0.357	-0.220	-0.091
	(3.06)	(1.78)	(0.01)	(-0.74)	(0.12)	(1.45)	(0.59)	(0.23)	(-0.70)	(-1.22)	(-0.87)	(-0.50)
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	0.482	0.533	0.666	1.011*	0.832*	0.350	0.994***	1.180***	1.174***	1.146***	1.037***	0.043
	(0.81)	(0.87)	(1.25)	(1.70)	(1.71)	(1.51)	(3.50)	(4.41)	(3.97)	(3.92)	(3.35)	(0.31)

Panel B: CAPM-Adjusted Return

	2003–2010						**2011–2019**					
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	0.568**	0.058	-0.284	0.162	0.011	-0.006	-0.147	0.022	-0.376*	-0.433**	-0.262	-0.224
	(1.99)	(0.27)	(-0.91)	(0.68)	(0.04)	(-0.03)	(-0.67)	(0.10)	(-1.95)	(-2.14)	(-1.17)	(-1.52)
2	0.397**	0.172	0.236	0.222	0.175	0.218	0.023	0.086	-0.083	-0.162	0.098	-0.259**
	(2.00)	(0.56)	(0.98)	(1.18)	(0.55)	(1.45)	(0.09)	(0.32)	(-0.54)	(-0.79)	(0.43)	(-2.06)
3	0.088	0.259	0.133	0.358*	0.237	0.034	0.061	-0.344*	-0.169	-0.228	-0.158	0.019
	(0.32)	(1.14)	(0.79)	(1.89)	(0.81)	(0.25)	(0.27)	(-1.89)	(-1.09)	(-1.14)	(-0.71)	(0.17)
4	-0.192	-0.348*	0.109	-0.049	0.381*	0.243**	-0.264	-0.408***	0.178	0.204	-0.418	-0.035
	(-0.86)	(-1.70)	(0.26)	(-0.25)	(1.82)	(2.34)	(-1.22)	(-2.94)	(1.49)	(1.27)	(-1.23)	(-0.37)
High	-0.391**	-0.403**	-0.159	0.461*	-0.030	-0.294***	-0.070	0.310***	0.110	0.052	-0.037	0.093*
	(-2.06)	(-2.29)	(-0.80)	(1.98)	(-0.12)	(-2.92)	(-0.56)	(3.02)	(1.02)	(0.32)	(-0.23)	(1.83)
LMH-R	0.959***	0.460	-0.126	-0.299	0.041	0.289	-0.077	-0.288	-0.486*	-0.486	-0.225	-0.317*
	(2.81)	(1.60)	(-0.30)	(-0.85)	(0.10)	(1.12)	(-0.31)	(-1.06)	(-1.88)	(-1.62)	(-0.81)	(-1.74)
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	-0.238*	-0.255**	-0.068	0.243*	0.181	0.419**	-0.077	0.117*	0.048	0.027	-0.107	-0.029
	(-1.87)	(-2.35)	(-0.45)	(1.93)	(1.33)	(2.04)	(-0.95)	(1.74)	(0.79)	(0.32)	(-1.07)	(-0.19)

Figure 1: Market ESG Ratings and ESG Uncertainty, Average Stock-Level ESG Uncertainty

The top graph shows the time-series of the market ESG score obtained from each data vendor, as well as the mean ESG rating across data vendors. The bottom graph shows the time-series of market ESG uncertainty, as well as equal- and value-weighted average of stock-level ESG uncertainty. Section 3.2 provides details on the construction of the variables.



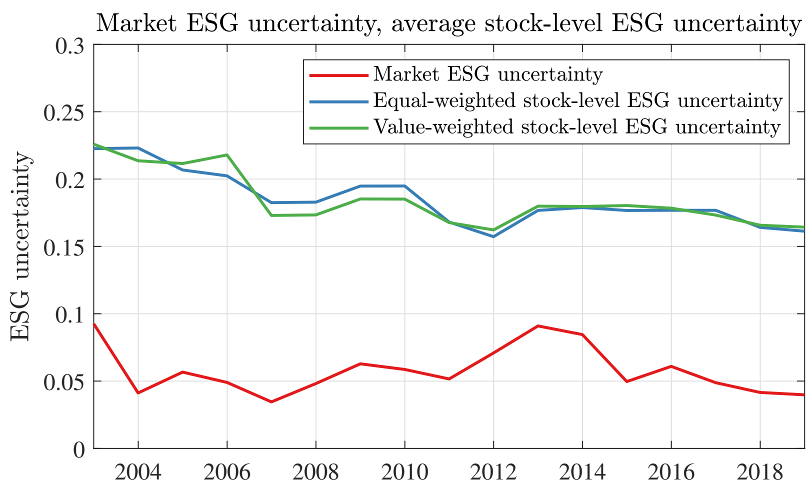
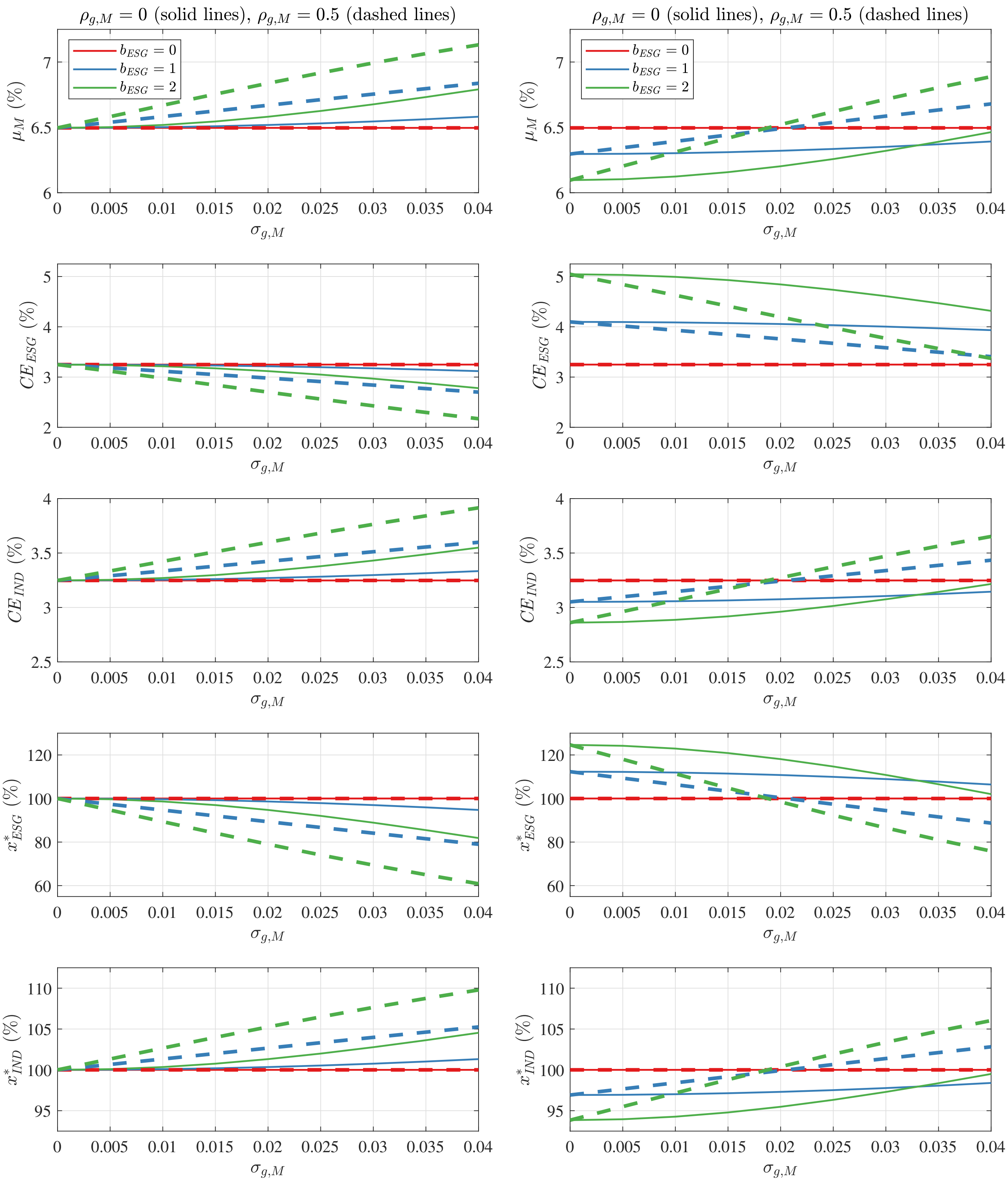


Figure 2: Equilibrium Equity Premium, Certainty Equivalent Return, and Market Demand

