Climate-triggered institutional price pressure:Does it affect firms' cost of equity?

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Abstract

We document that climate-triggered institutional portfolio rebalancing affects S&P 500 firms' cost of equity through climate change price pressure (CCPP). Using a demand-based asset pricing framework, we estimate firm-level CCPP from physical and transition exposures over 2005–2021. A one-standard-deviation intensification of CCPP raises the cost of equity by up to 6% of its average, with banks and insurers as the main drivers. Yet firms do not subsequently improve environmental performance, indicating that the statistically significant effect of CCPP on cost of equity is ineffective to alter corporate behavior. Our CCPP metrics can help policymakers and investors design targeted environmental strategies.

JEL classification: G11; G12; G13; G18; G31; G38; Q54; Q55

Keywords: Climate exposures; Cost of equity; Institutional price pressure; Corporate environmental profiles

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1 Introduction

There is an ongoing debate over whether shareholder engagement (voice) or stock divestment—defined as underweighting or exiting a stock—is effective in influencing firms' environmental policies and making them greener. Although most existing evidence supports the engagement channel, research on the divestment channel remains limited.[1] Recently, Berk and van Binsbergen (2025) (BB hereafter) find that divestment does not affect firms' cost of equity and, therefore, cannot compel firms to become greener. In contrast, Zerbib (2022) and Pastor et al. (2024) show that the BB results are sensitive to the model specification and parameter values. Similarly, Atta-Darkua et al. (2023) find that divestment affects firms' cost of equity when calibrating the BB model to a different dataset, yet it still does not induce greener behavior. Given this important and unsettled debate, we revisit the effects of divestment using a micro-founded, demand-based asset pricing framework with heterogeneous investors. This approach explicitly links investor portfolio rebalancing to stock price movements, providing a more nuanced view of how different types of investors affect the market. Our framework differs from BB, who apply a Capital Asset Pricing Model (CAPM) setting with homogeneous investors (mutual funds) and do not incorporate these microeconomic mechanisms.

We address four central and interrelated open questions. Does institutional portfolio rebalancing triggered by firm-level climate change exposures affect firms' cost of equity? If so, does it affect firms' future environmental profiles? Are physical or transition exposures more important for these effects? Which types of institutional investors drive them? We revisit these questions through the lens of *climate change price pressure* (CCPP)—stock price pressure arising from institutional portfolio rebalancing in response to firm-level climate change exposures. To our knowledge, this is the first study to analyze these questions within a unified framework, placing CCPP at the core of the analysis. Our study adopts a broader perspective than Noh et al. (2023), who examine the effects of CCPP on firms' future environmental

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[1] Recent studies showing that engagement leads to greener firms include Azar et al. (2021), Naaraayanan et al. (2021), Dimson et al. (2023), and Kahn et al. (2023). Broccardo et al. (2022) show that voice can achieve the socially optimal plan more easily than exit, and Edmans et al. (2023) argue that exit deprives polluting companies of any incentive to improve, as investors refusing to hold brown stocks eliminate potential pressure for reform.

profiles. Since any impact of CCPP on firms' cost of equity constitutes a channel for potential real economic effects, understanding this relationship is critical.

We derive a closed-form expression for the stock-specific CCPP within the Koijen and Yogo (2019) demand-based asset pricing framework, which is a natural choice for our analysis for two reasons. First, in equilibrium, each investor's optimal portfolio weight depends on stock characteristics that affect expected returns and risks. By incorporating firm-level climate change exposures as a stock characteristic, we derive a formula for CCPP that measures, at a given point in time, the percentage change in the equilibrium stock price resulting from a one-standard-deviation change in climate change exposures, holding all else constant. Second, the model accounts for heterogeneous investor responses to climate change exposures, as investors may perceive their effects on expected returns and risks differently.[2]

The CCPP formula holds in equilibrium and, therefore, incorporates the heterogeneous characteristics of *all* investors, including the sensitivities of their portfolio weights to changes in climate change exposures, stock ownership, and demand elasticities. CCPP exhibits two key properties. First, its magnitude is larger (smaller) for stocks held by investors with lower (higher) demand elasticity. Second, CCPP is negative (positive) when most investors underweight (overweight) a stock in response to an increase in climate change exposures.

We estimate alternative stock-specific CCPP measures stemming from physical and transition climate exposures, motivated by prior evidence on the heterogeneous effects of different types of climate change risks on stock prices (Faccini et al. (2023), Sautner et al. (2023b)). We proxy firm-level climate change exposures using the four textual measures of Sautner et al. (2023a)—total, physical, opportunity, and regulatory—extracted from firms' earnings conference calls, from which we derive four corresponding CCPP measures. We estimate each CCPP measure quarterly for each S&P 500 constituent stock from Q1 2005 to Q4 2021, using Thomson Reuters Institutional (13F) portfolio holdings of U.S. stocks. The pooled average CCPP is negative. For example, an increase of one standard deviation in total climate change exposures decreases the average stock's price by 7.9%.

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[2] For example, one investor may perceive a rise in regulatory climate risk exposure for a polluting energy firm as increasing its risk and thus underweight the stock, whereas another may interpret the same exposure—if the firm is also a green technology innovator (Cohen et al. (2020))—as enhancing expected returns and overweight it.

Next, we use panel regressions to examine the effect of each CCPP measure on the corresponding firm's cost of equity over alternative horizons. These regressions test whether stocks that are riskier—because their prices are more sensitive to increases in climate change exposures and the resulting decline in climate-triggered institutional demand, i.e., stocks with more negative CCPP—offer higher expected returns. Instead of relying on realized returns, we estimate firms' cost of equity using the option-based measures of expected excess returns proposed by Martin and Wagner (2019) and Chabi-Yo et al. (2023). These are real-time, forward-looking, and market-based measures. As such, they circumvent the limitation that inferences about expected returns based on realized returns may lack informativeness, provide timely updates to the cost of equity, and avoid the noise present in accounting-based alternatives (Kim (2022), Pástor et al. (2022)).[3]

We document that CCPP has a negative and statistically significant effect on firms' cost of equity, confirming the testable prediction regarding the relation between CCPP and expected returns. Firms' cost of equity rises as their stock CCPP becomes more negative in almost all cases, regardless of the option-implied measure or the type of climate change exposure driving CCPP. For example, a one-standard-deviation decrease in CCPP stemming from total climate change exposures lowers the option-implied Martin and Wagner (2019) cost of equity by 3% of the average monthly cost of equity. These effects prevail across different horizons, with the strongest impact observed one quarter ahead—by up to 6% of the respective average costs of equity for CCPP arising from opportunity exposures. At the aggregate level, banks and insurance companies are the largest contributors to CCPP, with banks responding primarily to opportunity and regulatory exposures, and insurance companies to physical exposures, through portfolio adjustments. Principles for Responsible Investment (PRI) signatories contribute more to CCPP than non-signatories. In line with the Koijen and Yogo (2019) model, we find that *individual* investors respond heterogeneously to increases in climate change exposures, with

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[3] Our choice of sample and period ensures high-quality data for both climate change exposures and cost of equity measures by minimizing missing observations. S&P 500 index constituent stocks are optionable and their equity options are highly liquid, providing rich informational content to estimate firms' cost of equity, as documented in prior studies (see e.g., Kostakis et al. (2011), Faccini et al. (2019), Kim (2022), Sautner et al. (2023b)). In addition, S&P 500 constituent stocks account for approximately 80% of the total market capitalization of U.S. public companies.

some underweighting and others overweighting their stock positions, thereby taking the opposite side of the trade.

Next, we use panel regressions to examine whether CCPP affects firms' future environmental profiles, proxied by green patents, environmental expenditures, environmental provisions, self-reported environmental fines, and carbon emission intensities. Firms can improve their future environmental profiles to mitigate the effect of CCPP on their cost of equity only if the benefits outweigh the costs of such reforms (Heinkel et al. (2001), Edmans et al. (2023)). We find that CCPP does not significantly affect firms' future environmental profiles, and this insignificance persists even over longer horizons. Additional robustness tests—including alternative measures of firms' future environmental profiles, price pressure from market-wide climate change risks, and differential effects of CCPP on brown versus green firms—confirm these findings. These results suggest that, although CCPP has a statistically significant effect on firms' cost of equity, it does not affect their environmental corporate decision-making. This finding aligns with Edmans et al. (2025), who argue that even a 50-basis-point change in the cost of equity is relatively small. Our conclusion echoes that of Atta-Darkua et al. (2023) and BB: divestment at current levels is insufficient to induce firms to alter their environmental profiles. Assessing how large CCPP must be to influence environmental outcomes is non-trivial, as it requires weighing the benefits of mitigating a higher cost of equity against the costs of reforms. These reforms may involve tangible assets (e.g., changes in production processes) and intangible ones (e.g., corporate culture, organizational structures, and labor relations), with the intangible costs being particularly difficult to quantify. From a social welfare perspective, achieving the social optimum requires that the CCPP raises a firm's cost of equity in proportion to its carbon emission intensities (Pedersen (2025)). Yet even in this case, corporate reforms will occur only if the benefits of adjustment exceed the associated costs.

Related literature and contributions. Our paper contributes to the empirical literature on whether firms' cost of equity and future environmental profiles are affected by institutional investors' portfolio rebalancing in response to climate change risks. Berg et al. (2022), Gantchev et al. (2022), Noh et al. (2023), and Choi et al. (2024) find that divestment by sustainable institutional investors lowers stock prices—interpreted as evidence of an increased cost of equity, and van der Beck (2023) reports that capital flows into ESG funds are positively correlated with future realized returns of ESG stocks.

However, BB find no effect of divestment by mutual funds. In contrast, Pastor et al. (2024) show that BB's results are sensitive to the assumed parameter values and should not be generalized. Consistent with this, Atta-Darkua et al. (2023) find that divestment affects the cost of equity after recalibrating BB's model using a different dataset. Moreover, Zerbib (2022) reports that divestment from sin stocks can raise their cost of equity by up to 10% relative to non-sin stocks. Similarly, the evidence on whether a negative CCPP improves firms' future environmental profiles is mixed. Some studies find that explicit (model-based, Noh et al. (2023)) or implicit CCPP measures affect firms' future emissions and E&S scores.[4] However, other studies report no such effects (Berg et al. (2022), Atta-Darkua et al. (2023), Heath et al. (2023)).

Our main contribution to the literature is threefold. First, we *directly* examine how climate-triggered institutional portfolio rebalancing affects firms' cost of equity and environmental profiles. We use a closed-form, theoretically grounded stock-level CCPP measure that captures both investors' heterogeneous rebalancing activities and their stock ownership structures. Second, our cost-of-equity measure is forward-looking, unlike realized return measures, which may provide limited information about expected returns. Third, by analyzing the effects of CCPP on both firms' cost of equity and environmental profiles within a unified framework, we provide an economic metric to assess whether CCPP can promote climate adaptation.

Noh et al. (2023) and Sautner et al. (2023b) are the studies most closely related to ours. Noh et al. (2023) calculates CCPP within the Koijen and Yogo (2019) framework using climate change risks measured by 'hard' information, such as E scores, carbon emissions, and green patents. They find that investor pressure for sustainability predicts firms' future environmental performance, although the effect is small. We take a step back and focus on the impact of CCPP on the cost of equity,

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[4] Implicit CCPP measures in this literature include those based on stock price impacts (Gibson et al. (2021)), stock valuations (Choi et al. (2024)), and stock returns (Hwang et al. (2021), Gantchev et al. (2022)), among others.

a channel through which CCPP may influence a firm's future environmental profile. Moreover, we calculate CCPP using 'soft' information derived from exchanges between managers and analysts on climate change exposures. These data capture insights beyond firm-level exposure measures based on 'hard' information and allow us to distinguish between different dimensions of climate change risk. Sautner et al. (2023b) find that climate change exposures are priced in the cross-section of S&P 500 stock returns, using the same textual factors and option-based measures of expected returns employed in our analysis. We complement their study by proposing CCPP as an alternative economic channel for these findings.

2 Theoretical model

We review the Koijen and Yogo (2019) demand-based asset pricing setting and extend it by including firm-level climate change exposures. We derive the model-based, stock-level CCPP and discuss its properties and estimation.

2.1 Characteristics-based portfolio weights

Consider an economy with I investors, indexed by i=1,..., I and N assets indexed by n=1,.., N. Each investor is endowed with wealth $A_{i,t}$ at t. One of the investors is the household, assumed to hold the remaining shares of each stock not held by institutional investors at t. At t, the investor i allocates her wealth across the assets in her investment universe set, $\mathcal{N}_{i,t} \subseteq \{1, \ldots, N\}$, and an outside asset, indexed by $n = 0$. We identify outside assets applying the criteria in Koijen and Yogo (2019) who show that in market equilibrium, the optimal portfolio weight of the investor i in the nth stock at t is given by:

$$\forall i, t: \quad \frac{w_{i,t}(n)}{w_{i,t}(0)} = \exp\left\{\beta_{0,i,t} me_t(n) + \boldsymbol{\beta}'_{1,i,t} \mathbf{x}_t(n) + \beta_{2,i,t}\right\} \epsilon_{i,t}(n), \tag{1}$$

where $me_t(n)$ denotes the log market equity, $\mathbf{x}_t(n)$ is the vector of other stock characteristics, including the log book equity, market beta, profitability, investment, and dividend-to-book equity, and the error term captures investor i's demand for unobserved characteristics of asset n (latent demand).

Given that firm-level climate change exposures are informative about expected returns and risks (Sautner et al. (2023b)), we extend the set of characteristics in equation (1) by adding firm-level climate change exposures,

$$\forall i, t: \quad \frac{w_{i,t}(n)}{w_{i,t}(0)} = \exp\left\{\beta_{0,i,t} me_t(n) + \beta_{1,i,t} cc_t(n) + \boldsymbol{\beta}'_{2,i,t}\mathbf{x}_t(n) + \beta_{3,i,t}\right\}\epsilon_{i,t}(n), \quad (2)$$

where $cc_t(n)$ denotes the climate change exposures of stock n at t. $\beta_{1,i,t}$ captures how investor i rebalances her portfolios with respect to firm-level climate change exposure and $\beta_{0,i,t}$ negatively relates to the demand elasticity of the number of shares held by investor i with respect to the stock price (Koijen and Yogo (2019)). $\beta_{1,i,t}$ varies across investors because of their different views on the assumed association of expected returns and risks with stock characteristics. An investor would overweight (underweight) a stock, if an increase in firms' climate change exposures is perceived to be positively (negatively) related to expected returns or negatively (positively) related to risks.[5]

2.2 Stock-level pressure: The model-based measure

The stock-level CCPP captures how institutional portfolio rebalancing triggered by firms' climate change exposures affects equilibrium stock prices, assuming ceteris paribus. To fix ideas, stock n's $CCPP_t(n)$ computed at t is the partial derivative of the equilibrium log stock price $p_t(n)$ of firm n with respect to a change of one standard deviation in its climate change exposures from one state of the world to another (we cross-sectionally standardize the climate change exposures)

$$CCPP_t(n) \equiv \frac{\partial p_t(n)}{\partial cc_t(n)} = \frac{\sum_i s_{i,t}(n)\beta_{1,i,t}\left(1 - w_{i,t}(n)\right)}{1 - \sum_i s_{i,t}(n)\beta_{0,i,t}\left(1 - w_{i,t}(n)\right)}, \quad (3)$$

where $p_t(n) = \log(P_t(n))$, and $s_{i,t}(n) = A_{i,t}w_{i,t}(n)/\sum_{i=1}^{I} A_{i,t}w_{i,t}(n)$ is the proportion of the total market capitalization held by investor i for stock n at t (that is, investor i's ownership of stock n at t). Appendix A.1 provides the proof of equation

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[5] Adding climate change exposures as a determinant of portfolio weights is also consistent with the literature which documents that climate change risks, proxied by ESG scores and carbon emissions, affect institutional investors' investments, measured by institutional portfolio holdings (e.g., Alok et al. (2020), Pástor et al. (2023)), or by institutional ownership (e.g., Fernando et al. (2017), Pedersen et al. (2020), Bolton and Kacperczyk (2021), Berg et al. (2022), Gantchev et al. (2022), Choi et al. (2024)).

(3).