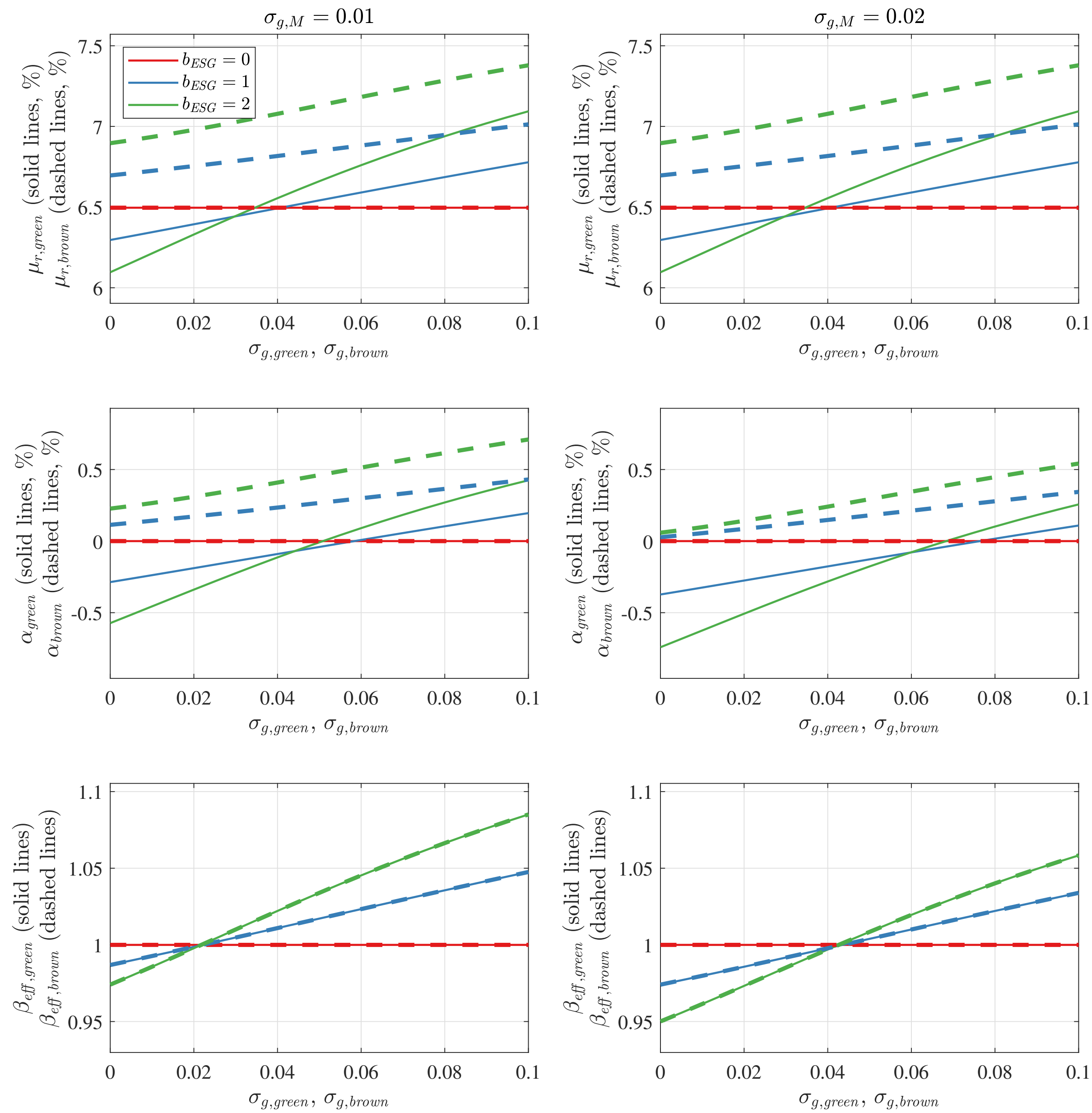
This figure shows the equilibrium market premium (μ_M), the certainty equivalent excess return for ESG-sensitive (CE_{ESG}) and ESG-indifferent (CE_{IND}) agents, the optimal market participation (x^*_{ESG} and x^*_{IND}), and their variation with the market ESG uncertainty, $\sigma_{g,M}$. The relative risk aversion, γ, is 2.81, and the market volatility, σ_M, is 15.19%. ESG-sensitive agents represent a fraction of $w_{ESG} = 20\%$ of the population and have a brown aversion $b_{ESG} = \{0, 1, 2\}$. ESG-indifferent agents represent $w_{IND} = 80\%$ of the population and have a brown aversion $b_{IND} = 0$. The correlation between the market return and the ESG score, $\rho_{g,M}$, is 0 (solid lines) or 0.5 (dashed lines). Panel A focuses on a green-neutral market ($\mu_{g,M} = 0$), while Panel B describes a green market ($\mu_{g,M} = 0.01$).



Panel A: Green-Neutral Market **Panel B:** Green Market

Figure 3: Two-Asset Pricing Equilibrium: Expected Stock Return, Alpha, and Effective Beta

Considering the green-neutral market described in Figure 3 Panel A, for green (solid lines) and brown (dashed lines) assets, this figure displays the equilibrium expected excess stock return, ($\mu_{r,green}$ and $\mu_{r,brown}$), the CAPM alpha, (α_{green} and α_{brown}), the effective beta, ($\beta_{eff,green}$ and $\beta_{eff,brown}$), and their variation with ESG uncertainty, $\sigma_{g,green}$, $\sigma_{g,brown}$. The mean ESG scores of the two assets are $\mu_{g,green} = 0.01$ and $\mu_{g,brown} = -0.01$. The market betas of the two assets are $\beta_{green} = \beta_{brown} = 1$, while their idiosyncratic return volatility is equal to 0.2. The correlation between return and the same-asset ESG score is $\rho_{g,M} = \rho_{rg,green} = \rho_{rg,brown} = 0.5$. The graphs on the left describe a market-wide ESG uncertainty that is equal to $\sigma_{g,M} = 0.01$, while the right plots display results for $\sigma_{g,M} = 0.02$.



Sustainable Investing with ESG Rating Uncertainty

Online Appendix

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This Online Appendix presents the proofs and derivations, as well as the supplementary empirical results. Most of the results presented here are discussed in the paper.

Section A. Proofs and Derivations

- A.1 Equilibrium Equity Premium in Multiple-Agent One-Asset Economy (Section 2.1)
- A.2 Proof of Proposition 1: Optimal Portfolio under ESG Uncertainty (Section 2.2)
- A.3 Proof of Proposition 2: Expected Returns without ESG Uncertainty (Section 2.3)
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Section B. Supplementary Material

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- Robustness of Return Predictability: Risk-Adjusted Performance
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A Proofs and Derivations

In all derivations that follow, the expectation operators are taken under the joint distribution of returns and ESG ratings.

A.1 Equilibrium Equity Premium in Multiple-Agent One-Asset Economy

Based on equation (4), the optimal market demand for agent i is

$$x_i^* = \frac{1}{\gamma_i} \frac{\mu_M + b_i \mu_{g,M}}{\sigma_{i,U}^2}, \tag{A.1}$$

where $\sigma_{i,U}^2 = \sigma_M^2 + b_i^2 \sigma_{g,M}^2 + 2 b_i \sigma_M \sigma_{g,M} \rho_{g,M}$. Aggregating across agents, we impose market clearing by setting $\sum_{i=1}^I w_i x_i^* = 1$. Thus,

$$\sum_{i=1}^{I} w_i \frac{1}{\gamma_i} \frac{\mu_M}{\sigma_{i,U}^2} + \sum_{i=1}^{I} w_i \frac{1}{\gamma_i} \frac{b_i \mu_{g,M}}{\sigma_{i,U}^2} = 1. \tag{A.2}$$

Finally, we solve for the equilibrium equity premium:

$$\mu_M = \gamma_M \sigma_{M,U}^2 - b_M \mu_{g,M,U}, \tag{A.3}$$

where

$$\gamma_M = \frac{1}{\sum_{i=1}^I w_i \frac{1}{\gamma_i}}, \tag{A.4}$$

$$\sigma_{M,U}^2 = \frac{\sum_{i=1}^I w_i \gamma_i^{-1}}{\sum_{i=1}^I w_i \gamma_i^{-1} \frac{1}{\sigma_{i,U}^2}}, \tag{A.5}$$

$$b_M = \frac{\sum_{i=1}^I w_i \gamma_i^{-1} b_i}{\sum_{i=1}^I w_i \gamma_i^{-1}}, \tag{A.6}$$

$$\mu_{g,M,U} = \frac{\sum_{i=1}^I w_i \frac{b_i}{\gamma_i \sigma_{i,U}^2}}{\frac{b_M}{\gamma_M \sigma_{M,U}^2}} \mu_{g,M}. \tag{A.7}$$

A.2 Proof of Proposition 1: Optimal Portfolio under ESG Uncertainty

The expected utility of agent i can be written as

$$\begin{aligned} E\left[V\left(\tilde{W}_{i,1}, \boldsymbol{X}_i\right)\right] &= E\left[-e^{-A_i \tilde{W}_{i,1} - B_i W_{i,0} \boldsymbol{X}_i' \tilde{\boldsymbol{g}}}\right] \\ &= E\left[-e^{-A_i W_{i,0}\left(1 + r_f + \boldsymbol{X}_i' \tilde{\boldsymbol{r}}\right) - B_i W_{i,0} \boldsymbol{X}_i' \tilde{\boldsymbol{g}}}\right] \end{aligned}$$

$$= -e^{-\gamma_i(1+r_f)} E\left[e^{-\gamma_i \boldsymbol{X}_i'(\tilde{\boldsymbol{r}}+b_i\tilde{\boldsymbol{g}})}\right], \tag{A.8}$$

where $\gamma_i = A_i W_{i,0}$ and $b_i = \frac{B_i}{A_i}$. Note that

$$\tilde{\boldsymbol{r}} + b_i\tilde{\boldsymbol{g}} \sim \mathcal{N}\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g, \boldsymbol{\Sigma}_{i,U}\right), \tag{A.9}$$

where $\boldsymbol{\Sigma}_{i,U} = \boldsymbol{\Sigma}_r + b_i^2\boldsymbol{\Sigma}_g + 2b\boldsymbol{\Sigma}_{rg}$. Then, the expected utility in (A.8) can be developed analytically

$$E\left[V\left(\tilde{W}_{i,1}, \boldsymbol{X}_i\right)\right] = -e^{-\gamma_i(1+r_f)} e^{-\gamma_i \boldsymbol{X}_i'(\boldsymbol{\mu}_r+b_i\boldsymbol{\mu}_g)+\frac{\gamma_i^2}{2}\boldsymbol{X}_i'\boldsymbol{\Sigma}_{i,U}\boldsymbol{X}_i}. \tag{A.10}$$

The investor chooses the optimal portfolio weights by maximizing the expression

$$\gamma_i \boldsymbol{X}_i'\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right) - \frac{\gamma_i^2}{2}\boldsymbol{X}_i'\boldsymbol{\Sigma}_{i,U}\boldsymbol{X}_i. \tag{A.11}$$

The first-order condition is

$$0 = -\gamma_i\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right) + \gamma_i^2\boldsymbol{\Sigma}_{i,U}\boldsymbol{X}_i. \tag{A.12}$$

The optimal portfolio that solves the above equation is then

$$\boldsymbol{X}_i^* = \frac{1}{\gamma_i}\boldsymbol{\Sigma}_{i,U}^{-1}\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right). \tag{A.13}$$

Then, we express the inverse of the covariance matrix of the return bundle as

$$\boldsymbol{\Sigma}_{i,U}^{-1} = \left(\boldsymbol{\Sigma}_r + b_i^2\boldsymbol{\Sigma}_g + 2b_i\boldsymbol{\Sigma}_{rg}\right)^{-1} = \boldsymbol{\Sigma}_r^{-1} + \boldsymbol{\Psi}_i, \tag{A.14}$$

where

$$\boldsymbol{\Psi}_i = \boldsymbol{\Sigma}_{i,U}^{-1} - \boldsymbol{\Sigma}_r^{-1} = -\boldsymbol{\Sigma}_r^{-1}\left(b_i^2\boldsymbol{\Sigma}_g + 2b_i\boldsymbol{\Sigma}_{rg}\right)\boldsymbol{\Sigma}_r^{-1}\left(\mathbf{I}_N + \left(b_i^2\boldsymbol{\Sigma}_g + 2b_i\boldsymbol{\Sigma}_{rg}\right)\boldsymbol{\Sigma}_r^{-1}\right)^{-1}. \tag{A.15}$$

The optimal strategy can finally be written as

$$\boldsymbol{X}_i^* = \frac{1}{\gamma_i}\boldsymbol{\Sigma}_r^{-1}\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right) + \frac{1}{\gamma_i}\boldsymbol{\Psi}_i\left(\boldsymbol{\mu}_r + b_i\boldsymbol{\mu}_g\right). \tag{A.16}$$

A.3 Proof of Proposition 2: Expected Returns without ESG Uncertainty

As the riskless asset is in zero net supply, the market portfolio consists exclusively of risky assets and is given by

$$\boldsymbol{X}_M = \sum_{i=1}^{I} \frac{W_{i,0}}{W_{M,0}} \boldsymbol{X}_i^* = \sum_{i=1}^{I} w_i \frac{1}{\gamma_i} \boldsymbol{\Sigma}_r^{-1} \left(\boldsymbol{\mu}_r + b_i \boldsymbol{\mu}_g\right), \tag{A.17}$$

where $w_i = \frac{W_{i,0}}{W_{M,0}}$ and $\boldsymbol{\mu}_r$ has to be determined in equilibrium. Then, it follows that

$$\frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2} \sigma_M^2 = \left(\sum_{i=1}^{I} w_i \frac{1}{\gamma_i}\right) \boldsymbol{\mu}_r + \left(\sum_{i=1}^{I} w_i \frac{b_i}{\gamma_i}\right) \boldsymbol{\mu}_g, \tag{A.18}$$

which entails that

$$\boldsymbol{\mu}_r = \frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2} \gamma_M \sigma_M^2 - b_M \boldsymbol{\mu}_g, \tag{A.19}$$

where $\gamma_M = \left(\sum_{i=1}^{I} w_i \gamma_i^{-1}\right)^{-1}$ and $b_M = \frac{\sum_{i=1}^{I} w_i \gamma_i^{-1} b_i}{\sum_{i=1}^{I} w_i \gamma_i^{-1}}$. The expected excess return of the market portfolio is

$$\mu_M = \boldsymbol{X}_M' \boldsymbol{\mu}_r = \gamma_M \sigma_M^2 - b_M \boldsymbol{X}_M' \boldsymbol{\mu}_g, \tag{A.20}$$

which yields

$$\mu_M + b_M \boldsymbol{X}_M' \boldsymbol{\mu}_g = \gamma_M \sigma_M^2, \tag{A.21}$$

and, finally, combining (A.19) and (A.21) leads to

$$\boldsymbol{\mu}_r = \frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2} \mu_M + b_M \frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2} \boldsymbol{X}_M' \boldsymbol{\mu}_g - b_M \boldsymbol{\mu}_g. \tag{A.22}$$

Recalling that $\boldsymbol{\beta} = \frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2}$ is the N-vector of market betas, the result follows.

A.4 Proof of Proposition 3: Expected Returns with ESG Uncertainty

Market clearing implies that, as the riskless asset is in zero net supply, the market portfolio consists exclusively of risky assets and is given by

$$\boldsymbol{X}_M = \sum_{i=1}^{I} w_i \boldsymbol{X}_i^* = \sum_{i=1}^{I} w_i \frac{1}{\gamma_i} \boldsymbol{\Sigma}_{i,U}^{-1} \boldsymbol{\mu}_r + \sum_{i=1}^{I} w_i \frac{1}{\gamma_i} b_i \boldsymbol{\Sigma}_{i,U}^{-1} \boldsymbol{\mu}_g, \tag{A.23}$$

where $\boldsymbol{\mu}_r$ has to be determined in equilibrium. We introduce the following notation:

$$\gamma_M^{-1} = \sum_{i=1}^{I} w_i \gamma_i^{-1}, \tag{A.24}$$

$$\boldsymbol{\Sigma}_{M,U}^{-1} = \frac{\sum_{i=1}^{I} w_i \gamma_i^{-1} \boldsymbol{\Sigma}_{i,U}^{-1}}{\sum_{i=1}^{I} w_i \gamma_i^{-1}}, \tag{A.25}$$

$$\mathbf{B}_M = \gamma_M \boldsymbol{\Sigma}_{M,U} \sum_{i=1}^{I} w_i \gamma_i^{-1} b_i \boldsymbol{\Sigma}_{i,U}^{-1}. \tag{A.26}$$

We then have

$$\boldsymbol{X}_M = \frac{1}{\gamma_M} \boldsymbol{\Sigma}_{M,U}^{-1} \boldsymbol{\mu}_r + \frac{1}{\gamma_M} \boldsymbol{\Sigma}_{M,U}^{-1} \mathbf{B}_M \boldsymbol{\mu}_g, \tag{A.27}$$

and hence

$$\frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2} \sigma_M^2 = \frac{1}{\gamma_M} \boldsymbol{\Sigma}_r \boldsymbol{\Sigma}_{M,U}^{-1} \boldsymbol{\mu}_r + \frac{1}{\gamma_M} \boldsymbol{\Sigma}_r \boldsymbol{\Sigma}_{M,U}^{-1} \mathbf{B}_M \boldsymbol{\mu}_g, \tag{A.28}$$

where $\frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2}$ is the vector of equilibrium market betas, $\boldsymbol{\beta}$. Therefore, solving for the vector of expected excess returns $\boldsymbol{\mu}_r$:

$$\boldsymbol{\mu}_r = \gamma_M \boldsymbol{\Sigma}_{M,U} \boldsymbol{\Sigma}_r^{-1} \frac{\boldsymbol{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2} \sigma_M^2 - \mathbf{B}_M \boldsymbol{\mu}_g. \tag{A.29}$$

In addition, we aggregate to obtain the market expected excess return μ_M:

$$\mu_M = \boldsymbol{X}_M' \boldsymbol{\mu}_r = \gamma_M \boldsymbol{X}_M' \boldsymbol{\Sigma}_{M,U} \boldsymbol{X}_M - \boldsymbol{X}_M' \mathbf{B}_M \boldsymbol{\mu}_g. \tag{A.30}$$

The vector of expected excess asset returns is then given by

$$\boldsymbol{\mu}_r = \frac{\boldsymbol{\Sigma}_{M,U} \boldsymbol{X}_M}{\boldsymbol{X}_M' \boldsymbol{\Sigma}_{M,U} \boldsymbol{X}_M} \mu_M - \left(\mathbf{B}_M \boldsymbol{\mu}_g - \frac{\boldsymbol{\Sigma}_{M,U} \boldsymbol{X}_M}{\boldsymbol{X}_M' \boldsymbol{\Sigma}_{M,U} \boldsymbol{X}_M} \boldsymbol{X}_M' \mathbf{B}_M \boldsymbol{\mu}_g \right). \tag{A.31}$$

From (A.30) and (A.31), we can therefore write that the equilibrium market and stock expected excess returns are

$$\mu_M = \gamma_M \sigma_{M,U}^2 - b_M \mu_{g,M,U}, \tag{A.32}$$

$$\boldsymbol{\mu}_r = \boldsymbol{\beta}_{\mathit{eff}} \mu_M - b_M \left(\boldsymbol{\mu}_{g,U} - \boldsymbol{\beta}_{\mathit{eff}} \mu_{g,M,U} \right), \tag{A.33}$$

where

$$\gamma_M^{-1} = \sum_{i=1}^{I} w_i \gamma_i^{-1}, \tag{A.34}$$

$$b_M = \frac{\sum_{i=1}^{I} w_i \gamma_i^{-1} b_i}{\sum_{i=1}^{I} w_i \gamma_i^{-1}}, \tag{A.35}$$

$$\mathbf{\Sigma}_{M,U}^{-1} = \frac{\sum_{i=1}^{I} w_i \gamma_i^{-1} \mathbf{\Sigma}_{i,U}^{-1}}{\sum_{i=1}^{I} w_i \gamma_i^{-1}}, \tag{A.36}$$

$$\mathbf{B}_M = \left(\sum_{i=1}^{I} w_i \gamma_i^{-1} \mathbf{\Sigma}_{i,U}^{-1} \right)^{-1} \sum_{i=1}^{I} w_i \gamma_i^{-1} b_i \mathbf{\Sigma}_{i,U}^{-1}, \tag{A.37}$$

$$\sigma_{M,U}^2 = \boldsymbol{X}_M' \mathbf{\Sigma}_{M,U} \boldsymbol{X}_M, \tag{A.38}$$

$$\mu_{g,M,U} = \boldsymbol{X}_M' \boldsymbol{\mu}_{g,U}, \tag{A.39}$$

$$\boldsymbol{\mu}_{g,U} = \frac{1}{b_M} \mathbf{B}_M \boldsymbol{\mu}_g, \tag{A.40}$$

$$\boldsymbol{\beta}_{\mathit{eff}} = \frac{\mathbf{\Sigma}_{M,U} \boldsymbol{X}_M}{\boldsymbol{X}_M' \mathbf{\Sigma}_{M,U} \boldsymbol{X}_M}. \tag{A.41}$$