Equation (3) is a comparative static and holds in market equilibrium, hence, it takes into account the heterogeneous actions of all investors. It shows that the CCPP of stock n equals the ownership-weighted sum of the coefficients $\beta_{1,i,t}$ divided by one minus the ownership-weighted sum of the coefficients $\beta_{0,i,t}$. The denominator in equation (3) is the aggregate demand elasticity of the total number of shares held by all investors with respect to the stock price (Koijen and Yogo (2019)). Therefore, CCPP is determined by two effects. First, investors adjust their portfolio weights in response to changes in firm-level climate change exposures, an effect captured by $\beta_{1,i,t}$. Second, this shift in demand induces a stock price response, governed by $\beta_{0,i,t}$. The higher (lower) the investor's demand elasticity, the smaller (larger) the stock price change for a given change in demand.

Hence, CCPP has two properties. First, its magnitude is larger for stocks held by investors with a lower demand elasticity, consistent with Broccardo et al. (2022), Gantchev et al. (2022), and van der Beck (2023). Second, CCPP can take positive or negative values, depending on the sign of the numerator in equation (3). The denominator is strictly positive under the restriction $\beta_{0,i,t} < 1$, which ensures a unique market-clearing equilibrium (Koijen and Yogo (2019)). If most investors underweight (overweight) stock n in response to higher climate exposures—that is, when $\beta_{1,i,t}$ is negative (positive)—the stock experiences a negative (positive) CCPP.

To estimate CCPP, we estimate equation (2) for each investor at any t by applying the generalized method of moments to her cross-sectional stock holdings. To address the endogeneity issue that arises from the correlation between the stock's market equity and latent demand, we construct, for each t, the Koijen and Yogo (2019) stock- and investor-specific instrument, $\widehat{me}_{i,t}(n)$, namely the log market equity of stock n as if all other investors (excluding i) held equal-weighted portfolios within their investment universe.

3 Data and variables

3.1 Institutional stock holdings

We obtain quarterly data on U.S. exchange-traded stock holdings of institutional investors from the Thomson Reuters Institutional (13F) Holdings database (s34) via Wharton Research Data Services (WRDS) from Q1 2005 to Q4 2021. About 91% of the 13F filers are U.S. investors. Among foreign filers, most are from Canada and the UK. We follow the investor classifications in Koijen and Yogo (2019): banks, insurance companies, investment advisors (including brokerage firms and hedge funds), mutual funds, pension funds, other institutional investors (including university endowments and foundations), and 'households'. In total, there are 10,420 (9,215) different 13F investors (once small investors are grouped as 'household').

3.2 Firms' climate change exposures

We proxy firm-level total, opportunity, regulatory, and physical climate change exposures using the respective textual measures of Sautner et al. (2023a), extracted from quarterly earnings conference call transcripts. The data are available on the authors' website.[6] Opportunity exposures arise from the transition from polluting to green technologies. Regulatory exposures capture costs associated with climate policies or regulatory changes. Physical exposures reflect the adverse effects of physical climate events. Each measure captures the share of manager-analyst conversations on the respective climate change topics during the firm's earnings conference call, with higher (lower) values indicating more (less) attention to that topic. We follow Sautner et al. (2023b) to process the data (see Internet Appendix IA.1), and employ their total and topic-based climate change exposures data for Q1 2005-Q4 2021, and Q1 2008-Q4 2021, respectively.

3.3 Option-implied firm-level cost of equity

We estimate the cost of equity (risk premium) for S&P 500 constituent firms using two alternative option-implied measures: Martin and Wagner (2019) (MW) and

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[6] https://osf.io/fd6jq/.

Chabi-Yo et al. (2023) (GLB), across multiple horizons (1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year). Internet Appendix IB describes how we calculate the MW measure using daily implied volatility data from S&P 500 constituent stock options and S&P 500 index options, obtained from the Volatility Surface in the IvyDB U.S. OptionMetrics database. GLB data are obtained from the authors' website.[7]

3.4 Firms' green activities and carbon emissions

We extract each firm's annual patents from the Kogan et al. (2017) Google patent database and identify green patents using the updated 2022 version of the Haščič and Migotto (2015) OECD classification system.[8] If a patent's Cooperative Patent Classification (CPC) code matches any code in the OECD-CPC list, we classify the patent as green. Based on the identified green patents, we construct three firm-year variables: (i) the number of green patents, (ii) the ratio of green patents scaled by the log of firm market value, and (iii) the economic value of green patents, following prior literature (e.g., Cohen et al. (2020), Sautner et al. (2023a)). We obtain annual firm-level data from Refinitiv on green expenditures, environmental provisions, and self-reported environmental fines, scaling each variable by total assets and treating missing values as zeros. We obtain annual data on firms' carbon intensities (Scope 1 and 2) from Trucost. We lag the carbon intensity data by one year when merging it with stock characteristics via CUSIP identifiers, due to the one-year delay in reporting carbon emissions. Appendix B.1 describes the green variables.

3.5 Stock data and characteristics

We obtain monthly data on stock prices, returns, dividends, and shares outstanding for U.S. common stocks trading on the NYSE, AMEX, and NASDAQ from the CRSP Monthly Stock Database. Accounting data are obtained from the Compustat North America Fundamentals Quarterly and Annual Databases. To merge CRSP with Compustat data, we lag Compustat observations by 6 to 18 months to ensure that accounting information is available as of the trading date. Appendix B.1

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[7] https://osf.io/7xcqw/.

[8] Data are available at https://github.com/KPSS2017 and https://data-explorer.oecd.org.

provides definitions of the stock characteristic variables. We keep quarter-end observations to merge firm-level climate change exposure data with stock characteristics data using GVKEY identifiers. We merge option data with stock characteristics via the WRDS Option Metrics CRSP Link Table. We match institutional stock holdings with stock characteristics data via the CUSIP identifiers. Following Koijen and Yogo (2019), each quarter we winsorize each stock characteristic, including climate change exposures, but excluding log market equity and log book equity, at the 2.5th and 97.5th percentiles of the respective stocks' cross-sectional distributions.

4 Empirical analysis

4.1 Stock-level CCPP: Estimation

For each quarter, we estimate the stock-level CCPP (equation (3)) for each S&P 500 constituent stock. We estimate equation (2) separately for the total and three topic-based climate change exposures using the full sample of U.S. common stocks. The estimation is done by quarter and by investor to obtain the investor-specific, time-varying coefficients $\beta_{1,i,t}$ and $\beta_{0,i,t}$, with an average of 3,356 investors per quarter.[9] Table 1 reports the pooled summary statistics for the estimated stock-level CCPP of S&P 500 constituent stocks, arising from total and topic-based climate change exposures.

[Table 1 about here.]

CCPP exhibits substantial heterogeneity across climate change exposure measures, stocks, and quarters. The variation is largest for total CCPP and smallest for physical CCPP. Consistent with the CCPP properties discussed in Section 2.2, CCPP takes both positive and negative values, with the vast majority being negative. For instance, unreported summary statistics indicate that only 15% of CCPP observations are positive for total climate change exposures. A one-standard-deviation increase in total exposures can lower (raise) stock prices by up

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[9] Following Koijen and Yogo (2019), we estimate the model quarterly for each investor holding more than 1,000 stocks. On average, there are 105 such investors per quarter. The remaining investors are grouped each quarter by type and AUM, with each group holding on average 2,000 stocks. There are on average 180 groups per quarter, with 17 investors per group. Following Koijen et al. (2024), we cross-sectionally standardize all stock characteristics except log market equity and log book equity.

to 39% (16%). Although extreme values may appear large—since they correspond to a one-standard-deviation change in climate exposures—average CCPP values are substantially smaller.

An increase of one standard deviation in total (or physical) climate change exposures lowers the average stock price by 7.9% (or 2.7%). The average magnitude of CCPP is comparable to that of the sustainability price pressure measure in Noh et al. (2023) (their Table A4), which is based on hard sustainability information over 2013–2021. The size of CCPP is consistent with an inelastic stock market. For each stock-quarter observation, we estimate the elasticity of aggregate demand using investor-specific coefficients on log market equity from equation (2) and individual investor ownership. The pooled average elasticity for 2005-2021 is 0.29, close to the pooled estimates in Koijen and Yogo (2019) (0.3) and Gabaix and Koijen (2022) (0.2).

Figure 1, Panels (a)-(d) (left axis), plots the cross-sectional average CCPP of S&P 500 constituent stocks over time, arising from total, opportunity, regulatory, and physical exposures, respectively. CCPP is negative for most of the period, regardless of exposure type. Notably, there is a downward trend from 2008 to 2016, which reverses after 2016.

[Figure 1 about here.]

The sign and pattern of the average CCPP can be explained by investors' portfolio rebalancing activities, consistent with the theoretical properties of the CCPP formula (equation (3)). Figure 1, Panels (a)–(d) (right axis), plots the cross-sectional average of the estimated investor sensitivity coefficients, $\beta_{1,i,t}$ from equation (2), capturing portfolio-weight responses to total, opportunity, regulatory, and physical exposures, respectively. Portfolio weights of the average investor respond less to changes in climate exposures over 2016–2020 compared to the pre-2016 period. The former period spans the end of Barack Obama's second term (November 2012–November 2016) and Donald Trump's first term (January 2017–January 2021), both signaled a relaxation in regulatory climate pressures. This may have reduced investors' incentives to underweight stocks with high climate exposures. Given this relaxation in climate regulation, it is unsurprising that the physical

CCPP exhibits a similar time-series pattern. The unreported Spearman (Pearson) correlation between physical and regulatory climate exposures is 0.26 (0.18). Firm-level physical exposures induce portfolio rebalancing when mapped to regulatory exposures. Notably, CCPP appears to intensify again in 2021, coinciding with the Biden administration's early actions to address climate change.[10]

4.2 Effects on firms' cost of equity

We investigate whether investor portfolio rebalancing triggered by climate change exposures affects firms' cost of equity. To do so, we employ a stock-level CCPP channel that captures the price impact of such rebalancing. Firms with more negative CCPP are riskier: they face larger price declines from potential increases in climate exposures and the resulting reductions in institutional demand. Consequently, investors require higher expected returns as compensation for holding these stocks. We test the hypothesis of a negative relation between expected returns and CCPP by estimating contemporaneous panel regressions of firms' option-implied cost of equity on their CCPP and controls:

$$CoE_{t,h}(n) = \alpha + \beta_1 CCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t,h}(n), \tag{4}$$

where $CoE_{t,h}(n)$, is the MW or GLB option-implied cost of equity for stock n at t for horizons h=1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year. We separately consider stock-level CCPP from total, opportunity, regulatory, and physical exposures. The vector of controls, $\mathbf{X}_t(n)$, log market equity, market beta, book-to-market ratio, profitability, investment, dividends-to-book equity, firm-level climate change exposure, momentum, and institutional ownership. We also include year-quarter (δ_t) and industry (ϕ_j) fixed effects.

Our regression specification is analogous to regressions of the cost of equity on implicit measures of price pressure proxied by institutional trading—such as fund

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[10] During Obama's second term, no major climate legislation passed through Congress due to the lack of a Democratic majority in both the House and Senate after 2014. Under Trump, Scott Pruitt—a prominent climate change skeptic—was appointed EPA head in 2016, and the U.S. withdrew from the Paris Agreement (announced 2017, effective 2019). In April 2021, Biden set a national target to reduce emissions by 50–52% from 2005 levels by 2030, formalized in an updated Paris Agreement commitment.

flows and trading activity variables (van der Beck, 2023) or institutional ownership (Gompers and Metrick, 2001) and references therein—commonly used in the literature. However, our approach differs in that it provides an *explicit*, rather than an *implicit*, proxy for price pressure by exploiting estimated sensitivity coefficients from a demand-based model.

Table 2 reports the effects of stock-level CCPP on the firm-level cost of equity across horizons ranging from one month to one year. The results support our hypothesis: the CCPP coefficient is negative and statistically significant after accounting for controls. The findings hold across horizons and for all types of climate change exposures, although the evidence is weaker for regulatory CCPP. This implies that on average, a firm's cost of equity rises when its CCPP declines, that is, when CCPP becomes more negative (less positive).[11]

The CCPP coefficients decrease somewhat monotonically as the horizon extends from the short-term to three quarters and one year. In contrast, the economic magnitude of the effect—computed as the impact of a one-standard-deviation change in CCPP relative to the mean cost of equity—exhibits an inverse U-shaped pattern across horizons. For example, a one-standard-deviation decrease in total CCPP lowers the MW annualized monthly cost of equity by about 3% (=0.220%/0.073) of its average, where 0.073 is the average monthly cost of equity reported in Table 1. For the one-quarter and one-year horizons, the monthly MW cost of equity rises by 4% (=0.258%/0.066) and 2% (=0.153%/0.067) of its average, respectively. In general, the economic effect of institutional rebalancing on firms' cost of equity ranges from about 1% to 6%, depending on the horizon and the type of climate change exposure. The effect is somewhat larger when cost of equity is proxied by MW than by GLB, which accounts for the higher-order moments of the risk-neutral distribution of returns. The stronger association between the Koijen and Yogo (2019) CCPP measure and the MW option-implied cost of equity reflects a methodological alignment: both are grounded in a mean-variance framework. By

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[11] To shed more light on this interpretation, we sort firms into two groups based on whether their CCPP is negative or non-negative. We then run panel regressions of firms' option-implied cost of equity on CCPP interacted with the sign indicator of whether the CCPP is negative or non-negative, including the same controls and fixed effects as in equation (4). Unreported results show that the negative relation between the cost of equity and CCPP is driven entirely by firms with negative CCPP, that is, their cost of equity rises as CCPP becomes more negative.

contrast, the weaker relation with GLB likely reflects that CCPP, constructed in a mean-variance setting, captures only the variance component of GLB but not its higher-order moments.

[Table 2 about here.]

The statistically significant effect of CCPP on the cost of equity extends Sautner et al. (2023b), who document a positive correlation between firm-level climate exposures and option-implied cost of equity. Importantly, CCPP remains significant in affecting the cost of equity even after controlling for firm-level climate exposures. Our findings also extend prior evidence that institutional underweighting based on ESG ratings increases firms' cost of equity (e.g., Pedersen et al. (2020), Pástor et al. (2021, 2022), Zerbib (2022), van der Beck (2023)). Finally, our results are consistent with the Bolton and Kacperczyk (2021) divestment hypothesis that carbon-related divestment by institutional investors raises firms' cost of equity.

On the other hand, our findings differ from Berk and van Binsbergen (2025) (BB), who report that divestment has a negligible effect on the firm's cost of equity. Three factors may explain this discrepancy. First, BB employ a CAPM framework with homogeneous investors, whereas we adopt a demand-based framework that allows for investor heterogeneity. Second, BB results are sensitive to the choice of data and investor types. They estimate a negligible 0.44 bps effect by calibrating their model to a subset of the FTSE USA 4 Good Select Index (2015–2020), focusing only on mutual funds. By contrast, Atta-Darkua et al. (2023) apply the BB model to MSCI ACWI stocks over a longer period (2006–2019) and include Climate Disclosure Project investors, finding a significantly larger 15 bps effect. More generally, Pastor et al. (2024) show that depending on the BB parameter values, the cost of equity could rise by up to 24 bps, consistent with our estimates. Third, BB's negligible effect is derived from calibrations to stock index data, whereas we analyze the cross-section of individual stocks. Zerbib (2022) finds that, on average, divestment raises the cost of equity of sin stocks by 10% relative to that of non-sin stocks when individual stocks are considered.

4.3 Which investors contribute to CCPP?

The model-based CCPP formula holds in equilibrium, aggregating information from all investors, and therefore cannot be computed separately by investor type. Nevertheless, we can assess whether the documented CCPP—and its effects on firms' cost of equity—are driven by all investors or specific groups by examining which types of investors rebalance their portfolios in response to climate exposures. For instance, if no investor adjusted holdings when climate exposures changed (i.e. $\beta_{1,i,t} = 0$), CCPP would be zero (equation (3)).

We expect that certain types of investors—such as banks, pension funds, and insurance companies—may be more sensitive to climate change exposures than others, such as investment advisors (brokerage firms) who primarily execute client orders. To test this, we estimate equation (2) separately for each investor type, pooling portfolio weight data on U.S. common stocks across quarters.

[Table 3 about here.]

Table 3 shows a statistically significant negative relation between firm-level total climate exposures and portfolio holdings for banks, insurance companies, and pension funds. Economically, a one-standard-deviation increase in total exposures reduces portfolio holdings by 9.9% for banks, 9.9% for insurance companies, and 5.9% for pension funds. Banks adjust their portfolio holdings the most in response to opportunities and regulatory exposures, consistent with their heightened sensitivity to policy and regulatory changes that affect credit risks and financing conditions. In contrast, insurance companies react more to physical exposures, which aligns with their direct financial vulnerability to climate-related damages and natural disasters. Interestingly, households overweight stocks with higher opportunity and regulatory exposures, while investment advisors show no significant reaction to changes in climate change exposures.