Under the hypothesis that agents are homogeneous in preferences ($\gamma_i = \gamma$ and $b_i = b$, $\forall i$), several simplifications are possible, leading to

$$\gamma_M = \gamma, \tag{A.42}$$

$$b_M = b, \tag{A.43}$$

$$\mathbf{\Sigma}_{M,U} = \mathbf{\Sigma}_r + b^2 \mathbf{\Sigma}_g + 2b \mathbf{\Sigma}_{rg}, \tag{A.44}$$

$$\mathbf{B}_M = b \mathbf{I}_N, \tag{A.45}$$

$$\sigma_{M,U}^2 = \underbrace{\boldsymbol{X}_M' \mathbf{\Sigma}_r \boldsymbol{X}_M}_{\sigma_M^2} + b^2 \underbrace{\boldsymbol{X}_M' \mathbf{\Sigma}_g \boldsymbol{X}_M}_{\sigma_{g,M}^2} + 2b \underbrace{\boldsymbol{X}_M' \mathbf{\Sigma}_{rg} \boldsymbol{X}_M}_{\sigma_{rg,M}}, \tag{A.46}$$

$$\mu_{g,M,U} = \boldsymbol{X}_M' \boldsymbol{\mu}_g, \tag{A.47}$$

$$\boldsymbol{\mu}_{g,U} = \boldsymbol{\mu}_g, \tag{A.48}$$

$$\boldsymbol{\beta}_{\mathit{eff}} = \frac{\left(\mathbf{\Sigma}_r + b^2 \mathbf{\Sigma}_g + 2b \mathbf{\Sigma}_{rg} \right) \boldsymbol{X}_M}{\sigma_M^2 + b^2 \sigma_{g,M}^2 + 2b \sigma_{rg,M}} = \frac{\sigma_M^2}{\sigma_{M,U}^2} \boldsymbol{\beta} + \frac{b^2 \sigma_{g,M}^2}{\sigma_{M,U}^2} \boldsymbol{\beta}_g + \frac{2b \sigma_{rg,M}}{\sigma_{M,U}^2} \boldsymbol{\beta}_{rg}, \tag{A.49}$$

where $\boldsymbol{\beta} = \frac{\mathbf{\Sigma}_r \boldsymbol{X}_M}{\sigma_M^2}$, $\boldsymbol{\beta}_g = \frac{\mathbf{\Sigma}_g \boldsymbol{X}_M}{\sigma_{g,M}^2}$, and $\boldsymbol{\beta}_{rg} = \frac{\mathbf{\Sigma}_{rg} \boldsymbol{X}_M}{\sigma_{rg,M}}$. The difference $\boldsymbol{\beta}_{\mathit{eff}} - \boldsymbol{\beta}$ is therefore

$$\boldsymbol{\beta}_{\mathit{eff}} - \boldsymbol{\beta} = \frac{b^2 \sigma_{g,M}^2}{\sigma_{M,U}^2} \left(\boldsymbol{\beta}_g - \boldsymbol{\beta} \right) + \frac{2b \sigma_{rg,M}}{\sigma_{M,U}^2} \left(\boldsymbol{\beta}_{rg} - \boldsymbol{\beta} \right). \tag{A.50}$$

Recalling equation (18), the N-vector of alpha can be expressed as

$$\boldsymbol{\alpha} = \boldsymbol{\mu}_r - \boldsymbol{\beta} \mu_M = \left(\boldsymbol{\beta}_{\mathit{eff}} - \boldsymbol{\beta} \right) \left(\mu_M + b_M \mu_{g,M} \right) - b_M \left(\boldsymbol{\mu}_g - \boldsymbol{\beta} \mu_{g,M} \right)$$

$$= \left(\frac{b^2 \sigma_{g,M}^2}{\sigma_{M,U}^2} \left(\boldsymbol{\beta}_g - \boldsymbol{\beta} \right) + \frac{2b\sigma_{rg,M}}{\sigma_{M,U}^2} \left(\boldsymbol{\beta}_{rg} - \boldsymbol{\beta} \right) \right) \left(\mu_M + b_M \mu_{g,M} \right) - b_M \left(\boldsymbol{\mu}_g - \boldsymbol{\beta} \mu_{g,M} \right). \quad \text{(A.51)}$$

A.5 Derivations for Two-Asset Economy

In the two-risky-asset case, we consider that ESG rating uncertainty is in play and use equation (14) to derive the optimal portfolio. Denoting by $\mathbf{I}_2$ the 2×2 identity matrix, we assume that

$$\boldsymbol{\Sigma}_r = \sigma_r^2 \mathbf{I}_2, \qquad \boldsymbol{\Sigma}_g = \begin{bmatrix} \sigma_{g,green}^2 & 0 \\ 0 & \sigma_{g,brown}^2 \end{bmatrix}, \qquad \boldsymbol{\Sigma}_{rg} = \begin{bmatrix} \sigma_{rg,green} & 0 \\ 0 & \sigma_{rg,brown} \end{bmatrix}. \quad \text{(A.52)}$$

In this case, we have

$$\begin{aligned} \boldsymbol{\Sigma}_{i,U} &= \boldsymbol{\Sigma}_r + b_i^2 \boldsymbol{\Sigma}_g + 2b_i \boldsymbol{\Sigma}_{rg} \\ &= \begin{bmatrix} \sigma_r^2 + b_i^2 \sigma_{g,green}^2 + 2b_i \sigma_{rg,green} & 0 \\ 0 & \sigma_r^2 + b_i^2 \sigma_{g,brown}^2 + 2b_i \sigma_{rg,brown} \end{bmatrix}, \end{aligned} \quad \text{(A.53)}$$

and then

$$\boldsymbol{\Sigma}_{i,U}^{-1} = \begin{bmatrix} \frac{1}{\sigma_r^2 + b_i^2 \sigma_{g,green}^2 + 2b_i \sigma_{rg,green}} & 0 \\ 0 & \frac{1}{\sigma_r^2 + b_i^2 \sigma_{g,brown}^2 + 2b_i \sigma_{rg,brown}} \end{bmatrix}. \quad \text{(A.54)}$$

We also assume that a green firm has a mean ESG score $\mu_g > 0$, while the brown firm has a mean score $-\mu_g$. We can then write the optimal portfolio strategy as

$$X_{i,green}^* = \frac{1}{\gamma_i} \frac{\mu_{r,green} + b_i \mu_g}{\sigma_r^2 + b_i^2 \sigma_{g,green}^2 + 2b_i \sigma_{rg,green}}, \quad \text{(A.55)}$$

$$X_{i,brown}^* = \frac{1}{\gamma_i} \frac{\mu_{r,brown} - b_i \mu_g}{\sigma_r^2 + b_i^2 \sigma_{g,brown}^2 + 2b_i \sigma_{rg,brown}}. \quad \text{(A.56)}$$

Notice that, for $\sigma_{g,green}, \sigma_{g,brown} > 0$ and $\sigma_{rg,green}, \sigma_{rg,brown} \geq 0$,

$$\lim_{b_i \to \infty} X_{i,green}^* = \lim_{b_i \to \infty} \frac{1}{\gamma_i} \frac{\mu_{r,green} + b_i \mu_g}{\sigma_r^2 + b_i^2 \sigma_{g,green}^2 + 2b_i \sigma_{rg,green}} = 0, \quad \text{(A.57)}$$

$$\lim_{b_i \to \infty} X_{i,brown}^* = \lim_{b_i \to \infty} \frac{1}{\gamma_i} \frac{\mu_{r,brown} - b_i \mu_g}{\sigma_r^2 + b_i^2 \sigma_{g,brown}^2 + 2b_i \sigma_{rg,brown}} = 0. \quad \text{(A.58)}$$

We now attempt to determine the equilibrium expected excess returns of the two risky assets. We consider that there are two categories of agents, *ESG* and *IND*, whose fractions of total wealth are w_{ESG} and w_{IND}. The first category has a brown aversion b_{ESG}, while $b_{IND} = 0$. The relative risk aversion is γ for all agents. Recalling (A.29), the equilibrium excess returns are $\boldsymbol{\mu}_r = \gamma_M \boldsymbol{\Sigma}_{M,U} \boldsymbol{\Sigma}_r^{-1} \boldsymbol{\beta} \sigma_M^2 - \mathbf{B}_M \boldsymbol{\mu}_g$, where:

$$\gamma_M = \gamma, \tag{A.59}$$

$$\boldsymbol{\Sigma}_{M,U} = \begin{bmatrix} \frac{\sigma_r^2 + b_{ESG}^2 \sigma_{g,green}^2 + 2b_{ESG}\sigma_{rg,green}}{1+(1-w_{ESG})\left(\frac{b_{ESG}^2\sigma_{g,green}^2}{\sigma_r^2} + \frac{2b_{ESG}\sigma_{rg,green}}{\sigma_r^2}\right)} & 0 \\ 0 & \frac{\sigma_r^2 + b_{ESG}^2 \sigma_{brown}^2 + 2b_{ESG}\sigma_{rg,brown}}{1+(1-w_{ESG})\left(\frac{b_{ESG}^2\sigma_{g,brown}^2}{\sigma_r^2} + \frac{2b_{ESG}\sigma_{rg,brown}}{\sigma_r^2}\right)} \end{bmatrix}, \tag{A.60}$$

$$\mathbf{B}_M = \begin{bmatrix} \frac{w_{ESG} b_{ESG}}{1+(1-w_{ESG})\left(\frac{b_{ESG}^2\sigma_{g,green}^2}{\sigma_r^2} + \frac{2b_{ESG}\sigma_{rg,green}}{\sigma_r^2}\right)} & 0 \\ 0 & \frac{w_{ESG} b_{ESG}}{1+(1-w_{ESG})\left(\frac{b_{ESG}^2\sigma_{g,brown}^2}{\sigma_r^2} + \frac{2b_{ESG}\sigma_{rg,brown}}{\sigma_r^2}\right)} \end{bmatrix}. \tag{A.61}$$

Consequently, the two assets have expected excess returns

$$\mu_{r,green} = \frac{\beta_{green}\gamma\sigma_M^2 \left(1 + b_{ESG}^2 \frac{\sigma_{g,green}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,green}}{\sigma_r^2}\right) - w_{ESG} b_{ESG} \mu_g}{1 + (1 - w_{ESG})\left(b_{ESG}^2 \frac{\sigma_{g,green}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,green}}{\sigma_r^2}\right)}, \tag{A.62}$$

$$\mu_{r,brown} = \frac{\beta_{brown}\gamma\sigma_M^2 \left(1 + b_{ESG}^2 \frac{\sigma_{g,brown}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,brown}}{\sigma_r^2}\right) + w_{ESG} b_{ESG} \mu_g}{1 + (1 - w_{ESG})\left(b_{ESG}^2 \frac{\sigma_{g,brown}^2}{\sigma_r^2} + 2b_{ESG}\frac{\sigma_{rg,brown}}{\sigma_r^2}\right)}. \tag{A.63}$$

Equation (27) is obtained taking the difference between (A.63) and (A.62) for $\beta_{green} = \beta_{brown}$, $\sigma_{g,green}^2 = \sigma_{g,brown}^2 = \sigma_g^2$, and $\sigma_{rg,green} = \sigma_{rg,brown} = \sigma_{rg}$.

A.6 Welfare in a One-Asset Economy

In the single-asset setup, the expected utility for optimizing agent i is given by

$$E\left[V\left(\tilde{W}_{i,1}, x_i^*\right)\right] = -E\left[e^{-A\tilde{W}_{i,1} - BW_{i,0}x_i^*\tilde{g}_M}\right]. \tag{A.64}$$

Considering the optimal market demand in (A.1) in the presence of ESG uncertainty, the value function can be evaluated as

$$E\left[V\left(\tilde{W}_{i,1}, x_i^*\right)\right] = -e^{-\gamma_i\left(1+r_f\right) - \gamma_i\left[\frac{1}{2\gamma_i}\left(\frac{\mu_M + b_i\mu_{g,M}}{\sigma_{i,U}}\right)^2\right]}. \tag{A.65}$$

Following Back (2010),[1] the term in square brackets represents the investor's certainty equivalent excess rate of return CE_i.

B Supplementary Material

[1]See equations 2.17 and 2.18 on page 39.

Table B.1: Number of Stocks Over Time

Panel A reports the number of stocks covered by each data vendor on a year-by-year basis. Panel B reports the number of stocks simultaneously covered by N data vendors on a year-by-year basis, where N ranges between 1 and 5.

Panel A: Number of Stocks Covered By Each Data Vendor

Year	Asset4	MSCI KLD	MSCI IVA	Bloomberg	Sustainalytics	RobecoSAM
2002	398	1,055	0	0	0	0
2003	400	2,805	0	0	0	0
2004	535	2,851	0	0	0	0
2005	600	2,687	0	125	0	0
2006	606	2,655	528	209	0	0
2007	620	2,566	609	709	0	0
2008	789	2,580	600	984	0	0
2009	892	2,598	599	1,065	0	0
2010	915	2,630	551	1,957	0	0
2011	912	2,472	537	2,077	0	0
2012	895	2,418	2,253	2,149	0	0
2013	890	2,125	2,388	2,242	0	0
2014	885	2,098	2,328	2,380	413	0
2015	1,436	2,124	2,282	2,514	441	0
2016	2,083	0	2,255	2,530	460	419
2017	2,218	0	2,139	2,658	452	616
2018	2,178	0	2,104	2,794	473	818

Panel B: Number of Stocks Covered By Multiple Data Vendors

Year	$N=1$	$N=2$	$N=3$	$N=4$	$N=5$	$N\geq 2$
2002	677	388	0	0	0	388
2003	2409	398	0	0	0	398
2004	2324	531	0	0	0	531
2005	2199	518	59	0	0	577
2006	2069	241	349	100	0	690
2007	1756	380	264	299	0	943
2008	1579	505	320	351	0	1,176
2009	1601	487	373	365	0	1,225
2010	1240	1,093	385	368	0	1,846
2011	1136	1,109	392	367	0	1,868
2012	631	702	1,060	625	0	2,387
2013	741	591	1,038	652	0	2,281
2014	781	586	1,030	289	381	2,286
2015	851	341	811	669	431	2,252
2016	797	645	1,119	87	391	2,242
2017	781	512	1,140	162	442	2,256
2018	817	425	1,042	336	446	2,249

Table B.2: Variable Definitions

Variables	Definitions
Panel A: ESG Rating Measures	
ESG	We collect ESG rating data from six data vendors: Asset4 (Refinitiv), MSCI KLD, MSCI IVA, Bloomberg, Sustainalytics, and RobecoSAM. For each rater pair-year, we sort all stocks covered by both raters according to the original rating scale of the respective data provider and calculate the percentile rank (normalized between 0 and 1) for each stock-rater pair. Then for each stock, we compute the pairwise average rating as the average rank across the two raters in the pair. Finally, we compute the firm-level ESG rating as the average pairwise rank across all rater pairs.
ESG Uncertainty	For each rater pair-year, we sort all stocks covered by both raters according to the original rating scale of the respective data provider and calculate the percentile rank (normalized between 0 and 1) for each stock-rater pair. Then, for each stock, we compute the pairwise rating uncertainty as the standard deviation of the ranks provided by the two raters in the pair. Finally, we compute the firm-level ESG rating uncertainty as the average pairwise rating uncertainty across all rater pairs.
ESG$^{\text{ALL}}$	For each rater-year, we sort all stocks covered by this rater according to the original rating scale and calculate the percentile rank (normalized between 0 and 1) for each stock. We compute the firm-level ESG rating as the average rank across all raters.
ESG Uncertainty$^{\text{ALL}}$	For each rater-year, we sort all stocks covered by this rater according to the original rating scale and calculate the percentile rank (normalized between 0 and 1) for each stock. We compute the firm-level ESG rating uncertainty as the standard deviation of the ranks provided by all raters.
Panel B: Other Stock Characteristics	
Excess Return	Stock return minus the one-month Treasury bill rate in a given month.
CAPM-Adjusted Return	Stock excess return minus the product of a stock's beta and excess return on the market in a given month. The excess return on the market is computed as the CRSP value-weighted index return minus the one-month Treasury bill rate. The beta of the stock is estimated in a five-year rolling window.
IO	The institutional ownership in a given quarter q, computed as follows: $IO_{i,q} = \sum_f SHR_{i,f,q}/SHROUT_{i,q}$, where $SHR_{i,f,q}$ refers to the number of shares of stock i held by institution f in quarter q, and $SHROUT_{i,q}$ refers to the shares outstanding at the same time. For each stock, we separately compute the ownership of three types of institutions: norm-constrained institutions, hedge funds, and other institutions. Specifically, we disaggregate the 13F institutional holdings based on institution type, namely, bank trust (type 1), insurance company (type 2), investment company (type 3), independent investment advisor (which includes hedge funds, type 4), and others (including corporate/private pension funds, public pension funds, university and foundation endowments, and miscellaneous, type 5), following Abarbanell et al. (2003). We consider types 1, 2, and 5 as norm-constrained institutions (Hong and Kacperczyk (2009)) and manually collect a list of names of hedge fund companies (Agarwal et al. (2013)). The remaining institutions are classified as other institutions, i.e., types 3 and 4, excluding hedge funds.
Log(Size)	The logarithm of stock market capitalization, computed as the number of common shares outstanding times the share price as reported in CRSP.
Log(BM)	The logarithm of the book-to-market ratio of a stock, where the book-to-market ratio is computed as the book value of equity divided by market capitalization at fiscal year-end, following Fama and French (2015).
6M Momentum	Formation period return for six-month momentum in a given month m, computed as the cumulative return from month $m-6$ to month $m-1$, following Jegadeesh and Titman (1993).
Log(Illiquidity)	The logarithm of stock illiquidity. Stock illiquidity in a given month m is computed as follows: $ILLIQ_{i,m} = \left(\sum_{d\in m} \lvert R_{i,d,m}\rvert / VOLD_{i,d,m}\right)/D_{i,m} \times 10^6$, where $R_{i,d,m}$ refers to the return of stock i in day d of month m, $VOLD_{i,d,m}$ refers to the dollar trading volume at the same time, and $D_{i,m}$ is the number of trading days for stock i in month m, following Amihud (2002).
Gross Profitability	Gross profitability in a given year t, computed as follows: $GP_{i,t} = (REVT_{i,t} - COGS_{i,t})/ASSET_{i,t}$, where $REVT_{i,t}$ refers to the total revenue (COMPUSTAT annual item REVT) of stock i in year t, $COGS_{i,t}$ refers to the cost of goods sold (item COGS), and $ASSET_{i,t}$ is the total assets (item AT), following Novy-Marx (2013).
Corporate Investment	Corporate investment in a given quarter q, computed as follows: $CI_{i,q} = PPE_{i,q} - (PPE_{i,q-1} + PPE_{i,q-2} + PPE_{i,q-3})/3$, where $PPE_{i,q}$ refers to the ratio of change in net property, plant, and equipment (COMPUSTAT quarterly item PPENTQ) divided by sales (item SALEQ) of stock i in quarter q. If SALEQ is 0 or negative, then replace SALEQ with 0.01, following Titman et al. (2004).
Leverage	Total liabilities (COMPUSTAT annual item LT) divided by market capitalization at fiscal year-end, following Bhandari (1988).
Log(Analyst Coverage)	The logarithm of the number of analysts following the firm as reported in I/B/E/S in each quarter.
Analyst Dispersion	The standard deviation of analysts' earnings (earnings per share, EPS) forecasts divided by the absolute value of the median earnings forecast as reported in I/B/E/S in each quarter.