Our findings are consistent with prior evidence that banks and insurance companies incorporate climate change risks into their investment decisions (e.g., Hong and Kacperczyk (2009), Bauer et al. (2021)). By contrast, brokerage firms (a subgroup of investment advisors, see Gompers and Metrick (2001)) do not respond to firms' climate change exposures, as expected, since they execute transactions on behalf of clients and are therefore not directly exposed. Our results also align with evidence that hedge funds (another subgroup of investment advisors) do not engage in socially responsible investing (Hwang et al. (2021), Koijen et al. (2024)).

We extend the above analysis by examining whether investors' heterogeneous portfolio sensitivities to climate change exposures depend on their climate consciousness. Following Gibson Brandon et al. (2022), we classify investors as PRI signatories or non-signatories, both within the full universe of investors and within each investor type (see Appendix C for details). Table 4 reports the results. Panel A shows that portfolio holdings are negatively related to firm-level total climate change exposures for both PRI and non-PRI investors when all investors are considered (columns 1 and 2). However, the magnitude of this relation differs across the two groups. The portfolio demand of PRI investors reacts more strongly to changes in total climate change exposures, thereby contributing more to the documented CCPP. This finding aligns with Pástor et al. (2023), who show that UNPRI signatories tilt their portfolios toward stocks with higher ESG scores. At a more granular level, the pattern also holds within investor types: PRI mutual funds and pension funds respond more to total exposures than their non-PRI counterparts, consistent with Humphrey and Li (2021), who find that PRI mutual funds have lower portfolio emissions. By contrast, the portfolios of non-PRI banks and insurance companies are more sensitive to climate change exposures than those of PRI investors. When examining the dissected climate exposures (Panels B-D), PRI investors react more strongly to opportunity and regulatory exposures than non-PRI investors.

[Table 4 about here.]

A final remark concerns who absorbs the price pressure—that is, which investors take the opposite side of trades when portfolios are adjusted. Table 3 shows that all investor *types*, except households, have negative β_1s, indicating that they *on average* underweight stocks as climate change exposures increase. This should not be interpreted as implying that *every* individual investor within each type has a negative β_1. To investigate this, we estimate β_1 for each *individual* investor by quarter, separately for each type of climate change exposure using equation (2). Figure 2, Panels (a)-(g), presents histograms of the estimated β_1 for all investors and for each investor type with respect to total climate change exposures. There is substantial variation in β_1 across individual investors, ranging from negative to positive values, indicating that some investors underweight while others overweight stocks as climate exposures increase, thereby taking the opposite side of the trade. This heterogeneity aligns with Koijen and Yogo (2019), who document variation in portfolio rebalancing across investors. Unreported results show similar patterns for the dissected climate change exposures.

[Figure 2 about here.]

4.4 Effects on firms' future environmental profiles

It is not clear in advance whether CCPP affects firms' future environmental profiles. Firms would adjust their environmental practices to mitigate the impact of CCPP on their cost of equity only if the benefits exceed the costs of such reforms (Heinkel et al. (2001), Edmans et al. (2023)). We explore this by running the following predictive panel regression,

$$\Delta Y_{t+h}(n) = \alpha + \beta_1 CCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t+h}(n), \tag{5}$$

where $\Delta Y_{t+h}(n)$ is the h-period ahead change in firm n's green activities, proxied separately by (i) number of green filed patents, (ii) ratio of green filed patents to log market equity, (iii) economic real value of green filed patents, (iv) ratio of environmental expenditures to total assets, (v) ratio of environmental provisions to total assets, (vi) ratio of environmental fines to total assets, and (vii) emission intensities. The vector of control variables $\mathbf{X}_t(n)$ follows Sautner et al. (2023a). Green patents capture firms' investments in green innovation and abatement technologies, reflecting actions that could mitigate the impact of CCPP on the cost of equity. Green expenditures, environmental provisions, and self-reported environmental fines allow us to isolate firms' environmental activities from broader items, such as total capital expenditures and overall liabilities, providing a more direct assessment of whether CCPP influences firms' environmental behavior.

Table 5 reports the results for CCPP stemming from total climate change exposures. Firms do not significantly increase their future investment in green technologies or environmental expenditures in response to CCPP. Likewise, provisions for potential environmental liabilities and self-reported environmental fines remain unaffected. We further confirm the robustness of these findings by considering alternative constructions of the Refinitiv green variables, including taking the logarithm of one plus environmental expenditures following Jing et al. (2024), scaling environmental expenditures by log market equity, and leaving missing values unfilled. Across all specifications, the results remain consistent: CCPP—whether stemming from total, opportunity, regulatory, or physical climate change exposures—does not induce firms to increase their environmental investments or activities. Unreported results also support these conclusions when using granted green patents, the alternative European Patent Office Climate Change Mitigation Technologies classification, or green patent variables computed at a quarterly frequency.

[Table 5 about here.]

Our findings suggest that firms do not become greener in response to CCPP, despite facing a higher cost of equity. In a frictionless world, this behavior could be interpreted as suboptimal, since firms would undertake reforms to maximize values. In reality, however, implementing environmental reforms entails costs—both measurable, such as changes in production processes, and non-measurable, such as shifts in the corporate culture and organizational structure. These costs constitute frictions. Consistent with Heinkel et al. (2001) and Edmans et al. (2023), firms' decisions not to improve environmentally could thus be interpreted as the outcome of a cost-benefit analysis rather than suboptimal behavior. Our results imply that the costs of reforms outweigh an increase in the cost of equity of roughly 6% of its average value, as documented in Section 4.2. More generally, while the effect of CCPP on the cost of equity is statistically significant, it is ineffective in influencing corporate decision-making, as it does not induce changes in firms' environmental profiles. This aligns with Edmans et al. (2025), who argue that even a 50-basis-point change in the cost of equity is too small to alter firms' environmental actions. Our conclusion echoes that of Atta-Darkua et al. (2023) and BB: divestment at current levels is insufficient to induce firms to alter their environmental profiles.

5 Further analysis

We conduct additional robustness tests. First, investors may consider market-wide as well as firm-level climate change exposures when rebalancing their portfolios. To capture this, we construct an additional climate change price pressure measure with respect to aggregate (i.e., market-wide) climate change risks, termed $ACCPP$. We examine its effects on firms' cost of equity and future environmental profiles. In Internet Appendix IC, we provide the derivation, the relation between ACCPP and CCPP, and the panel regression results including both CCPP and ACCPP. The results are similar to the baseline analysis: price pressure—whether from aggregate or firm-level exposures—raises the cost of equity but does not induce firms to alter their future environmental profiles.

Second, Hartzmark and Shue (2023) document that changes in firms' cost of capital affect their future environmental performance differently for brown versus green firms. We investigate the relation between CCPP and firms' future environmental profiles separately for brown, neutral, and green firms, and find no significant effects, confirming the evidence in Section 4.4. Internet Appendix Table ID.1. reports these results. The findings remain robust for CCPP stemming from any type of climate change exposure, as well as for ACCPP. Our results differ from Hartzmark and Shue (2023), who find that brown firms increase their future carbon emission intensities following an increase in their cost of capital. This discrepancy may arise because, in their setting, changes in firms' cost of capital are not exclusively tied to sustainable investing and may reflect other factors. In contrast, CCPP-induced changes in the cost of equity in our study are linked solely to sustainable investing.

6 Conclusions and implications

We take a novel approach to *directly* address the open question of whether institutional portfolio rebalancing—driven by firms' physical and transition climate exposures—affects the cost of equity for S&P 500 firms and their future environmental profiles. Our analysis employs a stock-level climate change price pressure (CCPP) channel, derived as a local equilibrium sensitivity within the Koijen and Yogo (2019) framework. CCPP captures the mechanism through which divestment can affect stock prices and expected returns: anticipated selling pressure, even if unrealized today, raises the risk of future price declines, which investors incorporate into expected returns and demand compensation for. We find that, on average, investors underweight firms with high climate change exposures, generating a CCPP that raises the cost of equity by up to 6% of its average. However, this climate-triggered price pressure does not induce firms to improve their environmental performance. This finding is analogous to Duchin et al. (2025), who find that divestment from pollutive plants does not reduce pollution overall.

Our results imply that, at current levels of divestment, CCPP raises firms' equity financing costs without altering their climate-related behavior. This may be because the costs of environmental reforms—spanning tangible assets, corporate culture, and labor relations—outweigh the prospective benefits of a lower cost of equity. This does not imply that the divestment mechanism is ineffective in principle. If more investors were to divest, results could differ. At current divestment levels, investor engagement may be more effective than price pressure in driving corporate reforms. This is particularly concerning given recent exits of major institutional investors from climate coalitions.[12] Finally, policymakers could leverage our CCPP metrics to design targeted environmental regulations, identifying sectors where firms face more negative CCPP—and thus higher cost of equity—to foster corporate investment in sustainability. The sensitivities of portfolio holdings to climate exposures—an integral part of the CCPP—can also indicate whether investors rebalance their portfolios in line with their sustainability commitments (see Internet Appendix IF for an application to the Harvard University Endowment).

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[12] In December 2022, Vanguard left the Net Zero Alliance. Between February and May 2024, State Street, PIMCO, Invesco, J.P. Morgan Asset Management, and Swiss Re exited Climate 100+, while BlackRock withdrew its U.S. business.

References

Alok, S., Kumar, N., and Wermers, R. (2020). Do Fund Managers Misestimate Climatic Disaster Risk. *Review of Financial Studies*, 33(3):1146–1183.

Atta-Darkua, V., Glossner, S., Krueger, P., and Matos, P. (2023). Decarbonizing Institutional Investor Portfolios: Helping to Green the Planet or Just Greening Your Portfolio? Working paper, University of Virginia.

Azar, J., Duro, M., Kadach, I., and Ormazabal, G. (2021). The Big Three and Corporate Carbon Emissions around the World. *Journal of Financial Economics*, 142(2):674–696.

Bauer, R., Ruof, T., and Smeets, P. (2021). Get Real! Individuals Prefer More Sustainable Investments. *Review of Financial Studies*, 34(8):3976–4043.

Berg, F., Heeb, F., and Kölbel, J. F. (2022). The Economic Impact of ESG Ratings. Working paper, Massachusetts Institute of Technology.

Berk, J. B. and van Binsbergen, J. H. (2025). The Impact of Impact Investing. *Journal of Financial Economics*, 164:103972.

Bolton, P. and Kacperczyk, M. (2021). Do Investors Care about Carbon Risk ? *Journal of Financial Economics*, 142(2):517–549.

Broccardo, E., Hart, O., and Zingales, L. (2022). Exit versus Voice. *Journal of Political Economy*, 130(12):3101–3145.

Chabi-Yo, F., Dim, C., and Vilkov, G. (2023). Generalized Bounds on the Conditional Expected Excess Return on Individual Stocks. *Management Science*, 69(2):922–939.

Choi, D., Gao, Z., Jiang, W., and Zhang, H. (2024). Carbon Firm Devaluation and Green Actions. Working paper, The Chinese University of Hong Kong.

Cohen, L., Gurun, U. G., and Nguyen, Q. H. (2020). The ESG-Innovation Disconnect: Evidence from Green Patenting. Working paper, National Bureau of Economic Research.

Dimson, E., Karakaş, O., and Li, X. (2023). Coordinated Engagements. Working paper, European Corporate Governance Institute.

Duchin, R., Gao, J., and Xu, Q. (2025). Sustainability or Greenwashing: Evidence from the Asset Market for Industrial Pollution. *Journal of Finance*, 80(2):699–754.

Edmans, A., Gosling, T., and Jenter, D. (2025). Sustainable Investing: Evidence from the Field. Working paper, European Corporate Governance Institute.

Edmans, A., Levit, D., and Schneemeier, J. (2023). Socially Responsible Divestment. Working paper, European Corporate Governance Institute.

Faccini, R., Konstantinidi, E., Skiadopoulos, G., and Sarantopoulou-Chiourea, S. (2019). A New Predictor of U.S. Real Economic Activity: The S&P 500 Option Implied Risk Aversion. *Management Science*, 65(10):4927–4949.

Faccini, R., Matin, R., and Skiadopoulos, G. (2023). Dissecting Climate Risks: Are They Reflected in Stock Prices? *Journal of Banking and Finance*, 155:106948.

Fernando, C. S., Sharfman, M. P., and Uysal, V. B. (2017). Corporate Environmental Policy and Shareholder Value: Following the Smart Money. *Journal of Financial and Quantitative Analysis*, 52(5):2023–2051.

Gabaix, X. and Koijen, R. S. J. (2022). In Search of the Origins of Financial Fluctuations: The Inelastic Markets Hypothesis. Working paper, National Bureau of Economic Research.

Gantchev, N., Giannetti, M., and Li, R. (2022). Does Money Talk? Divestitures and Corporate Environmental and Social Policies. *Review of Finance*, 26(6):1469–1508.

Gibson, R., Krueger, P., and Mitali, S. F. (2021). The Sustainability Footprint of Institutional Investors: ESG Driven Price Pressure and Performance. Working paper, University of Geneva.

Gibson Brandon, R., Glossner, S., Krueger, P., Matos, P., and Steffen, T. (2022). Do Responsible Investors Invest Responsibly? *Review of Finance*, 26(6):1389–1432.

Gompers, P. A. and Metrick, A. (2001). Institutional Investors and Equity Prices. *Quarterly Journal of Economics*, 116(1):229–259.

Hartzmark, S. M. and Shue, K. (2023). Counterproductive Sustainable Investing: The Impact Elasticity of Brown and Green Firms. Working paper, Boston College.

Haščič, I. and Migotto, M. (2015). Measuring Innovation Using Patent Data. Working paper, OECD Environment Working Papers.

Heath, D., Macciocchi, D., Michaely, R., and Ringgenberg, M. C. (2023). Does Socially Responsible Investing Change Firm Behavior? *Review of Finance*, 27(6):2057–2083.

Heinkel, R., Kraus, A., and Zechner, J. (2001). The Effect of Green Investment on Corporate Behavior. *Journal of Financial and Quantitative Analysis*, 36(4):431–449.

Hong, H. and Kacperczyk, M. (2009). The Price of Sin: The Effects of Social Norms on Markets. *Journal of Financial Economics*, 93(1):15–36.

Humphrey, J. E. and Li, Y. (2021). Who goes green: Reducing mutual fund emissions and its consequences. *Journal of Banking and Finance*, 126:106098.

Hwang, C.-Y., Titman, S., and Wang, Y. (2021). Investor Tastes, Corporate Behavior and Stock Returns: An Analysis of Corporate Social Responsibility. *Management Science*, 68(10):7065–7791.

Jing, C., Keasey, K., Lim, I., and Xu, B. (2024). Analyst Coverage and Corporate Environmental Policies. *Journal of Financial and Quantitative Analysis*, 59(4):1586–1619.

Kahn, M. E., Matsusaka, J., and Shu, C. (2023). Divestment and Engagement: The Effect of Green Investors on Corporate Carbon Emissions. Working paper, National Bureau of Economic Research.

Kim, Y. (2022). Does Corporate Investment Respond to the Time-Varying Cost of Capital? Empirical Evidence. *Journal of Financial and Quantitative Analysis*, 57(2):629–668.

Kogan, L., Papanikolaou, D., Seru, A., and Stoffman, N. (2017). Technological innovation, resource allocation, and growth. *Quarterly Journal of Economics*, 132(2):665–712.

Koijen, R. S. J., Richmond, R. J., and Yogo, M. (2024). Which Investors Matter for Equity Valuations and Expected Returns? *Review of Economic Studies*, 91:2387–2424.

Koijen, R. S. J. and Yogo, M. (2019). A Demand System Approach to Asset Pricing. *Journal of Political Economy*, 127(4):1475–1515.

Kostakis, A., Panigirtzoglou, N., and Skiadopoulos, G. (2011). Market Timing with Option-Implied Distributions: A Forward-Looking Approach. *Management Science*, 57(7):1231–1249.

Martin, I. W. and Wagner, C. (2019). What Is the Expected Return on a Stock? *Journal of Finance*, 74(4):1887–1929.

Naaraayanan, S. L., Sachdeva, K., and Sharma, V. (2021). The Real Effects of Environmental Activist Investing. Working paper, European Corporate Governance Institute.

Noh, D., Oh, S., and Song, J. (2023). Unpacking the Demand for Sustainable Equity Investing. Working paper, Hong Kong University of Science and Technology.

Pástor, Ľ., Stambaugh, R. F., and Taylor, L. A. (2021). Sustainable Investing in Equilibrium. *Journal of Financial Economics*, 142(2):550–571.

Pástor, Ľ., Stambaugh, R. F., and Taylor, L. A. (2022). Dissecting Green Returns. *Journal of Financial Economics*, 146(2):403–424.

Pástor, Ľ., Stambaugh, R. F., and Taylor, L. A. (2023). Green Tilts. Working paper, University of Chicago.

Pastor, L., Stambaugh, R. F., and Taylor, L. A. (2024). Sustainable Investing. Working paper, National Bureau of Economic Research.

Pedersen, L. H. (2025). Carbon Pricing versus Green Finance. *Journal of Finance*, forthcoming.

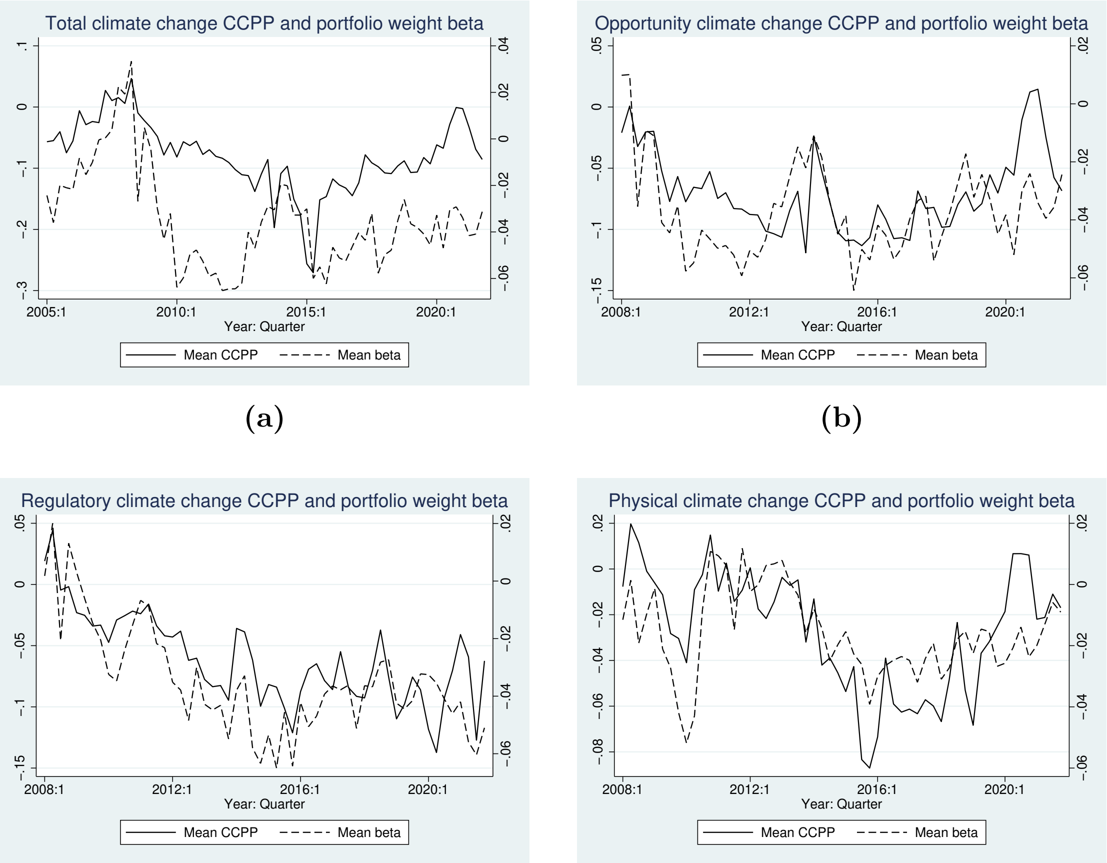
Pedersen, L. H., Fitzgibbons, S., and Pomorski, L. (2020). Responsible Investing: The ESG-efficient Frontier. *Journal of Financial Economics*, 142:572–597.

Sautner, Z., van Lent, L., Vilkov, G., and Zhang, R. (2023a). Firm-Level Climate Change Exposure. *Journal of Finance*, 78(3):1227–1831.

Sautner, Z., van Lent, L., Vilkov, G., and Zhang, R. (2023b). Pricing Climate Change Exposure. *Management Science*, 69(12):7540–7561.

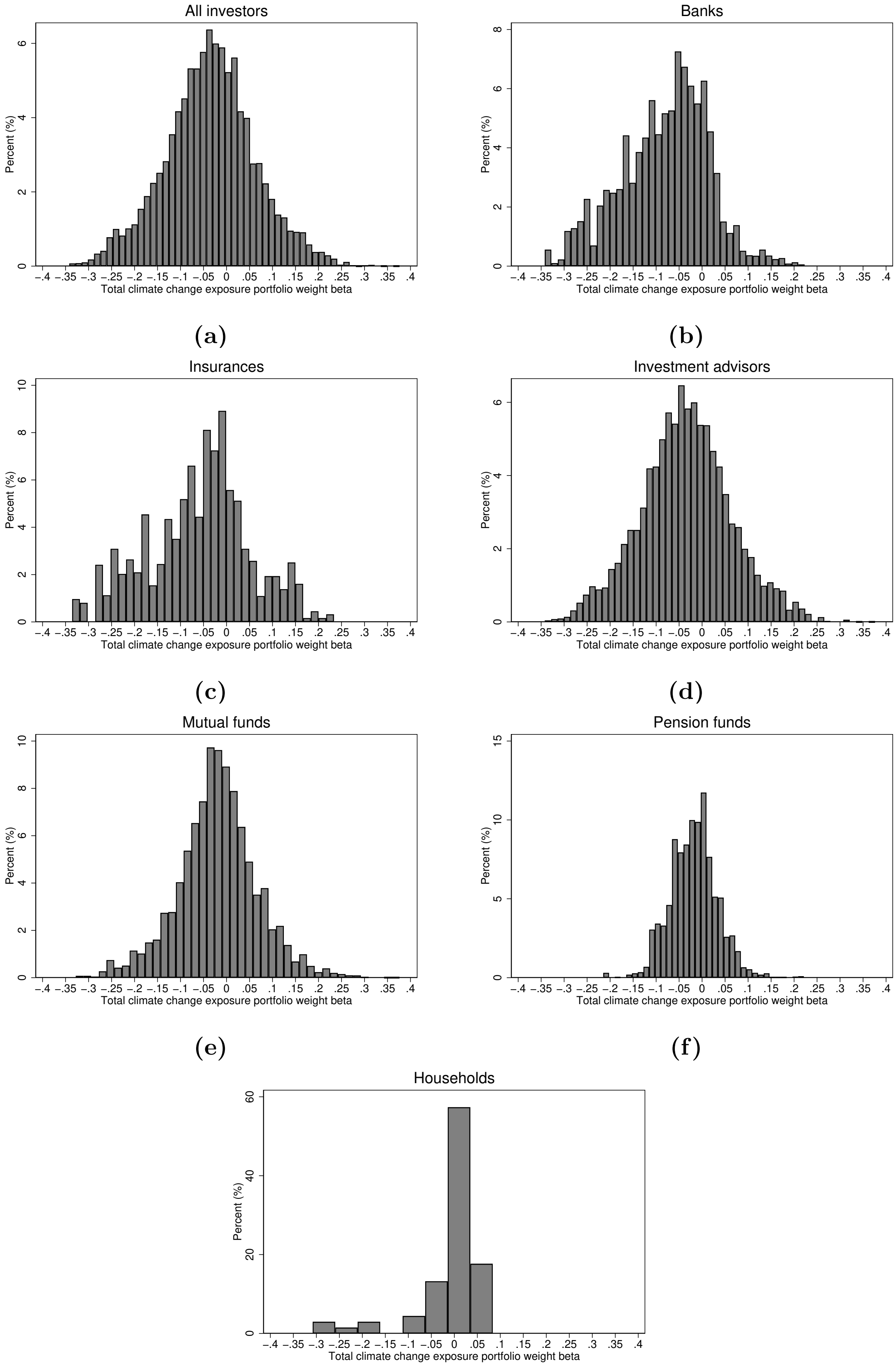
van der Beck, P. (2023). Flow-Driven ESG Returns. Working paper, Harvard Business School.

Zerbib, O. D. (2022). A Sustainable Capital Asset Pricing Model (S-CAPM): Evidence from Green Investing and Sin Stock Exclusion. *Review of Finance*, 26(6):1345–1388.



(a) **(b)** **(c)** **(d)**

Figure 1. Panels (a)-(d) (left axis) plot the cross-sectional average CCPP of S&P 500 constituent stocks (before cross-sectional standardization), arising from investors' portfolio rebalancing triggered by changes in stocks' total, opportunity, regulatory, and physical climate change exposures, respectively. CCPP is calculated by equation (3). The right axis plots the time-series evolution of the sensitivity of the relative portfolio weights with respect to these exposures, respectively (i.e., the cross-sectional average of individual investors' coefficients $\beta_{1,i,t}$), estimated from equation (2). For CCPP stemming from total (topic-based) climate change exposures, the sample period spans 2005:1-2021:4 (2008:1-2021:4), as dictated by the availability of climate change exposure data discussed in Sautner et al. (2023b).



(a)

(b)

(c)

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(e)

(f)

(g)

Figure 2. Panels (a)-(g) plot the histogram of the sensitivities $\beta_{1,i,t}$ of individual investors' relative portfolio weights with respect to the total climate change exposure for all investors, banks, insurance, investment advisors, mutual funds, pension funds, and households, respectively. We estimate β_1 by estimating equation (2) by quarter and by *individual* investor. The sample period is from 2005:1 to 2021:4.

Table 1. Summary statistics: S&P 500 stocks

Variable	Mean	SD	Min	Median	Max	Obs.
Panel A: Firm-level climate change exposures						
Total ($\times 10^3$)	0.318	0.611	0.001	0.108	4.751	43707
Opp ($\times 10^3$)	0.092	0.242	0.000	0.015	2.214	35939
Reg ($\times 10^3$)	0.016	0.049	0.000	0.000	0.516	35939
Phy ($\times 10^3$)	0.003	0.008	0.000	0.000	0.052	35939
Panel B: Option-implied firm-level cost of equity						
MW30	0.073	0.097	-0.005	0.044	1.123	43707
MW91	0.066	0.082	-0.002	0.041	0.969	43703
MW182	0.064	0.073	0.001	0.042	0.859	43691
MW273	0.069	0.076	0.003	0.046	0.797	29655
MW365	0.067	0.070	0.005	0.046	0.709	28855
GLB30	0.100	0.110	0.003	0.064	1.073	43707
GLB91	0.085	0.092	0.002	0.056	0.894	43703
GLB182	0.080	0.082	0.002	0.053	0.764	43691
GLB273	0.081	0.081	0.003	0.053	0.673	29655
GLB365	0.078	0.075	0.003	0.054	0.618	28855
Panel C: Firm-level CCPP estimates						
CCPP_total	-0.079	0.082	-0.392	-0.072	0.158	39967
CCPP_opp	-0.070	0.063	-0.320	-0.070	0.158	32651
CCPP_reg	-0.060	0.062	-0.364	-0.057	0.094	32651
CCPP_phy	-0.027	0.041	-0.180	-0.027	0.091	32651

Notes: This table reports the mean (Mean), standard deviation (SD), minimum (Min), median (Median), maximum (Max), and observations (Obs.) for the employed firm-level climate change exposures, option-implied firm-level cost of equity, and the estimated stock-level CCPP for S&P 500 constituent stocks (before cross-sectional standardization) in equation (3). *Total*, *Opp*, *Reg*, and *Phy* measure the relative frequency of bigrams related to overall climate change, opportunity, regulatory, and physical climate-related topics, in each firm's quarterly transcript of earnings conference calls and are scaled by 10^3, respectively. *MW30-MW365* (*GLB30-GLB365*) is the Martin and Wagner (2019) (Chabi-Yo et al. (2023)) annualized option-implied cost of equity over horizons of 1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year, respectively. *CCPP_total*, *CCPP_opp*, *CCPP_reg*, and *CCPP_phy* measure the effects of investor rebalancing on stock prices stemming from total, opportunity, regulatory, and physical climate change exposures, respectively. For CCPP stemming from total (topic-based) climate change exposures, the sample period spans 2005:1–2021:4 (2008:1–2021:4), as dictated by the availability of climate change exposure data discussed in Sautner et al. (2023b).

Table 2. Effects of CCPP on firms' cost of equity: S&P 500 stocks

	One-month	One-quarter	Two-quarter	Three-quarter	One-year
Panel A: Martin and Wagner (2019) cost of equity					
CCPP_total	-0.220***	-0.258***	-0.248***	-0.189***	-0.153**
	(-3.49)	(-4.53)	(-4.54)	(-2.74)	(-2.30)
N	39743	39739	39730	27506	26787
Adj.R^2	0.644	0.630	0.610	0.621	0.629
Economic effect	3%	4%	4%	3%	2%
CCPP_opp	-0.319***	-0.367***	-0.347***	-0.254**	-0.203**
	(-3.55)	(-4.46)	(-4.40)	(-2.48)	(-2.06)
N	32428	32427	32423	22178	21483
Adj.R^2	0.647	0.633	0.613	0.625	0.634
Economic effect	4%	6%	5%	4%	3%
CCPP_reg	0.014	-0.096	-0.107	0.041	0.060
	(0.17)	(-1.22)	(-1.42)	(0.43)	(0.64)
N	32428	32427	32423	22178	21483
Adj.R^2	0.646	0.632	0.612	0.625	0.634
Economic effect	0.2%	1%	2%	0.6%	0.9%
CCPP_phy	-0.308***	-0.314***	-0.300***	-0.296***	-0.257***
	(-5.17)	(-5.79)	(-5.80)	(-4.78)	(-4.36)
N	32428	32427	32423	22178	21483
Adj.R^2	0.647	0.633	0.613	0.626	0.635
Economic effect	4%	5%	5%	4%	4%

Table continued

Table 2. continued

	One-month	One-quarter	Two-quarter	Three-quarter	One-year
Panel B: Chabi-Yo et al. (2023) cost of equity					
CCPP_total	-0.106**	-0.184***	-0.184***	-0.179***	-0.151***
	(-2.32)	(-5.70)	(-6.36)	(-5.07)	(-4.41)
N	39743	39739	39730	27506	26787
Adj.R^2	0.812	0.850	0.858	0.859	0.863
Economic effect	1%	2%	2%	2%	2%
CCPP_opp	-0.131**	-0.229***	-0.223***	-0.229***	-0.190***
	(-2.04)	(-4.92)	(-5.32)	(-4.32)	(-3.68)
N	32428	32427	32423	22178	21483
Adj.R^2	0.806	0.847	0.854	0.855	0.859
Economic effect	1%	3%	3%	3%	2%
CCPP_reg	0.065	-0.077*	-0.094**	-0.090*	-0.077
	(1.04)	(-1.71)	(-2.33)	(-1.82)	(-1.58)
N	32428	32427	32423	22178	21483
Adj.R^2	0.806	0.846	0.854	0.855	0.859
Economic effect	0.7%	1%	1%	1%	1%
CCPP_phy	-0.183***	-0.200***	-0.191***	-0.212***	-0.184***
	(-4.48)	(-6.47)	(-6.79)	(-6.12)	(-5.44)
N	32428	32427	32423	22178	21483
Adj.R^2	0.806	0.847	0.854	0.856	0.859
Economic effect	2%	2%	2%	3%	2%
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Notes: This table reports panel regression results of firms' option-implied cost of equity on CCPP and controls

$$CoE_{t,h}(n) = \alpha + \beta_1 CCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t,h}(n),$$

where $CoE_{t,h}(n)$, is the nth stock Martin and Wagner (2019) (Panel A) and Chabi-Yo et al. (2023) (Panel B) option-implied cost of equity estimated at t for alternative horizons h=1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year. We include CCPP arising from investor portfolio rebalancing triggered by changes in total ($CCPP_t(n)$), opportunity ($CCPPOpp_t(n)$), regulatory ($CCPPReg_t(n)$) and physical climate change exposures ($CCPPPhy_t(n)$), separately. The vector of control variables $X_t(n)$ for the nth stock includes the market beta, log market equity, book-to-market ratio, profitability, investment, dividends-to-book equity, firm-level climate change exposure, momentum, and institutional ownership. All independent variables are cross-sectionally standardized within each quarter across S&P 500 stocks. Year-quarter and industry fixed effects are included. The economic effect is calculated as the effect of a one-standard-deviation change in the climate change price pressure on the mean value of the cost of equity (reported in Table 1). Standard errors are clustered at the firm level, and the corresponding t-statistics are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The sample period spans 2005:1-2021:4 (2008:1-2021:4) for the total (topic-based) climate change exposures. We multiply the estimated coefficients by 100 for display purposes.