Table B.3: Summary Statistics

We collect ESG rating data from six data vendors: Asset4 (Refinitiv), MSCI KLD, MSCI IVA, Bloomberg, Sustainalytics, and RobecoSAM. Panel A reports the average ESG rating uncertainty for each rater pair. For each rater pair-year, we sort all stocks covered by both raters according to the original rating scale of the respective data provider and calculate the percentile rank (normalized between 0 and 1) for each stock-rater pair. Then, for each stock, we compute the pairwise rating uncertainty as the standard deviation of the ranks provided by the two raters in the pair. Finally, we compute the average ESG rating uncertainty across all stocks for each rater pair-year and average them over time. In Panel B, we compute the correlation in the percentile ranks for each rater pair-year and then average them over time. Panel C presents the summary statistics for the stock-level data used in the paper. We report the mean, standard deviation, median, and quantile distribution of the annual ESG rating and ESG rating uncertainty, monthly stock performance, quarterly institutional ownership, and other annual and monthly stock characteristics. Panel D presents the summary statistics for the portfolio-level data used in the paper. At the end of year t, stocks are independently sorted into quintiles according to their ESG ratings and ESG rating uncertainty to generate 25 (5×5) portfolios. For each of the 25 portfolios, we compute the value-weighted ESG rating and ESG rating uncertainty in year $t+1$, and the value-weighted return in each month in year $t+1$. We rebalance the portfolios at the end of year $t+1$. We report the time-series averages of annual ESG rating and ESG rating uncertainty, and monthly return for each of the 25 portfolios. Our sample period ranges from 2002 to 2019. Table B.2 provides detailed definitions for each variable.

Panel A: Pairwise ESG Rating Uncertainty

	Asset4	MSCI KLD	MSCI IVA	Bloomberg	Sustainalytics	RobecoSAM
Asset4	-	0.185	0.185	0.134	0.144	0.149
MSCI KLD	0.185	-	0.180	0.183	0.151	-
MSCI IVA	0.185	0.180	-	0.195	0.171	0.181
Bloomberg	0.134	0.183	0.195	-	0.133	0.138
Sustainalytics	0.144	0.151	0.171	0.133	-	0.119
RobecoSAM	0.149	-	0.181	0.138	0.119	-

Panel B: Pairwise ESG Rating Correlation

	Asset4	MSCI KLD	MSCI IVA	Bloomberg	Sustainalytics	RobecoSAM
Asset4	-	0.321	0.326	0.639	0.595	0.547
MSCI KLD	0.321	-	0.349	0.310	0.547	-
MSCI IVA	0.326	0.349	-	0.253	0.411	0.353
Bloomberg	0.639	0.310	0.253	-	0.677	0.645
Sustainalytics	0.595	0.547	0.411	0.677	-	0.707
RobecoSAM	0.547	-	0.353	0.645	0.707	-

Panel C: Quantile Distribution of Stock Characteristics

	Mean	Std.Dev.	Quantile Distribution				
			10%	25%	Median	75%	90%
ESG	0.461	0.202	0.219	0.310	0.437	0.595	0.753
ESG Uncertainty	0.180	0.112	0.051	0.097	0.162	0.246	0.330
ESG^{ALL}	0.490	0.206	0.239	0.337	0.472	0.630	0.788
ESG $\text{Uncertainty}^{\text{ALL}}$	0.207	0.124	0.051	0.110	0.195	0.291	0.373
Return	1.049	11.171	-11.257	-4.627	1.005	6.443	12.964
Excess Return	0.980	11.174	-11.330	-4.698	0.936	6.373	12.897
CAPM-Adjusted Return	-0.195	9.796	-10.840	-5.028	-0.231	4.410	10.128
Norm-Constrained IO	0.182	0.097	0.051	0.117	0.189	0.243	0.295
Hedge Fund IO	0.173	0.110	0.047	0.101	0.159	0.227	0.310
Other IO	0.381	0.168	0.132	0.289	0.401	0.494	0.577
Log(Size)	14.726	1.608	12.703	13.575	14.669	15.792	16.890
Log(BM)	-0.772	0.808	-1.819	-1.243	-0.688	-0.213	0.149
6M Momentum	0.054	0.264	-0.235	-0.085	0.045	0.175	0.333
Log(Illiquidity)	-7.119	2.079	-9.698	-8.647	-7.278	-5.736	-4.303
Gross Profitability	0.313	0.303	0.037	0.109	0.273	0.460	0.696
Corporate Investment	0.159	7.035	-0.077	-0.018	0.000	0.018	0.092
Leverage	1.596	3.222	0.090	0.227	0.546	1.378	4.558
Log(Analyst Coverage)	2.175	0.815	1.099	1.609	2.303	2.773	3.135
Analyst Dispersion	0.121	0.365	0.007	0.014	0.030	0.079	0.224

Table B.3 (continued)

Panel D: Portfolio Characteristics Sorted by ESG Rating and Uncertainty					
ESG Rating	ESG Uncertainty				
	Low	2	3	4	High
Panel D1: ESG Rating					
Low	0.252	0.259	0.277	0.287	0.305
2	0.368	0.386	0.384	0.390	0.373
3	0.474	0.479	0.467	0.487	0.483
4	0.575	0.589	0.600	0.603	0.597
High	0.848	0.811	0.753	0.732	0.702
Panel D2: ESG Uncertainty					
Low	0.135	0.146	0.179	0.215	0.275
2	0.159	0.152	0.172	0.207	0.317
3	0.131	0.156	0.179	0.207	0.293
4	0.139	0.136	0.172	0.208	0.295
High	0.093	0.114	0.160	0.193	0.260
Panel D3: Return					
Low	1.117	1.149	0.733	1.003	0.916
2	1.353	1.133	0.976	1.061	0.831
3	1.009	0.855	0.951	1.101	1.050
4	0.857	0.856	1.169	1.147	0.916
High	0.664	0.784	0.840	1.158	1.026

Table B.4: Risk-Adjusted Performance of Portfolios Sorted by ESG Rating and Uncertainty

At the end of year t, stocks are first sorted into quintiles according to their ESG rating uncertainty. Within each ESG rating uncertainty group, stocks are further sorted into quintiles according to their ESG ratings to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the value-weighted return in each month in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of monthly Fama-French-Carhart 4-factor-adjusted returns (FFC) for each of the 25 portfolios, as well as for the investment strategy of going long (short) the low- (high)-ESG-rating stocks ("LMH-R"). The column "All" reports similar statistics for portfolios sorted by ESG ratings only. The row "All" reports returns for portfolios sorted by ESG uncertainty only, as well as the investment strategy of going long (short) the high (low) ESG-uncertainty stocks ("HML-U"). In Panel B, portfolio returns are adjusted by the Fama-French 6-factor model (FF6). Table B.2 provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

	Panel A: FFC-Adjusted Return						**Panel B: FF6-Adjusted Return**					
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	0.214	0.054	-0.329*	-0.115	-0.113	-0.091	0.251	0.091	-0.327*	-0.155	-0.030	-0.092
	(1.28)	(0.37)	(-1.91)	(-0.76)	(-0.64)	(-0.76)	(1.49)	(0.65)	(-1.88)	(-1.02)	(-0.15)	(-0.78)
2	0.209	0.099	0.095	0.062	0.140	-0.005	0.189	0.193	0.019	0.055	0.131	-0.001
	(1.37)	(0.49)	(0.69)	(0.44)	(0.70)	(-0.04)	(1.15)	(1.03)	(0.13)	(0.37)	(0.65)	(-0.01)
3	0.111	0.006	0.018	0.090	0.048	0.051	0.113	0.031	0.043	0.171	-0.009	0.052
	(0.65)	(0.05)	(0.16)	(0.65)	(0.26)	(0.63)	(0.69)	(0.22)	(0.36)	(1.24)	(-0.05)	(0.61)
4	-0.215	-0.344***	0.172	0.093	0.042	0.124*	-0.179	-0.301***	0.145	0.094	0.119	0.117
	(-1.41)	(-2.94)	(0.92)	(0.77)	(0.20)	(1.71)	(-1.24)	(-2.62)	(0.77)	(0.77)	(0.58)	(1.60)
High	-0.246**	-0.041	0.012	0.304**	-0.012	-0.090	-0.250**	-0.017	-0.049	0.297**	-0.084	-0.094*
	(-2.13)	(-0.39)	(0.10)	(2.25)	(-0.09)	(-1.61)	(-2.13)	(-0.16)	(-0.39)	(2.04)	(-0.65)	(-1.71)
LMH-R	0.459**	0.095	-0.341	-0.419*	-0.101	-0.002	0.501**	0.109	-0.277	-0.452**	0.054	0.003
	(2.30)	(0.49)	(-1.42)	(-1.96)	(-0.42)	(-0.01)	(2.36)	(0.61)	(-1.14)	(-2.02)	(0.22)	(0.02)
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	-0.162**	-0.064	0.013	0.163**	0.056	0.218	-0.154**	-0.027	-0.045	0.157**	0.035	0.189
	(-2.15)	(-0.89)	(0.17)	(2.44)	(0.66)	(1.65)	(-2.02)	(-0.38)	(-0.58)	(2.38)	(0.41)	(1.42)

Table B.5: Risk-Adjusted Performance of Portfolios Sorted by ESG Rating and Uncertainty: Subsample Analysis