Table 3. Estimated β_1 coefficients on climate change exposures for each type of investors

	Banks	Insurances	Investment advisors	Mutual	Pension	Households
Panel A: Total climate change exposures						
Total	-0.099***	-0.099**	-0.006	-0.020	-0.059***	0.004
	(-3.79)	(-2.36)	(-0.25)	(-1.61)	(-6.54)	(0.83)
N	5,650,302	2,025,617	38,284,594	9,018,819	2,669,357	172,763
Panel B: Opportunity climate change exposures						
Opp	-0.087***	-0.061*	0.002	-0.020*	-0.045***	0.010*
	(-3.80)	(-1.86)	(0.07)	(-1.86)	(-5.27)	(1.81)
N	4,751,794	1,677,635	34,693,070	7,418,803	2,271,576	142,735
Panel C: Regulatory climate change exposures						
Reg	-0.069***	-0.062**	-0.010	-0.018*	-0.041***	0.008*
	(-4.55)	(-2.40)	(-0.71)	(-1.92)	(-5.15)	(1.82)
N	4,751,794	1,677,635	34,693,070	7,418,803	2,271,576	142,735
Panel D: Physical climate change exposures						
Phy	-0.015	-0.044**	0.006	-0.016**	-0.017***	-0.024***
	(-1.05)	(-2.13)	(0.72)	(-2.01)	(-2.89)	(-4.51)
N	4,751,794	1,677,635	34,693,070	7,418,803	2,271,576	142,735
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the estimated β coefficients by GMM in equation (2) for each type of investor. We proxy climate change exposures by the total (*Total*), opportunity (*Opp*), regulatory (*Reg*), and physical (*Phy*) climate change exposures (Panels A, B, C, and D, respectively). We employ U.S. common stock portfolio holdings by 13F institutional investors. We use the same stock characteristics variables as in Koijen and Yogo (2019) (Market beta, log market equity, log book equity, profitability, investment, and dividend to book equity). Following Koijen et al. (2024), we cross-sectionally standardize all characteristics, except log market equity and log book equity, within each quarter and across U.S. common stocks. Columns 1-6 report results for banks, insurance companies, investment advisors, mutual funds, and pension funds, households defined in subsection 3.1, respectively. Standard errors are clustered at the investor level and the corresponding t-statistics are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The quarterly sample period is 2005:1 to 2021:4 (2008:1 to 2021:4) for total (topic-based) climate change exposures.

Table 4. Estimated β_1's on climate change exposures for PRI and non-PRI signatories

	PRI	Non-PRI	PRI	Non-PRI	PRI	Non-PRI	PRI	Non-PRI	PRI	Non-PRI	PRI	Non-PRI
	Investors		Banks		Insurance		Investment advisor		Mutual		Pensions	
Panel A: Total climate change exposures												
Total	-0.058***	-0.039**	-0.036***	-0.103***	-0.025	-0.091**	-0.041	-0.000	-0.055**	-0.022	-0.070***	-0.047***
	(-2.98)	(-2.51)	(-4.80)	(-3.72)	(-0.34)	(-2.02)	(-0.75)	(-0.02)	(-2.05)	(-1.63)	(-4.41)	(-5.17)
N	3505693	54841156	407730	4916604	86599	1800955	1301606	35916680	1261553	7191297	337540	2180902
Panel B: Opportunity climate change exposures												
Opp	-0.050**	-0.030**	-0.029**	-0.093***	-0.027	-0.057*	-0.019	0.002	-0.055**	-0.019	-0.060***	-0.037***
	(-2.57)	(-1.98)	(-2.27)	(-3.77)	(-0.40)	(-1.67)	(-0.38)	(0.09)	(-2.12)	(-1.60)	(-4.10)	(-4.44)
N	3454955	50089904	390903	4360891	86599	1591036	1296959	33397194	1259886	6159409	309943	1961633
Panel C: Regulatory climate change exposures												
Reg	-0.055***	-0.033***	-0.036***	-0.071***	-0.006	-0.059**	-0.062*	-0.008	-0.042**	-0.018*	-0.044***	-0.038***
	(-4.34)	(-3.34)	(-3.06)	(-4.46)	(-0.11)	(-2.19)	(-1.65)	(-0.56)	(-2.42)	(-1.67)	(-4.57)	(-4.18)
N	3454955	50089904	390903	4360891	86599	1591036	1296959	33397194	1259886	6159409	309943	1961633
Panel D: Physical climate change exposures												
Phy	-0.003	-0.010	-0.013***	-0.015	-0.028	-0.044**	0.008	0.006	0.001	-0.024***	-0.030***	-0.011*
	(-0.21)	(-1.55)	(-2.83)	(-1.01)	(-0.58)	(-1.97)	(0.22)	(0.70)	(0.07)	(-2.84)	(-5.77)	(-1.88)
N	3454955	50089904	390903	4360891	86599	1591036	1296959	33397194	1259886	6159409	309943	1961633

Notes: This table reports the estimated β_1 coefficients by GMM in equation (2) for each type of PRI and non-PRI signatory investor. We proxy climate change exposures by the total (*Total*), opportunity (*Opp*), regulatory (*Reg*), and physical (*Phy*) climate change exposures (Panels A, B, C, and D, respectively). We employ U.S. common stock portfolio holdings by 13F institutional investors. We use the same stock characteristics variables as in Koijen and Yogo (2019) (Market beta, log market equity, log book equity, profitability, investment, and dividend to book equity). Following Koijen et al. (2024), we cross-sectionally standardize all characteristics, except log market equity and log book equity, within each quarter and across the U.S. common stocks. We report the results for PRI signatory (non-PRI signatory) 13F investors, banks, insurance companies, investment advisors, mutual funds, and pension funds, respectively. Standard errors are clustered at the investor level and the corresponding t-statistics are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The quarterly sample period is 2006:2 to 2021:4 (2008:1 to 2021:4) for total (topic-based) climate change exposures.

Table 5. Effects of CCPP on firms' green activities: S&P 500 stocks

	One-year	Two-year	Three-year	Four-year	Five-year
Panel A: #Green filed patents					
CCPP_total	-0.133*	-0.141	-0.035	-0.014	0.007
	(-1.71)	(-1.35)	(-0.27)	(-0.08)	(0.03)
N	9329	8587	7870	7193	6519
Adj.R^2	0.008	0.018	0.031	0.043	0.043
Panel B: Green filed patents/log market equity					
CCPP_total	-0.012*	-0.015	-0.006	-0.003	-0.001
	(-1.73)	(-1.62)	(-0.53)	(-0.20)	(-0.03)
N	9329	8587	7870	7193	6519
Adj.R^2	0.012	0.023	0.036	0.048	0.047
Panel C: Economic real value of green filed patents					
CCPP_total	0.082	1.406	2.983	2.359	1.962
	(0.09)	(0.72)	(1.25)	(0.97)	(0.75)
N	9329	8587	7870	7193	6519
Adj.R^2	0.047	0.079	0.106	0.136	0.140
Panel D: Environmental expenditures/total assets					
CCPP_total	19.983	15.915	26.713	25.263	27.843
	(0.81)	(0.40)	(0.72)	(0.49)	(0.43)
N	9315	8577	7858	7182	6509
Adj.R^2	0.016	0.029	0.040	0.048	0.062
Panel E: Environmental provisions/total assets					
CCPP_total	3.933	-28.670	-21.770	-0.659	19.625
	(0.20)	(-0.78)	(-0.49)	(-0.01)	(0.31)
N	8719	7997	7296	6632	5969
Adj.R^2	0.034	0.050	0.079	0.116	0.143
Panel F: Environmental fines/total assets					
CCPP_total	0.001	-0.001	-0.007	-0.008	-0.009
	(0.32)	(-0.07)	(-0.92)	(-0.92)	(-0.88)
N	6902	6218	5554	4922	4288
Adj.R^2	0.180	0.152	0.294	0.308	0.441
Panel G: Trucost total carbon emission intensities					
CCPP_total	-2.309	-3.592	-5.683	-5.968	-7.145
	(-0.49)	(-0.52)	(-0.75)	(-0.71)	(-0.88)
N	7236	6696	6163	5646	5133
Adj.R^2	0.102	0.196	0.291	0.383	0.437
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Notes: This table reports panel regression results of firms' future changes in green activities on CCPP and controls:

$$\Delta Y_{t+h}(n) = \alpha + \beta_1 CCPP_t + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t+h}(n),$$

where $\Delta Y_{t+h}(n)$ is the h-period ahead changes in firm n's (i) number of green filed patents, (ii) ratio of green filed patents to log market equity, (iii) economic real value of green filed patents, (iv) ratio of environmental expenditures to total assets, (v) ratio of environmental provisions to total assets, (vi) ratio of environmental fines to total assets, and (vii) emission intensities, separately. The forecasting horizon h =1 year, 2 years, 3 years, 4 years, and 5 years ahead (Columns 1-5, respectively). $CCPP_t(n)$ denotes the CCPP for stock n resulting from institutional portfolio rebalancing triggered by changes in total climate change exposures. $X_t(n)$ is the vector of control variables: size, asset tangibility, leverage, profitability, cash ratio, capital expenditures, R&D expenses, institutional ownership for stock n, and the firm's current green activity measures for stock n. All independent variables are cross-sectionally standardized within each quarter across S&P 500 stocks. Year-quarter and industry fixed effects are included. Standard errors are clustered at the firm level, and the corresponding t-statistics are reported in parentheses. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The quarterly sample period is from 2005 to 2021.

A Model Appendix

A.1 Stock-level CCPP derivation (equation (3))

The market clearing condition for stock n at t, $P_t(n)S_t(n) = \sum_{i=1}^{I} A_{i,t} w_{i,t}(n)$, implies that the vector of the equilibrium log stock prices of all stocks at t is,

$$\mathbf{p}_t = \log\left(\sum_{i=1}^{I} A_{i,t}\mathbf{w}_{i,t}(\mathbf{p}_t)\right) - \mathbf{s}_t, \tag{A.1}$$

where $\mathbf{s}_t$ denotes the vector of the log outstanding shares of all stocks at t. Differentiating equation (A.1) with respect to the vector of climate change exposures of all stocks at t, $\mathbf{cc}'_t$:

$$\frac{\partial \mathbf{p}_t}{\partial \mathbf{cc}'_t} = \mathbf{H}_t^{-1}\left(\sum_{i=1}^{I} A_{i,t}\frac{\partial \mathbf{w}_{i,t}}{\partial \mathbf{p}'_t}\frac{\partial \mathbf{p}_t}{\partial \mathbf{cc}'_t} + \sum_{i=1}^{I} A_{i,t}\frac{\partial \mathbf{w}_{i,t}}{\partial \mathbf{cc}'_t}\right), \tag{A.2}$$

where $\mathbf{H}_t = \sum_i^I A_{i,t}\,\mathrm{diag}\left(\mathbf{w}_{i,t}\right)$. To calculate $\frac{\partial \mathbf{w}_{i,t}}{\partial \mathbf{p}'_t}$, and $\frac{\partial \mathbf{w}_{i,t}}{\partial \mathbf{cc}'_t}$, consider

$$\frac{w_{i,t}(n)}{w_{i,t}(0)} = \delta_{i,t}(n) \equiv \exp\left(\beta_{0,i,t} me_t(n) + \beta_{1,i,t} cc_t(n) + \boldsymbol{\beta}'_{2,i,t}\mathbf{x}_t(n) + \beta_{3,i,t}\right)\epsilon_{i,t}(n), \tag{A.3}$$

$$w_{i,t}(n) = \delta_{i,t}(n) w_{i,t}(0) \tag{A.4}$$

We aggregate the portfolio weights of all stocks within the investment universe of investor i,

$$\sum_{m\in\mathcal{N}_{i,t}} w_{i,t}(m) = w_{i,t}(0)\sum_{m\in\mathcal{N}_{i,t}} \delta_{i,t}(m), \tag{A.5}$$

where m denotes the stock in investor i's investment universe, and

$$\sum_{m\in\mathcal{N}_{i,t}} w_{i,t}(m) = 1 - w_{i,t}(0), \tag{A.6}$$

Equations (A.5) and (A.6) yield

$$w_{i,t}(0) = \frac{1}{1 + \sum_{m\in\mathcal{N}_{i,t}} \delta_{i,t}(m)} \tag{A.7}$$

Substituting equation (A.7) into equation (A.4) yields

$$w_{i,t}(n) = \frac{\delta_{i,t}(n)}{1 + \sum_{m \in \mathcal{N}_{i,t}} \delta_{i,t}(m)} \tag{A.8}$$

Differentiating $w_{i,t}(n)$ in equation (A.8) separately with respect to $cc_t(n)$ and $cc_t(l)$, where l denotes any other stock in the investment universe of investor i, yields

$$\begin{aligned}\frac{\partial w_{i,t}(n)}{\partial cc_t(n)} &= \frac{\delta'_{i,t}(n)}{1 + \sum_{m \in \mathcal{N}_{i,t}} \delta_{i,t}(m)} - \frac{\delta_{i,t}(n)}{(1 + \sum_{m \in \mathcal{N}_{i,t}} \delta_{i,t}(m))^2}\delta'_{i,t}(n) \\ &= \beta_{1,i,t} w_{i,t}(n) - \beta_{1,i,t} w_{i,t}(n) w_{i,t}(n) = \beta_{1,i,t} w_{i,t}(n)\left(1 - w_{i,t}(n)\right), \textit{and}\end{aligned} \tag{A.9}$$

$$\frac{\partial w_{i,t}(n)}{\partial cc_t(l)} = -\frac{\delta_{i,t}(n)}{(1 + \sum_{m \in \mathcal{N}_{i,t}} \delta_{i,t}(m))^2}\delta'_{i,t}(l) = -\beta_{1,i,t} w_{i,t}(n) w_{i,t}(l) \tag{A.10}$$

Equations (A.9) and (A.10) yield

$$\frac{\partial \mathbf{w}_{i,t}}{\partial \mathbf{cc}'_t} = \beta_{1,i,t}\mathbf{G}_{i,t}, \tag{A.11}$$

where $\mathbf{G}_{i,t} = \mathrm{diag}\left(\mathbf{w}_{i,t}\right) - \mathbf{w}_{i,t}\mathbf{w}'_{i,t}$. Through analogous steps,

$$\frac{\partial \mathbf{w}_{i,t}}{\partial \mathbf{p}'_t} = \beta_{0,i,t}\mathbf{G}_{i,t} \tag{A.12}$$

Substituting equations (A.11) and (A.12) into equation (A.2) yields

$$\frac{\partial \mathbf{p_t}}{\partial \mathbf{cc}'_t} = \left(\mathrm{I} - \sum_{i=1}^{I} \beta_{0,i,t} A_{i,t} \mathbf{H_t}^{-1} \mathbf{G}_{i,t}\right)^{-1} \left(\sum_{i=1}^{I} \beta_{1,i,t} A_{i,t} \mathbf{H_t}^{-1} \mathbf{G}_{i,t}\right), \tag{A.13}$$

where $\mathbf{G}_{i,t} = \mathrm{diag}\left(\mathbf{w}_{i,t}\right) - \mathbf{w}_{i,t}\mathbf{w}'_{i,t}$.

The CCPP for stock n is given by the nth diagonal element of the matrix in equation (A.13):

$$\frac{\partial p_t(n)}{\partial cc_t(n)} = \frac{\sum_i s_{i,t}(n)\beta_{1,i,t}\left(1 - w_{i,t}(n)\right)}{1 - \sum_i s_{i,t}(n)\beta_{0,i,t}\left(1 - w_{i,t}(n)\right)}, \tag{A.14}$$

where $p_t(n) = \log(P_t(n))$ and $s_{i,t}(n)$ represents investor i's share of stock n's market capitalization at t, defined as $s_{i,t}(n) = A_{i,t}w_{i,t}(n) / \sum_i^I A_{i,t}w_{i,t}(n)$.

B Data Appendix

B.1 Variable definitions

Table B.1. Variables Definitions

Variables	Definitions
Panel A: Firm-level green variables	
Total/Opp/Reg/Phy	Frequency of climate change-related bigrams—categorized as total/opportunity/regulatory/physical exposure—in firms' earnings conference call transcripts per firm-quarter. Source: Sautner et al. (2023a).
GP_filed	Number of green patents filed per firm-year. Source: Self-constructed.
GP_filed ratio	Number of green patents filed per firm-year, scaled by the logarithm of the firm's market equity. Source: Self-constructed.
GP_value	Present real value of expected future cash flows from green patents per firm-year. Source: Self-constructed.
Env_expense	Expenditures on environmental protection, prevention, reduction, and control of environmental impacts and hazards per firm-year, scaled by the firm's total assets. Source: Refinitiv.
Env_prov	Provisions kept aside to cover potential environmental liabilities per firm-year, scaled by the firm's total assets. Source: Refinitiv.
Env_fines	Amount of fines paid for violations of environmental regulations per firm-year, scaled by the firm's total assets. Source: Refinitiv.
CI_Trucost	Sum of scope 1 and 2 carbon emissions per firm-year, scaled by the firm's revenues. Source: Trucost.
Panel B: Option-implied firm-level cost of equity	
MW (30,91,182,273,365)	Option-implied annualized cost of equity measure over horizons of 1-month, 1-quarter, 2-quarter, 3-quarter and 1-year per firm-day, by Martin and Wagner (2019). Source: Self-constructed.
GLB (30,91,182,273,365)	Option-implied annualized cost of equity measure over horizons of 1-month, 1-quarter, 2-quarter, 3-quarter and 1-year per firm-day, by Chabi-Yo et al. (2023). Source: https://osf.io/7xcqw/.

Table continued

Table B.1. continued

Variables	Definitions
	Panel C: Firm-level stock characteristics
LNme	Log of the product of stock prices (PRC) and shares outstanding (SHROUT) per firm-month. Source: CRSP Monthly Stock.
LNbe	Log of the sum of shareholder equity (SEQ), deferred taxes, and investment tax credit (TXDITC), minus the book value of preferred stock (PSTK), per firm-quarter. Source: Compustat North America Fundamentals Quarterly and Annual.
Beta	Monthly stock beta, estimated from a 60-month rolling regression of stock excess returns on market excess returns, requiring at least 24 months of data. Source: CRSP Monthly Stock database, Kenneth R. French Data Library.
Profit	Ratio of operating profits to book equity per firm-quarter, where the operating profits are annual revenues (REVT) minus the cost of goods sold (COGS), selling, general, and administrative expenses (XSGA), and interest expenses (XINT). Source: Compustat North America Fundamentals Quarterly and Annual database.
Gat	Annual log growth rate of total assets (AT) per firm-quarter. Source: Compustat North America Fundamentals Quarterly and Annual.
DivAbe	Annual dividends (DIV) per split-adjusted share multiplied by shares outstanding, divided by book equity per firm-quarter. Source: CRSP Monthly Stock database, Compustat North America Fundamentals Quarterly and Annual.
BtM	Ratio of book equity to market equity per firm-quarter. Source: CRSP Monthly Stock database, Compustat North America Fundamentals Quarterly and Annual.
Momentum	Cumulative return of the stock during the 11-month period covering months t-11 through t-1 per firm-month. Source: CRSP Monthly.
Size	Log of a firm's total assets (AT) per firm-quarter. Source: Compustat North America Fundamentals Quarterly and Annual.
Tangibility	Ratio of property, plant, and equipment (PPENT) to total assets (AT) per firm-quarter. Data are obtained from Compustat North America Fundamentals Quarterly and Annual.
Leverage	Total debt (DLTT+DLC) divided by total assets (AT) per firm-quarter. Source: Compustat North America Fundamentals Quarterly and Annual.
Capx	Capital expenditures (CAPX) divided by total assets (AT) per firm-quarter. Source: Compustat North America Fundamentals Quarterly and Annual.
R&D	Research and development expenses (XRD) divided by total assets (AT) per firm-quarter. Missing XRD values set to zero. Source: Compustat North America Fundamentals Quarterly and Annual.

Table continued

Table B.1. continued

Variables	Definitions
Cash	Cash and short-term investments (CHE) divided by total assets (AT) per firm-quarter. Source: Compustat North America Fundamentals Quarterly and Annual.
IO	Percentage ownership held by the institutional investors (INSTOWN PERC) per firm-quarter. Source: Thomson Reuters.

C Matching 13F investors with PRI investors

We follow Gibson Brandon et al. (2022), their Appendix Table IA1, and match the names of institutional investors in the 13F database with those of the PRI signatories (publicly available at https://www.unpri.org) using the fuzzy matching technique. First, we clean the investor names in both the PRI signatory lists and the 13F database for case type, punctuation, stop words, incorporation words, and special characters, and exclude PRI signatories classified as service providers. Second, we merge the PRI signatory lists with the 13F database by quarter. In each quarter, we calculate the Jaro-Winkler (JW) distance between each name in the 13F database and those in the PRI signatory list from 2006q2 (the starting quarter for the PRI signatories data) to 2021q4. Third, we retain any name pairs in the two databases if their JW distance is greater than 0.85 and the investor's headquarters country is the same in both the PRI signatory list and the 13F database. Fourth, for each investor, we retain only the match with the highest JW distance. In cases where multiple matches share the highest JW distance, we manually verify them by comparing the investor names in the 13F database and UNPRI signatory lists, keeping only the correct match. Fifth, we manually review each retained pair and keep only the correct matches. Finally, for each institutional investor, we assign the PRI signatory status in the quarter of the match, marking all subsequent quarters as signatory and all prior quarters as non-signatory.

Internet Appendix

Climate-triggered institutional price pressure: Does it affect firms' cost of equity?

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IA Data Appendix

IA.1 Processing the Sautner et al. (2023a) measures

Zero values in the Sautner et al. (2023a) measures do not necessarily reflect the absence of climate change exposures, as firms may not address the same topics in subsequent earnings calls. Likewise, missing observations resulting from the absence of an earnings call could lead to underreporting of such exposures. We report the proportion of missing and zero values in the Sautner et al. (2023a) quarterly climate change exposure data for S&P 500 stocks, covering Q1 2002 (the first quarter of their dataset) through Q4 2021.[1] The proportion of missing values for any given type of climate change exposure is around 10%, as illustrated in Panel (a) of Figure IA.1. Approximately 40% and 80% of non-missing observations for total and opportunity exposures, respectively, have a value of zero, whereas more than 90% of observations for regulatory and physical exposures are zero, as shown in in Panel (b) of Figure IA.1.

Sautner et al. (2023a,b) address missing and zero-value observations in the quarterly climate change exposure data by applying an exponentially weighted moving average (EWMA) model. The EWMA value $y_{n,t}$ for firm n at time t is computed using firm n's climate change exposure observations from time 0 to t

$$y_{n,t} = \frac{\sum_{z=0}^{t} x_{n,t-z}(1-\alpha)^z}{\sum_{z=0}^{t}(1-\alpha)^z}, \tag{IA.1}$$

where z is a time index ranging over the interval $[0, t]$, spanning from the time when firm n first has a non-missing observation for the respective climate change exposure variable (time 0) up to the current time t, and $x_{n,t-z}$ denotes the corresponding climate change exposure observations. The decay parameter α is given by $1 - \exp(-\ln(2)/\tau)$, with the half-life parameter of six months denoted as τ, which is the decay time for the weight value to reach half its original value.[2]

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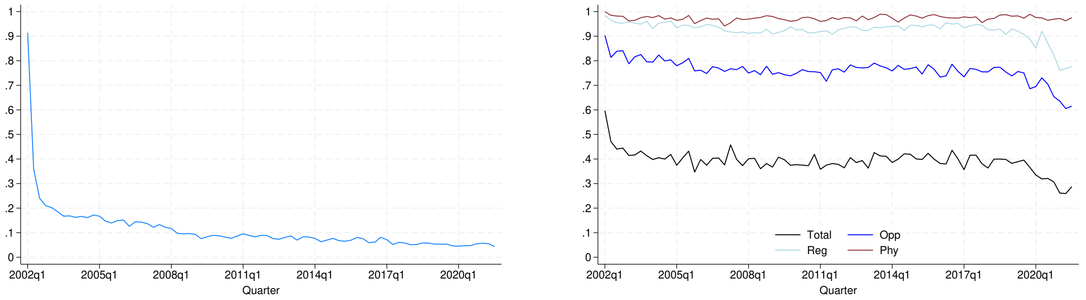
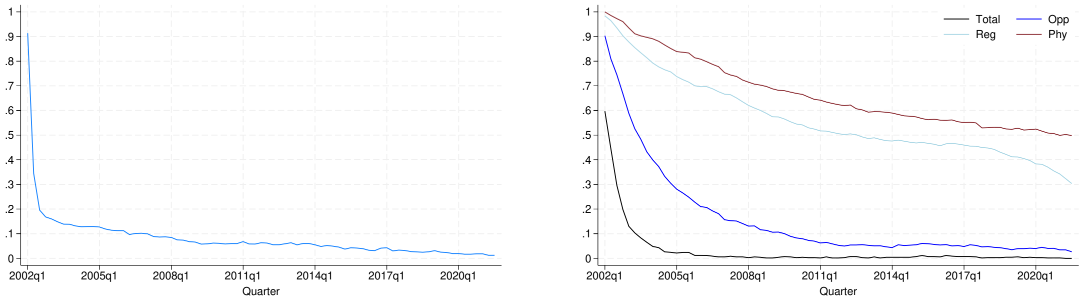
[1] For each type of climate change exposure, we compute the proportion of missing (zero) values in each quarter by dividing the number of stocks with missing (zero) exposure data by the total number of S&P 500 stocks (those with non-missing climate change exposure, respectively). The proportions of missing observations are identical across different types of climate exposures. We use data on the total and topic-based climate change exposures from Q1 2005 to Q4 2021 and Q1 2008 to Q4 2021, respectively.

[2] Sautner et al. (2023b) find that the empirical results are robust to the choice of the half-life parameter, with similar results obtained for values of τ between 3 to 12 months. We follow them



(a) Proportion of missing climate change exposure data for S&P 500 stocks **(b)** Proportion of zero climate change exposure data for S&P 500 stocks



(c) Proportion of missing climate change exposure data for S&P 500 stocks after exponential smoothing **(d)** Proportion of zero climate change exposure data for S&P 500 stocks after exponential smoothing

Figure IA.1. This figure plots the proportion of missing (zero) observations in the Sautner et al. (2023a) quarterly climate change exposure data for S&P 500 stocks, with Panel (a) (Panel (b)) displaying missing (zero) values from Q1 2002 to Q4 2021. For each type of climate change exposure, we calculate the proportion of missing (zero) values in each quarter by dividing the number of stocks with missing (zero) exposure data by the total number of S&P 500 stocks (those with non-missing exposure, respectively). The proportions of missing observations are identical across different types of climate exposures. Panels (c) and (d) report information analogous to Panels (a) and (b), respectively, after applying the exponential weighted moving average smoothing as in Sautner et al. (2023b). *Total*, *Opp*, *Reg*, and *Phy* measure the relative frequency of bigrams related to overall climate change, opportunity, regulatory, and physical climate-related topics, occurring in the earnings conference call transcripts, respectively.

Once we apply exponential smoothing, around 10% of S&P 500 stocks still have missing values for their climate change exposures after 2005, as shown in Panel (c) of Figure IA.1. The percentage of missing observations decreases slightly compared with that before smoothing. On the other hand, the percentage of zero observations for climate change exposures declines significantly over time after applying exponential smoothing. Following Sautner et al. (2023b), we use the exponentially smoothed data on total and topic-based climate change exposures from Q1 2005

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and set $\tau = 6$ months.

to Q4 2021 and Q1 2008 to Q4 2021, respectively. This ensures that over 95% of S&P 500 stocks have non-zero values for total climate change exposures, while at least 30% have non-zero values for their topic-based climate change exposures, as illustrated in Panel (d) of Figure IA.1.

IB Option-implied firm-level cost of equity

Martin and Wagner (2019) measure is given by

$$\mathbb{E}_t R_{n,t+1} - R_{f,t+1} = \left[\mathrm{SVIX}_t^2 + \frac{1}{2}\left(\mathrm{SVIX}_{n,t}^2 - \overline{\mathrm{SVIX}}_t^2 \right) \right] R_{f,t+1}, \tag{IB.2}$$

where $R_{n,t+1}$ and $R_{f,t+1}$ denote the simple return of stock n and the risk-free rate from t to t+1, respectively. SVIX_t^2 represents the risk-neutral variance of the S&P 500 index at t. $\overline{\mathrm{SVIX}}_t^2 = \sum_n w_{n,t} \mathrm{SVIX}_{n,t}^2$, is the value-weighted average of the individual stocks' risk-neutral variances $\mathrm{SVIX}_{n,t}^2$ at t, where $w_{n,t}$ is the weight of stock n in the market portfolio, based on its market capitalization at t.

$$\mathrm{SVIX}_t^2 = \frac{2}{S_{m,t}^2 R_{f,t+1}} \left[\int_{S_{m,t}R_{f,t+1}}^{\infty} \mathrm{call}_{m,t}(K)dK + \int_0^{S_{m,t}R_{f,t+1}} \mathrm{put}_{m,t}(K)dK \right] \tag{IB.3}$$

$$\mathrm{SVIX}_{n,t}^2 = \frac{2}{S_{n,t}^2 R_{f,t+1}} \left[\int_{S_{n,t}R_{f,t+1}}^{\infty} \mathrm{call}_{n,t}(K)dK + \int_0^{S_{n,t}R_{f,t+1}} \mathrm{put}_{n,t}(K)dK \right], \tag{IB.4}$$

where $S_{m,t}$ and $S_{n,t}$ denote the S&P 500 index price and the price of S&P 500 index constituent stock n at t, respectively. $\mathrm{call}_{m,t}(K)$ and $\mathrm{put}_{m,t}(K)$ denote the out-of-the-money S&P 500 index call and put option prices, respectively, and $\mathrm{call}_{n,t}(K)$ and $\mathrm{put}_{n,t}(K)$ denote the out-of-the-money call and put option prices on S&P 500 index constituent stock, respectively. All option prices are measured at t, with strike price K and maturity t+1.

To calculate Martin and Wagner (2019) option-implied expected excess return, we obtain the daily time-varying list of S&P 500 constituent stocks from CRSP from 2005 to 2021 using the Python code provided by WRDS. We download daily implied volatility data on S&P 500 index options and constituent stocks' options from the IvyDB U.S. OptionMetrics Volatility Surface database. For each underlying stock, we select out-of-the-money call and put options with absolute delta values below 0.5 and standardized maturities of 30, 91, 182, 273, and 365 days. We obtain daily forward prices and daily zero-coupon rates with corresponding maturities from the IvyDB U.S. OptionMetrics Forward Price and the Zero Coupon Yield Curve databases, respectively, and daily spot prices from the IvyDB U.S. OptionMetrics Security Prices database.

To approximate the integrals in equations (IB.3) and (IB.4), for each underlying stock, maturity, and time, we interpolate the available implied volatilities as a function of moneyness (K/S), following Chabi-Yo et al. (2023). Specifically, we first define a moneyness grid of 1000 equally-spaced points within the [1/3, 3] range. Then, we apply a piecewise cubic Hermite polynomial to interpolate the implied volatility. We horizontally extrapolate implied volatilities outside the [1/3, 3] moneyness range. Next, we convert implied volatilities to the corresponding call and put prices using the Black and Scholes (1973) formula, and compute the risk-neutral variances. We calculate the option-implied cost of equity on a daily basis and then take its average over each quarter, in line with Sautner et al. (2023a). We calculate the option-implied cost of equity for alternative horizons (1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year) corresponding to the index and equity options' standardized maturities of 30, 91, 182, 273, and 365 days.