At the end of year t, stocks are first sorted into quintiles according to their ESG rating uncertainty. Within each ESG rating uncertainty group, stocks are further sorted into quintiles according to their ESG ratings to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the value-weighted return in each month in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of monthly Fama-French-Carhart 4-factor-adjusted returns (FFC) for each of the 25 portfolios, as well as for the investment strategy of going long (short) the low- (high)-ESG-rating stocks ("LMH-R"). The column "All" reports similar statistics for portfolios sorted by ESG ratings only. The row "All" reports returns for portfolios sorted by ESG uncertainty only, as well as the investment strategy of going long (short) the high (low) ESG-uncertainty stocks ("HML-U"). We divide the full sample into two subperiods, and report results for 2003–2010 on the left and 2011–2019 on the right. In Panel B, portfolio returns are adjusted by the Fama-French 6-factor model (FF6). Table B.2 provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Panel A: FFC-Adjusted Return

	2003–2010						**2011–2019**					
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	0.459*	-0.020	-0.256	0.101	0.018	-0.035	0.124	0.132	-0.198	-0.210	-0.203	-0.026
	(1.69)	(-0.10)	(-0.86)	(0.40)	(0.07)	(-0.19)	(0.67)	(0.75)	(-1.03)	(-1.15)	(-0.76)	(-0.22)
2	0.327	0.148	0.213	0.141	0.288	0.221	0.138	0.335	0.059	0.046	0.245	-0.118
	(1.51)	(0.50)	(0.87)	(0.70)	(0.86)	(1.53)	(0.77)	(1.26)	(0.41)	(0.24)	(1.17)	(-1.04)
3	-0.054	0.131	0.111	0.265	0.341	0.046	0.358*	-0.214	-0.050	-0.150	-0.075	0.061
	(-0.22)	(0.62)	(0.61)	(1.28)	(1.06)	(0.32)	(1.68)	(-1.23)	(-0.47)	(-0.79)	(-0.35)	(0.73)
4	-0.122	-0.254	0.164	-0.071	0.402*	0.269***	-0.220	-0.243*	0.171	0.264	-0.281	0.034
	(-0.54)	(-1.27)	(0.44)	(-0.37)	(1.86)	(2.84)	(-1.02)	(-1.89)	(1.60)	(1.58)	(-0.80)	(0.33)
High	-0.366*	-0.397**	-0.081	0.488**	0.071	-0.229**	-0.094	0.259***	0.051	-0.010	0.057	0.056
	(-1.83)	(-2.56)	(-0.47)	(2.54)	(0.26)	(-2.47)	(-0.74)	(2.96)	(0.49)	(-0.06)	(0.40)	(1.35)
LMH-R	0.825**	0.377	-0.175	-0.387	-0.052	0.194	0.218	-0.127	-0.249	-0.200	-0.260	-0.082
	(2.41)	(1.38)	(-0.49)	(-1.22)	(-0.12)	(0.77)	(1.02)	(-0.63)	(-1.02)	(-0.78)	(-0.81)	(-0.62)
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	-0.220*	-0.238**	-0.021	0.219*	0.294**	0.513***	-0.066	0.155**	0.038	0.029	-0.013	0.053
	(-1.71)	(-2.61)	(-0.15)	(1.90)	(2.60)	(2.69)	(-0.79)	(2.40)	(0.63)	(0.36)	(-0.14)	(0.33)

Panel B: FF6-Adjusted Return

	2003–2010						**2011–2019**					
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	0.480	-0.114	-0.301	0.030	0.100	-0.109	0.163	0.232	-0.165	-0.223	-0.126	0.013
	(1.63)	(-0.62)	(-1.02)	(0.12)	(0.34)	(-0.62)	(0.92)	(1.45)	(-0.87)	(-1.17)	(-0.45)	(0.12)
2	0.205	0.304	-0.086	0.128	0.203	0.161	0.155	0.374	0.125	0.056	0.267	-0.075
	(0.90)	(1.07)	(-0.37)	(0.65)	(0.59)	(1.12)	(0.80)	(1.49)	(0.86)	(0.28)	(1.23)	(-0.65)
3	-0.078	0.085	0.057	0.320	0.254	-0.019	0.325	-0.170	0.005	-0.061	-0.094	0.090
	(-0.29)	(0.38)	(0.30)	(1.41)	(0.77)	(-0.13)	(1.65)	(-0.97)	(0.05)	(-0.34)	(-0.47)	(1.02)
4	-0.108	-0.160	-0.079	-0.056	0.469**	0.251***	-0.189	-0.251**	0.197*	0.224	-0.194	0.030
	(-0.44)	(-0.85)	(-0.21)	(-0.28)	(2.14)	(2.96)	(-0.97)	(-1.98)	(1.91)	(1.34)	(-0.61)	(0.28)
High	-0.291	-0.340**	-0.160	0.503**	-0.061	-0.210**	-0.136	0.239**	-0.011	-0.035	0.060	0.030
	(-1.39)	(-2.05)	(-0.87)	(2.34)	(-0.24)	(-2.18)	(-1.08)	(2.57)	(-0.11)	(-0.23)	(0.43)	(0.73)
LMH-R	0.770*	0.227	-0.141	-0.473	0.160	0.101	0.299	-0.006	-0.153	-0.187	-0.186	-0.018
	(1.98)	(0.91)	(-0.39)	(-1.43)	(0.38)	(0.41)	(1.41)	(-0.03)	(-0.66)	(-0.70)	(-0.56)	(-0.14)
ESG Rating	ESG Uncertainty						ESG Uncertainty					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	-0.165	-0.178*	-0.162	0.223**	0.233*	0.398*	-0.086	0.154**	0.014	0.012	0.013	0.099
	(-1.22)	(-1.81)	(-1.32)	(2.01)	(1.91)	(1.99)	(-1.03)	(2.30)	(0.22)	(0.16)	(0.14)	(0.65)

Table B.6: Institutional Ownership of Portfolios Sorted by ESG Rating and Uncertainty Based on Alternative Definition

At the end of year t, stocks are independently sorted into quintiles according to their ESG ratings (i.e., ESG^{ALL}) and ESG rating uncertainty (i.e., $ESG\ Uncertainty^{ALL}$) to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the average institutional ownership in each quarter in year $t+1$ and rebalance the portfolios at the end of year $t+1$. Panel A reports the time-series averages of quarterly institutional ownership of norm-constrained institutions for each of the 25 portfolios and the average difference in institutional ownership between high- and low-ESG-rating portfolios ("HML-R"), as well as between high- and low-ESG-rating-uncertainty portfolios ("HML-U"). Panels B and C report similar statistics for average ownership of hedge funds and other institutions, respectively. Table B.2 provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Panel A: Norm-Constrained Institutions

ESG Rating^{ALL}	ESG Uncertainty^{ALL}							
	Low	2	3	4	High	HML-U	t-stat	All
Low	0.166	0.180	0.180	0.184	0.149	-0.016	(-0.64)	0.176
2	0.183	0.189	0.193	0.209	0.192	0.008*	(1.68)	0.192
3	0.194	0.203	0.206	0.206	0.198	0.004	(0.64)	0.201
4	0.181	0.208	0.210	0.219	0.218	0.038***	(4.20)	0.212
High	0.234	0.234	0.230	0.232	0.155	-0.078***	(-2.74)	0.232
HML-R	0.068***	0.054***	0.049***	0.048***	0.006			0.056***
	(11.99)	(10.74)	(8.53)	(8.94)	(0.28)			(11.95)

Panel B: Hedge Funds

ESG Rating^{ALL}	ESG Uncertainty^{ALL}							
	Low	2	3	4	High	HML-U	t-stat	All
Low	0.157	0.156	0.160	0.162	0.127	-0.029**	(-2.51)	0.158
2	0.138	0.149	0.153	0.152	0.148	0.010**	(2.29)	0.148
3	0.157	0.144	0.147	0.145	0.154	-0.003	(-0.45)	0.150
4	0.135	0.143	0.141	0.140	0.139	0.004	(0.45)	0.141
High	0.127	0.125	0.129	0.125	0.102	-0.025***	(-3.83)	0.127
HML-R	-0.030***	-0.031***	-0.031***	-0.038***	-0.025***			-0.032***
	(-5.54)	(-8.78)	(-6.35)	(-6.27)	(-3.24)			(-8.09)

Panel C: Other Institutions

ESG Rating^{ALL}	ESG Uncertainty^{ALL}							
	Low	2	3	4	High	HML-U	t-stat	All
Low	0.345	0.360	0.359	0.362	0.287	-0.057	(-1.42)	0.355
2	0.345	0.379	0.375	0.388	0.365	0.021**	(2.03)	0.370
3	0.372	0.360	0.376	0.377	0.361	-0.011	(-1.46)	0.367
4	0.339	0.375	0.371	0.374	0.368	0.029	(1.41)	0.371
High	0.370	0.361	0.367	0.356	0.278	-0.091***	(-2.71)	0.365
HML-R	0.025*	0.001	0.008	-0.006	-0.009			0.009
	(1.95)	(0.07)	(0.91)	(-0.56)	(-0.31)			(0.97)

Table B.7: Performance of Portfolios Sorted by ESG Rating and Uncertainty Based on Alternative Definition

At the end of year t, stocks are first sorted into quintiles according to their ESG rating uncertainty (i.e., $ESG\ Uncertainty^{ALL}$). Within each ESG rating uncertainty group, stocks are further sorted into quintiles according to their ESG ratings (i.e., ESG^{ALL}) to generate 25 (5×5) portfolios. The low- (high)-ESG-rating and ESG-rating-uncertainty portfolios comprise the bottom (top) quintile of stocks based on the ESG rating and ESG rating uncertainty, respectively. For each of the 25 portfolios, we compute the value-weighted return in each month in year $t + 1$ and rebalance the portfolios at the end of year $t + 1$. Panel A reports the time-series averages of monthly returns for each of the 25 portfolios, as well as for the investment strategy of going long (short) the low- (high)-ESG-rating stocks ("LMH-R"). The column "All" reports similar statistics for portfolios sorted by ESG ratings only. The row "All" reports returns for portfolios sorted by ESG uncertainty only, as well as the investment strategy of going long (short) the high (low) ESG-uncertainty stocks ("HML-U"). In Panel B portfolio returns are further adjusted by the CAPM, in Panel C by the Fama-French-Carhart 4-factor model (FFC), in Panel D by the Fama-French 6-factor model (FF6). Table B.2 provides detailed definitions for each variable. Newey-West adjusted t-statistics are shown in parentheses. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