IC Aggregate climate change price pressure

IC.1 Aggregate CCPP: Theory

We construct two price pressure measures with respect to firm-level and aggregate (i.e. market-wide) climate change exposures, denoted as $CCPP$ and $ACCPP$, respectively. To this end, we modify the key equation in Koijen and Yogo (2019) which relates the portfolio weights to climate change risks and other stock characteristics. We consider the *interaction* between firm-level and aggregate climate change risks in the relation between the investor i's portfolio weight on stock n (relative to the outside asset) at t and climate change risks. To fix ideas, the specification in the main body of the paper is

$$\frac{w_{i,t}(n)}{w_{i,t}(0)} = \exp[\beta_{0,i,t}me_t(n) + \beta_{1,i,t}cc_t(n) + \boldsymbol{\beta}_{2,i,t}^{'}\mathbf{x}_t(n) + \beta_{3,i,t}]\epsilon_{i,t}(n) \tag{IC.5}$$

In the case where we include the interaction between firm-level and the aggregate climate change risks, equation (IC.5) becomes

$$\begin{aligned}\frac{w_{i,t}(n)}{w_{i,t}(0)} = \exp[&\beta_{0,i,t}me_t(n) + \beta_{1,i,t}^{*}cc_t(n) \times Aggregate_t + \boldsymbol{\beta}_{2,i,t}^{'}\mathbf{x}_t(n) \\ &+ \beta_{3,i,t}]\epsilon_{i,t}(n)\end{aligned} \tag{IC.6}$$

Under (IC.6),

$$CCPP_t(n) \equiv \frac{\partial p_t(n)}{\partial cc_t(n)} = \frac{\sum_i s_{i,t}(n)\beta_{1,i,t}^{*}Aggregate_t\left(1 - w_{i,t}(n)\right)}{1 - \sum_i s_{i,t}(n)\beta_{0,i,t}\left(1 - w_{i,t}(n)\right)} \tag{IC.7}$$

and

$$ACCPP_t(n) \equiv \frac{\partial p_t(n)}{\partial Aggregate_t} = \frac{\sum_i s_{i,t}(n)\beta_{1,i,t}^{*}cc_t(n)\left(1 - w_{i,t}(n)\right)}{1 - \sum_i s_{i,t}(n)\beta_{0,i,t}\left(1 - w_{i,t}(n)\right)} \tag{IC.8}$$

Three important remarks are in order. First, the $CCPP$ measures under the model (IC.5), which does not include market-wide climate risks in the portfolio weights equation, are identical to those from model (IC.6)[3]

$$CCPP_t(n) \equiv \frac{\partial p_t(n)}{\partial cc_t(n)} = \frac{\sum_i s_{i,t}(n)\beta_{1,i,t}\left(1 - w_{i,t}(n)\right)}{1 - \sum_i s_{i,t}(n)\beta_{0,i,t}\left(1 - w_{i,t}(n)\right)} \tag{IC.9}$$

In other words, the inclusion of market-wide climate change risks in the equation which relates portfolio weights to firm-level climate change risks yields a $CCPP$ formula which is the same as the the one derived under model (IC.5). Hence, the estimated CCPP in the main paper remains the same, even when market-wide climate change risks are considered.

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[3] This is because β_1^* in model (IC.6) equals β_1 in model (IC.5) divided by the value of the aggregate climate change risks, i.e.,

$$\beta_1^* = \beta_1 / Aggregate$$

One can see this by considering the simple case $y = exp(\beta_1 x)$ and $y = exp(\beta_2 cx)$. We can rewrite the latter as $y = exp[(\beta_2 c)x]$. Hence, $\beta_1 = \beta_2 c$ or $\beta_2 = \beta_1 / c$.

Second,

$$ACCPP_t(n) = CCPP_t(n) \times cc_t(n)/Aggregate_t \tag{IC.10}$$

Equation (IC.10) shows that there is a non-linear, time-varying relation between $ACCPP$ and $CCPP$, which depends on the magnitude of firm-level climate change exposure relative to that of the market-wide climate change risks. The negative CCPP exerted by investors in response to an increase in aggregate climate risks becomes more negative (i.e. investors would be selling more) for firms with higher firm-level climate change exposures when a certain type of aggregate climate risks materializes. Equivalently stated, stocks with more negative idiosyncratic CCPP are more sensitive to aggregate climate change risks.

Third, equation (IC.6) is the only plausible specification from an econometrics perspective, if one wishes to include aggregate climate change risks in equation (IC.5) for the purpose of defining $ACCPP$.[4] However, the value of the new variable defined as the interaction between firm-level and aggregate climate risks lacks a clear interpretation. For instance, a high value of this variable does not tell if this high value results from high firm-level and low aggregate climate risks, the reverse, or both types of risks being high. Related to that, note that equations (IC.5) and (IC.6) are *not* reduced-form models. On the contrary, their specifications stem from the assumptions about the relation between expected stock returns, risks, and firms' stock characteristics (Koijen and Yogo (2019)). For the interaction term to appear in equation (IC.6), one needs to assume that this interaction term also affects expected returns or risks. The lack of interpretation of interaction terms also explains why interaction terms are typically not employed as predictors in the literature on the prediction of expected returns or risks.

IC.2 Aggregate CCPP: Estimation

We estimate three different $ACCPP$ measures capturing the effect of changes in total, physical, and regulatory aggregate climate change risks, respectively. To

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[4] Given that we estimate equation (IC.5) for each quarter using the cross-section of investors' portfolio holdings, the aggregate climate measure cannot be introduced in a stand-alone fashion, because there is no variation in the "Aggregate" variable across the cross-sectional holdings within quarter t. Similarly, the $cc_t(n)$ variable cannot appear in a stand-alone fashion in (IC.6), because it would be perfectly collinear with $cc_t(n) \times Aggregate_t$.

perform the estimation of the three respective ACCPP measures, we employ the daily Ardia et al. (2023) total market-wide climate change risk measure (MCCC) and the two Faccini et al. (2023) physical and regulatory market-wide climate change risk measures, respectively. The MCCC is a textual measure constructed from major U.S. newspapers and newswires, capturing media attention to climate change risks without dissecting them in physical and regulatory climate change risks. The two Faccini et al. (2023) measures are textual measures constructed from Reuters news related to climate change, capturing media attention to U.S. climate policy change risks and physical risks, respectively.[5] To merge these aggregate climate risk measures with the quarterly stock holdings data, we calculate the quarterly average of their daily values.

Figure IC.1, Panels A-C, plots the time-series variation in the cross-sectional average of ACCPP stemming from changes in total, physical, and regulatory aggregate climate change risks, respectively. This figure reveal weak correlations between CCPP and ACCPP, as well as between CCPP and aggregate climate change risks. These visual impressions are corroborated by their (unreported) low pairwise correlation coefficients.

IC.3 CCPP and ACCPP effects on firms' cost of equity

We run contemporaneous panel regressions of firms' option-implied cost of equity on their CCPP, ACCPP, and controls.

$$CoE_{t,h}(n) = \alpha + \beta_1 CCPP_t(n) + \beta_2 ACCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t,h}(n), \quad \text{(IC.11)}$$

where $CoE_{t,h}(n)$, is either the MW or GLB option-implied cost of equity for the nth stock estimated at t corresponding to the horizon h= 1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year. We consider the stock-level CCPP (and ACCPP) arising from institutional portfolio rebalancing triggered by firm-level (and market-level) total, regulatory, and physical climate change exposures, separately. The vector $X_t(n)$ of control variables includes the log market equity, market beta, book-to-market ratio, profitability, investment, dividends-to-book equity, firm-level climate

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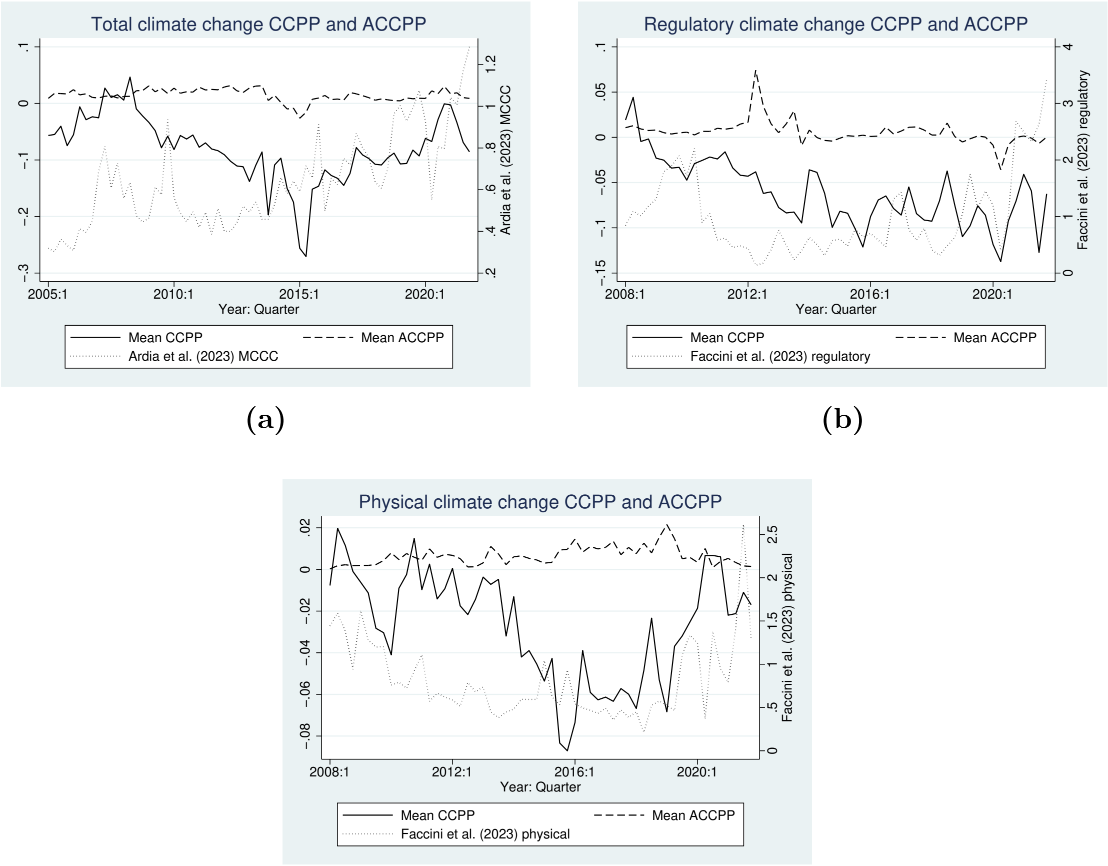
[5] Data are obtained from https://sentometrics-research.com/download/mccc/ and https://sites.google.com/view/george-skiadopoulos/research/selected-publications.



(a) **(b)**

(c)

Figure IC.1. Panels (a)-(c) plot the cross-sectional average of the CCPP (ACCPP) of the S&P 500 constituent stocks (before cross-sectional standardization) arising from investors' portfolio rebalancing triggered by changes in stocks' (aggregate) total, regulatory, and physical climate change exposures, respectively. The CCPP and ACCPP are calculated by equations (IC.9) and (IC.10), respectively. For CCPP stemming from total (topic-based) climate change exposures, the sample period spans 2005:1-2021:4 (2008:1-2021:4), as dictated by the availability of climate change exposure data discussed in Sautner et al. (2023b). We also plot the Ardia et al. (2023) market-wide climate change risk measure, Faccini et al. (2023) regulatory and physical market-wide climate change risk measures, respectively.

change exposure, momentum, and institutional ownership of the stock n at t. Furthermore, we include the year-quarter (δ_t) and industry (ϕ_j) fixed effects. Standard errors are clustered at the firm level. We multiply the estimated coefficients by 100.

Table IC.1 reports the effects of stock-level CCPP and ACCPP on the firm-level cost of equity over different horizons ranging from one month to one year. The ACCPP stemming from Ardia et al. (2023) market-level total climate change risks and Faccini et al. (2023) market-level regulatory climate change risks has a statistically significant effect on firms' option-implied cost of equity. Interestingly, the ACCPP stemming from Faccini et al. (2023) market-level physical climate change risks does not affect the cost of equity. This echoes Faccini et al. (2023) that market-wide physical risks are not priced in U.S. stocks.

Table IC.1. Effects of CCPP and ACCPP on firms' cost of equity: S&P 500 stocks

	One-month	One-quarter	Two-quarter	Three-quarter	One-year
Panel A: Martin and Wagner (2019) cost of equity					
CCPP_total	-0.248***	-0.278***	-0.264***	-0.196***	-0.159**
	(-3.88)	(-4.77)	(-4.73)	(-2.75)	(-2.32)
ACCPP_total	-0.220**	-0.151*	-0.122	-0.044	-0.042
	(-2.51)	(-1.89)	(-1.61)	(-0.45)	(-0.46)
N	39743	39739	39730	27506	26787
Adj.R^2	0.644	0.630	0.610	0.621	0.629
CCPP_reg	-0.022	-0.130	-0.139*	0.021	0.041
	(-0.25)	(-1.61)	(-1.80)	(0.22)	(0.44)
ACCPP_reg	-0.253***	-0.234***	-0.222***	-0.134	-0.122
	(-3.02)	(-3.08)	(-3.12)	(-1.60)	(-1.57)
N	32428	32427	32423	22178	21483
Adj.R^2	0.647	0.632	0.613	0.625	0.634
CCPP_phy	-0.299***	-0.301***	-0.286***	-0.280***	-0.243***
	(-4.93)	(-5.52)	(-5.53)	(-4.47)	(-4.11)
ACCPP_phy	0.045	0.065	0.068	0.073	0.065
	(0.68)	(1.19)	(1.35)	(1.03)	(0.97)
N	32428	32427	32423	22178	21483
Adj.R^2	0.647	0.633	0.613	0.626	0.635

Table continued

Table IC.1. continued

	One-month	One-quarter	Two-quarter	Three-quarter	One-year
Panel B: Chabi-Yo et al. (2023) cost of equity					
CCPP_total	-0.131***	-0.205***	-0.203***	-0.186***	-0.156***
	(-2.84)	(-6.22)	(-6.88)	(-5.17)	(-4.51)
ACCPP_total	-0.194***	-0.160***	-0.145***	-0.043	-0.033
	(-3.26)	(-3.37)	(-3.45)	(-0.80)	(-0.67)
N	39743	39739	39730	27506	26787
Adj.R^2	0.812	0.850	0.858	0.859	0.863
CCPP_reg	0.047	-0.101**	-0.119***	-0.106**	-0.090*
	(0.75)	(-2.22)	(-2.92)	(-2.16)	(-1.86)
ACCPP_reg	-0.125**	-0.168***	-0.175***	-0.111**	-0.090**
	(-2.35)	(-3.79)	(-4.33)	(-2.30)	(-2.02)
N	32428	32427	32423	22178	21483
Adj.R^2	0.806	0.846	0.854	0.855	0.859
CCPP_phy	-0.180***	-0.198***	-0.189***	-0.198***	-0.171***
	(-4.38)	(-6.36)	(-6.64)	(-5.67)	(-5.05)
ACCPP_phy	0.018	0.008	0.010	0.063*	0.060*
	(0.38)	(0.23)	(0.33)	(1.66)	(1.71)
N	32428	32427	32423	22178	21483
Adj.R^2	0.806	0.847	0.854	0.856	0.859
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Notes: This table reports panel regression results of firms' option-implied cost of equity on CCPP, ACCPP, and controls

$$CoE_{t,h}(n) = \alpha + \beta_1 CCPP_t(n) + \beta_2 ACCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t,h}(n),$$

where $CoE_{t,h}(n)$, is either the Martin and Wagner (2019) (Panel A) or Chabi-Yo et al. (2023) (Panel B) option-implied cost of equity for stock n estimated at t corresponding to the horizon h=1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year. We include CCPP (ACCPP) arising from institutional portfolio rebalancing triggered by changes in firm-level (aggregate) total, regulatory, and physical climate change exposures, separately. The vector of control variables $X_t(n)$ for the nth stock includes the market beta, log market equity, book-to-market ratio, profitability, investment, dividends-to-book equity, firm-level climate change exposure, momentum, and institutional ownership. All independent variables are cross-sectionally standardized within each quarter across S&P 500 stocks. Year-quarter and industry fixed effects are included. Standard errors are clustered at the firm level, and the corresponding t-statistics are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The S&P 500 sample period spans 2005:1-2021:4 (2008:1-2021:4) for the total (topic-based) climate change exposures. We multiply the estimated coefficients by 100 for display purposes.