	Panel A: Return						**Panel B: CAPM-Adjusted Return**					
ESG Rating^{ALL}	ESG Uncertainty^{ALL}						ESG Uncertainty^{ALL}					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	1.219***	0.997***	1.178***	0.848**	0.731*	0.995***	0.134	-0.027	0.155	-0.142	-0.276	-0.049
	(3.03)	(2.84)	(3.29)	(2.16)	(1.94)	(2.70)	(0.81)	(-0.16)	(0.76)	(-0.77)	(-1.34)	(-0.37)
2	1.079***	1.026***	1.164***	0.993***	0.794**	0.846**	0.045	0.006	0.193	-0.009	-0.163	-0.147
	(2.89)	(2.69)	(3.37)	(2.68)	(2.01)	(2.46)	(0.33)	(0.03)	(1.17)	(-0.06)	(-0.87)	(-1.32)
3	1.009***	1.028***	1.168***	1.165***	1.090***	1.019***	0.007	0.005	0.144	0.197	0.216	0.079
	(2.63)	(2.83)	(3.17)	(3.51)	(3.34)	(3.12)	(0.05)	(0.03)	(0.91)	(1.62)	(1.35)	(0.93)
4	1.055***	0.543	1.183***	0.893**	1.001***	1.045***	0.115	-0.429***	0.197	-0.082	0.050	0.118*
	(3.13)	(1.54)	(3.19)	(2.56)	(2.91)	(3.48)	(0.80)	(-3.07)	(1.12)	(-0.68)	(0.31)	(1.77)
High	0.697**	0.774**	0.872***	1.146***	1.030***	0.816***	-0.177	-0.125	-0.050	0.198	0.203	-0.085
	(2.08)	(2.41)	(2.83)	(3.56)	(3.62)	(2.63)	(-1.44)	(-1.10)	(-0.44)	(1.48)	(1.57)	(-1.45)
LMH-R	0.522**	0.223	0.306	-0.298	-0.299	0.179	0.311	0.098	0.204	-0.340	-0.480**	0.037
	(2.32)	(1.08)	(1.34)	(-1.23)	(-1.29)	(1.12)	(1.40)	(0.42)	(0.82)	(-1.27)	(-1.99)	(0.21)
ESG Rating^{ALL}	ESG Uncertainty^{ALL}						ESG Uncertainty^{ALL}					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	0.830**	0.789**	1.035***	1.001***	0.954***	0.124	-0.072	-0.150*	0.071	0.049	0.079	0.150
	(2.51)	(2.46)	(3.28)	(3.18)	(3.24)	(0.90)	(-0.83)	(-1.94)	(0.93)	(0.75)	(0.92)	(1.04)

	Panel C: FFC-Adjusted Return						**Panel D: FF6-Adjusted Return**					
ESG Rating^{ALL}	ESG Uncertainty^{ALL}						ESG Uncertainty^{ALL}					
	Low	2	3	4	High	All	Low	2	3	4	High	All
Low	0.154	-0.007	0.165	-0.154	-0.288	-0.037	0.175	-0.007	0.179	-0.211	-0.333	-0.040
	(1.00)	(-0.05)	(0.87)	(-0.82)	(-1.38)	(-0.29)	(1.14)	(-0.05)	(0.95)	(-1.14)	(-1.59)	(-0.33)
2	0.075	0.030	0.162	0.024	-0.152	-0.143	0.123	0.103	0.203	-0.010	-0.106	-0.132
	(0.54)	(0.15)	(1.03)	(0.16)	(-0.78)	(-1.25)	(0.92)	(0.57)	(1.22)	(-0.07)	(-0.53)	(-1.12)
3	0.032	0.038	0.130	0.221*	0.189	0.083	0.046	0.073	0.124	0.254**	0.190	0.057
	(0.24)	(0.23)	(0.86)	(1.93)	(1.21)	(1.02)	(0.32)	(0.44)	(0.83)	(2.15)	(1.21)	(0.64)
4	0.136	-0.411***	0.261	-0.038	0.087	0.140**	0.106	-0.371**	0.255	-0.060	0.127	0.155**
	(0.98)	(-2.84)	(1.48)	(-0.31)	(0.53)	(2.06)	(0.73)	(-2.49)	(1.42)	(-0.46)	(0.75)	(2.26)
High	-0.200*	-0.087	-0.033	0.260*	0.172	-0.080	-0.180	-0.064	-0.085	0.209	0.119	-0.086*
	(-1.76)	(-0.81)	(-0.29)	(1.91)	(1.30)	(-1.55)	(-1.58)	(-0.60)	(-0.74)	(1.38)	(0.96)	(-1.66)
LMH-R	0.354*	0.080	0.198	-0.414	-0.460*	0.043	0.354*	0.057	0.264	-0.420	-0.452**	0.046
	(1.75)	(0.40)	(0.88)	(-1.50)	(-1.89)	(0.27)	(1.74)	(0.28)	(1.20)	(-1.44)	(-1.99)	(0.30)
ESG Rating^{ALL}	ESG Uncertainty^{ALL}						ESG Uncertainty^{ALL}					
	Low	2	3	4	High	HML-U	Low	2	3	4	High	HML-U
All	-0.080	-0.125*	0.089	0.083	0.065	0.145	-0.062	-0.100	0.052	0.026	0.046	0.108
	(-0.98)	(-1.72)	(1.14)	(1.28)	(0.76)	(1.04)	(-0.75)	(-1.41)	(0.68)	(0.39)	(0.52)	(0.75)

Table B.8: ESG Rating, Uncertainty, and Stock Returns: Alternative Definition for ESG Rating and Uncertainty

This table presents the results of the following monthly Fama-MacBeth regressions, as well as their corresponding Newey-West adjusted t-statistics:

$$Perf_{i,m} = \alpha_0 + \beta_1 ESG_{i,m-1} + \beta_2 ESG_{i,m-1} \times Low\ ESG\ Uncertainty_{i,m-1} + \beta_3 Low\ ESG\ Uncertainty_{i,m-1} + \boldsymbol{\beta}_4' \boldsymbol{M}_{i,m-1} + e_{i,m},$$

where $Perf_{i,m}$ refers to the excess return (models 1 to 4) or CAPM-adjusted return (models 5 to 8) of stock i in month m, $ESG_{i,m-1}$ refers to the ESG rating measured by ESG^{ALL}, $Low\ ESG\ Uncertainty_{i,m-1}$ refers to a dummy variable that takes a value of 1 if the ESG rating uncertainty measured by $ESG\ Uncertainty^{ALL}$ is in the bottom quintile across all stocks in that month and 0 otherwise. The vector $\boldsymbol{M}$ stacks all other control variables, including the Log(Size), Log(BM), 6M Momentum, Log(Illiquidity), Gross Profitability, Corporate Investment, Leverage, Log(Analyst Coverage) and Analyst Dispersion. Table B.2 provides detailed definitions for each variable. Numbers with "*", "**", and "***" are significant at the 10%, 5%, and 1% levels, respectively.

Stock Returns Regressed on Lagged ESG Rating and Uncertainty

	Excess Return				CAPM-Adjusted Return			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
ESG^{ALL}	0.002	0.110	0.003	0.137	0.048	0.161	0.110	0.247
	(0.02)	(0.81)	(0.02)	(0.80)	(0.29)	(1.14)	(0.59)	(1.48)
$\text{ESG}^{\text{ALL}} \times \text{Low ESG Uncertainty}^{\text{ALL}}$			-0.071	-0.138			-0.221*	-0.275**
			(-0.60)	(-0.95)			(-1.74)	(-2.23)
$\text{Low ESG Uncertainty}^{\text{ALL}}$			0.117	0.128			0.175	0.174*
			(1.38)	(1.22)			(1.62)	(1.67)
Log(Size)	-0.100	-0.038	-0.101	-0.036	-0.045	0.109	-0.043	0.111
	(-1.31)	(-0.28)	(-1.29)	(-0.27)	(-0.59)	(0.73)	(-0.56)	(0.74)
Log(BM)	0.000	0.009	-0.001	0.010	-0.022	0.019	-0.024	0.018
	(0.01)	(0.19)	(-0.01)	(0.21)	(-0.20)	(0.18)	(-0.22)	(0.18)
6M Momentum	0.334	0.188	0.328	0.188	0.274	0.106	0.272	0.108
	(0.79)	(0.43)	(0.77)	(0.43)	(0.59)	(0.23)	(0.58)	(0.23)
Log(Illiquidity)		0.056		0.058		0.103**		0.103**
		(1.04)		(1.08)		(2.20)		(2.21)
Gross Profitability		0.179		0.189		0.355*		0.363*
		(1.05)		(1.13)		(1.90)		(1.94)
Corporate Investment		0.036		0.034		-0.007		-0.010
		(0.65)		(0.61)		(-0.12)		(-0.16)
Leverage		-0.037		-0.036		-0.035		-0.034
		(-0.80)		(-0.80)		(-0.76)		(-0.76)
Log(Analyst Coverage)		-0.020		-0.023		-0.174		-0.178
		(-0.16)		(-0.19)		(-1.45)		(-1.49)
Analyst Dispersion		-0.536***		-0.545***		-0.828***		-0.834***
		(-2.74)		(-2.75)		(-4.32)		(-4.24)
Constant	2.308*	1.812	2.299*	1.788	0.596	-0.535	0.530	-0.597
	(1.79)	(1.10)	(1.72)	(1.07)	(0.45)	(-0.28)	(0.39)	(-0.30)
Obs	283,671	254,873	283,671	254,873	272,728	245,451	272,728	245,451
R-squared	0.046	0.080	0.048	0.082	0.043	0.076	0.045	0.078