IC.4 CCPP and ACCPP effects on firms' future environmental profiles

To examine the effects of aggregate climate shocks on firms' future environmental profiles, we regress firms' future green activities on CCPP, ACCPP, controls, and fixed effects.

$$\Delta Y_{t+h}(n) = \alpha + \beta_1 CCPP_t(n) + \beta_2 ACCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t+h}(n), \quad \text{(IC.12)}$$

where $\Delta Y_{t+h}(n)$ is the h-period ahead change in firm n's (i) number of green filed patents, (ii) ratio of green filed patents to log market equity, (iii) economic real value of green filed patents, (iv) ratio of environmental expenditures to total assets, (v) ratio of environmental provisions to total assets, (vi) ratio of environmental fines to total assets, and (vii) emission intensities, separately. The forecasting horizon $h =$ one year, two years, three years, four years, and five years ahead (columns 1-5, respectively).

Table IC.2 reports the results for CCPP and ACCPP stemming from total climate change exposures and aggregate climate shocks. Due to space constraints, results for other types of climate risks are omitted but are similar. Overall, firms do not significantly change their future green activities in response to CCPP and ACCPP. These findings confirm that institutional climate-triggered price pressure does not affect firms' future climate change profiles, even when firm-level and market-wide risks are jointly considered.

Table IC.2. Effects of CCPP and ACCPP on firms' green activities: S&P 500 stocks

	One-year	Two-year	Three-year	Four-year	Five-year
Panel A: #Green filed patents					
CCPP_total	-0.122*	-0.113	0.014	0.057	0.075
	(-1.69)	(-1.12)	(0.10)	(0.27)	(0.27)
ACCPP_total	0.072	0.160	0.305	0.441	0.449
	(0.76)	(0.68)	(0.72)	(0.73)	(0.61)
N	9324	8585	7868	7191	6517
Adj.R^2	0.008	0.018	0.031	0.043	0.043
Panel B: Green filed patents/log market equity					
CCPP_total	-0.011*	-0.013	-0.002	0.002	0.004
	(-1.72)	(-1.44)	(-0.18)	(0.12)	(0.16)
ACCPP_total	0.005	0.012	0.024	0.033	0.031
	(0.66)	(0.64)	(0.70)	(0.67)	(0.54)
N	9324	8585	7868	7191	6517
Adj.R^2	0.012	0.023	0.036	0.048	0.047
Panel C: Economic real value of green filed patents					
CCPP_total	-0.275	1.693	3.556	3.074	2.445
	(-0.31)	(0.78)	(1.33)	(1.11)	(0.85)
ACCPP_total	-1.759	1.709	3.597	4.569	3.238
	(-0.89)	(0.66)	(0.98)	(0.98)	(0.60)
N	9324	8585	7868	7191	6517
Adj.R^2	0.047	0.079	0.106	0.136	0.140
Panel D: Environmental expenditures/total assets					
CCPP_total	21.684	11.395	24.289	36.073	40.059
	(0.75)	(0.24)	(0.45)	(0.58)	(0.54)
ACCPP_total	9.705	-27.767	-16.415	67.658	81.333
	(0.25)	(-0.27)	(-0.09)	(0.34)	(0.40)
N	9312	8576	7857	7181	6508
Adj.R^2	0.016	0.029	0.040	0.048	0.062
Panel E: Environmental provisions/total assets					
CCPP_total	16.979	-18.036	-14.056	9.448	27.395
	(0.73)	(-0.51)	(-0.33)	(0.17)	(0.43)
ACCPP_total	78.502	63.198	48.670	65.316	54.074
	(1.46)	(1.01)	(0.65)	(1.07)	(0.91)
N	8716	7996	7295	6631	5968
Adj.R^2	0.035	0.050	0.079	0.116	0.143
Panel F: Environmental fines/total assets					
CCPP_total	0.001	-0.001	-0.007	-0.005	-0.008
	(0.16)	(-0.15)	(-0.78)	(-0.57)	(-0.73)
ACCPP_total	-0.003	-0.004	0.003	0.016	0.005
	(-0.74)	(-0.45)	(0.30)	(1.04)	(0.29)
N	6897	6216	5552	4920	4286
Adj.R^2	0.180	0.152	0.294	0.308	0.441

Continued

Table IC.2. continued

	One-year	Two-year	Three-year	Four-year	Five-year
Panel G: Trucost total carbon emission intensities					
CCPP_total	-1.998	-3.053	-4.262	-3.339	-4.610
	(-0.36)	(-0.36)	(-0.44)	(-0.32)	(-0.46)
ACCPP_total	2.077	3.536	10.015	19.246	19.983
	(0.26)	(0.25)	(0.54)	(0.93)	(0.97)
N	7236	6696	6163	5646	5133
Adj.R^2	0.102	0.196	0.291	0.385	0.439
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Notes: This table reports panel regression results of firms' future changes in green activities on CCPP, ACCPP, and controls:

$$\Delta Y_{t+h}(n) = \alpha + \beta_1 CCPP_t + \beta_2 ACCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t+h}(n),$$

where $\Delta Y_{t+h}(n)$ is the h-period ahead changes in firm n's (i) number of green filed patents, (ii) ratio of green filed patents to log market equity, (iii) economic real value of green filed patents, (iv) ratio of environmental expenditures to total assets, (v) ratio of environmental provisions to total assets, (vi) ratio of environmental fines to total assets, and (vii) emission intensities, separately. The forecasting horizon h =1 year, 2 years, 3 years, 4 years, and 5 years ahead (Columns 1-5, respectively). We include CCPP (ACCPP) arising from institutional portfolio rebalancing triggered by changes in firm-level (and aggregate) total, regulatory, and physical climate change exposures, separately. $X_t(n)$ is the vector of control variables: size, asset tangibility, leverage, profitability, cash ratio, capital expenditures, R&D expenses, institutional ownership for stock n, and firm n's current environmental profile. All independent variables are cross-sectionally standardized within each quarter across S&P 500 stocks. Year-quarter and industry fixed effects are included. Standard errors are clustered at the firm level, and the corresponding t-statistics are reported in parentheses. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The quarterly S&P 500 stocks sample period is from 2005 to 2021.

ID CCPP and firms' future environmental profiles: Does greenness matter?

We follow Hartzmark and Shue (2023) and classify the firms into quintiles according to their Trucost emission intensities reported in the previous year. Quintiles 1 and

5 represent green and brown firms, respectively, and the middle three quintiles represent neutral firms. We regress future changes in the green variables considered in Section 4.4 on the interaction of CCPP and a type indicator with three categories (Brown, Neutral, and Green), controls, and fixed effects as in equation (5):

$$\Delta Y_{t+h}(n) = \alpha + \beta_1 CCPP_t(n) \times Type_t(n) + \beta_2 Type_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t+h}(n), \tag{ID.13}$$

Table ID.1 reports the coefficients of the interaction terms between CCPP and firm types (Brown, Neutral, and Green) for CCPP stemming from total climate change exposures. We can see that CCPP is not significantly related to firms' future environmental profiles, even when firms are considered separately by type, thus confirming the evidence in Section 5.2. Results remain robust when considering CPPP stemming from any type of climate change exposures, as well as ACCPP effects.

Table ID.1. Brown firms, Green firms, CCPP, and firms' green activities: S&P 500 stocks

	One-year	Two-year	Three-year	Four-year	Five-year
	Panel A: #Green filed patents				
CCPP_total × Brown	-0.045	-0.077	-0.103	-0.170	-0.328
	(-0.67)	(-0.47)	(-0.56)	(-0.75)	(-1.00)
CCPP_total × Neutral	-0.220	-0.291	-0.158	-0.074	0.071
	(-1.60)	(-1.59)	(-0.67)	(-0.21)	(0.15)
CCPP_total × Green	0.021	0.063	0.089	-0.058	-0.199
	(0.25)	(0.40)	(0.36)	(-0.20)	(-0.59)
N	7006	6475	5945	5443	4964
Adj.R^2	0.005	0.015	0.026	0.030	0.026

Continued

Table ID.1. continued

	One-year	Two-year	Three-year	Four-year	Five-year
Panel B: Green filed patents/log market equity					
CCPP_total × Brown	-0.004	-0.007	-0.009	-0.012	-0.023
	(-0.67)	(-0.48)	(-0.55)	(-0.54)	(-0.70)
CCPP_total × Neutral	-0.021*	-0.030*	-0.019	-0.011	0.001
	(-1.74)	(-1.87)	(-0.93)	(-0.36)	(0.02)
CCPP_total × Green	0.003	0.006	0.007	-0.004	-0.015
	(0.35)	(0.45)	(0.34)	(-0.16)	(-0.53)
N	7006	6475	5945	5443	4964
Adj.R^2	0.010	0.020	0.032	0.038	0.033
Panel C: Economic real value of green filed patents					
CCPP_total × Brown	0.482	5.730	2.999	1.185	-2.172
	(0.18)	(0.93)	(0.47)	(0.26)	(-0.43)
CCPP_total × Neutral	-0.744	-0.595	1.949	1.315	1.874
	(-0.41)	(-0.21)	(0.58)	(0.35)	(0.41)
CCPP_total × Green	-1.118	1.534	6.406	4.209	2.921
	(-0.36)	(0.38)	(1.42)	(0.74)	(0.42)
N	7006	6475	5945	5443	4964
Adj.R^2	0.040	0.057	0.078	0.094	0.087
Panel D: Environmental expenditures/total assets					
CCPP_total × Brown	64.079	47.666	200.950	41.538	43.468
	(0.62)	(0.22)	(0.75)	(0.09)	(0.08)
CCPP_total × Neutral	4.065	-26.804	-43.468	-55.138	-51.734
	(0.18)	(-0.81)	(-0.81)	(-0.81)	(-0.71)
CCPP_total × Green	-30.538	-55.020	-48.220	-72.366	-103.134
	(-1.32)	(-1.50)	(-0.91)	(-1.01)	(-1.20)
N	7003	6473	5940	5438	4959
Adj.R^2	0.009	0.019	0.029	0.036	0.046
Panel E: Environmental provisions/total assets					
CCPP_total × Brown	19.449	-34.944	104.419	295.633	334.503
	(0.33)	(-0.35)	(0.79)	(1.62)	(1.37)
CCPP_total × Neutral	-31.604	-35.574	-12.778	-13.815	6.320
	(-1.39)	(-1.00)	(-0.32)	(-0.26)	(0.11)
CCPP_total × Green	-30.610	-46.894	-48.823	-47.153	-52.312
	(-1.57)	(-1.29)	(-1.01)	(-0.74)	(-0.68)
N	6677	6147	5617	5115	4638
Adj.R^2	0.033	0.065	0.106	0.158	0.196
Panel F: Environmental fines/total assets					
CCPP_total × Brown	0.021	0.027	0.029	0.056	0.037
	(1.14)	(1.26)	(0.92)	(1.49)	(0.82)
CCPP_total × Neutral	0.001	0.004	-0.004	-0.012	-0.005
	(0.13)	(0.71)	(-0.71)	(-1.21)	(-0.61)
CCPP_total × Green	-0.002	-0.005	-0.009	-0.014*	-0.006
	(-0.54)	(-0.97)	(-1.47)	(-1.96)	(-0.92)
Adj.R^2	0.183	0.152	0.292	0.293	0.455
N	5466	4940	4415	3916	3440

Continued

Table ID.1. continued

	One-year	Two-year	Three-year	Four-year	Five-year
Panel G: Trucost total carbon emission intensities					
CCPP_total × Brown	-0.390	5.858	-1.115	-5.034	-5.751
	(-0.09)	(0.74)	(-0.09)	(-0.29)	(-0.29)
CCPP_total × Neutral	-0.282	0.304	-0.344	-0.296	-1.086
	(-0.53)	(0.33)	(-0.27)	(-0.17)	(-0.58)
CCPP_total × Green	0.272	1.050	1.507	3.324	4.166
	(0.45)	(1.03)	(1.00)	(1.46)	(1.36)
N	7088	6553	6022	5508	5018
Adj.R^2	0.150	0.239	0.294	0.298	0.333
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Notes: This table reports panel regressions of firms' future green activities on the interaction terms between stock-level CCPP and a type variable (an indicator of brown, neutral, and green firms), and controls:

$$\Delta Y_{t+h}(n) = \alpha + \beta_1 CCPP_t(n) \times Type_t(n) + \beta_2 Type_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t+h}(n),$$

where $\Delta Y_{t+h}(n)$ is the h-period ahead changes in firm n's (i) number of green filed patents, (ii) ratio of green filed patents to log market equity, (iii) economic real value of green filed patents, (iv) ratio of environmental expenditures to total assets, (v) ratio of environmental provisions to total assets, (vi) ratio of environmental fines to total assets, and (vii) emission intensities, separately. The forecasting horizon h =1 year, 2 years, 3 years, 4 years, and 5 years ahead (Columns 1-5, respectively). We include the interaction term between stock-level CCPP (stemming from total exposures, $CCPP_t(n)$) and the type of brown, neutral and green firms. $X_t(n)$ is the vector of control variables: size, asset tangibility, leverage, profitability, cash ratio, capital expenditures, R&D expenses, institutional ownership for stock n, and the firm n's current environmental profile. All independent variables are cross-sectionally standardized within each quarter across S&P 500 stocks. Year-quarter and industry fixed effects are included. Standard errors are clustered at the firm level and the corresponding t-statistics are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The S&P 500 sample period is from 2005 to 2021.

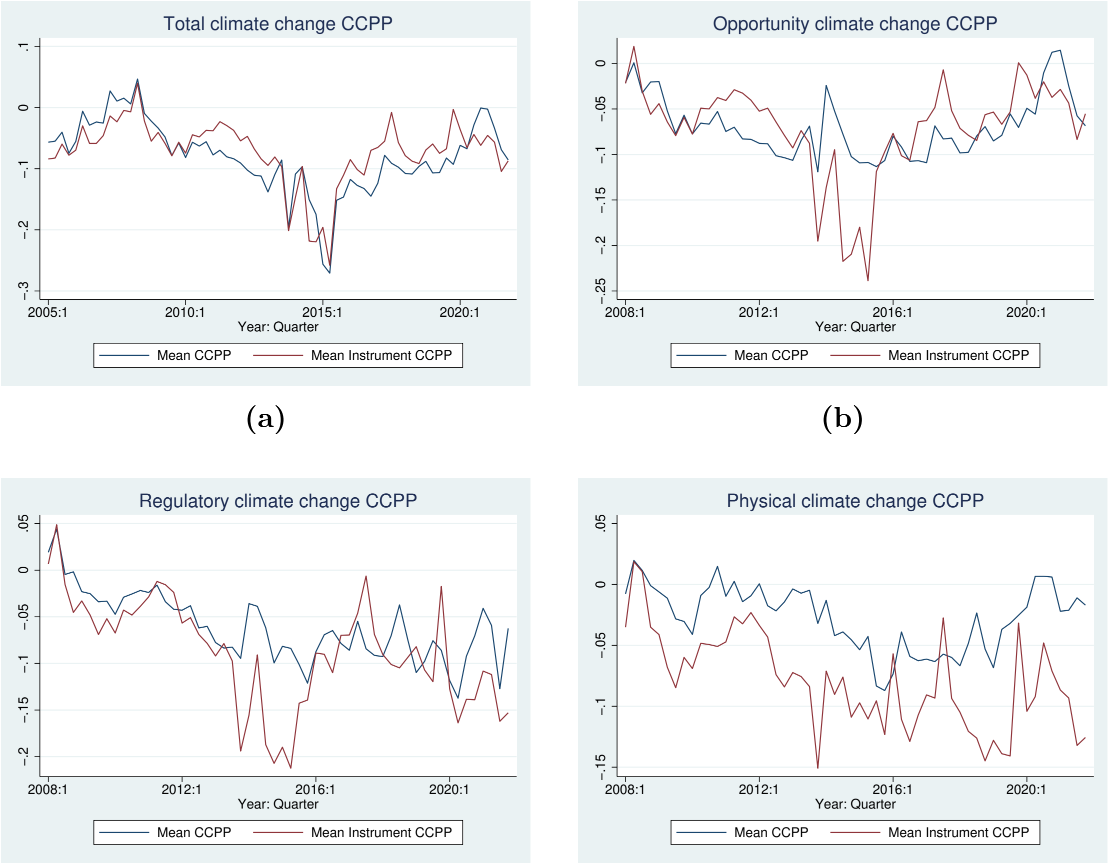
IE On reverse causality

The relation between portfolio holdings and climate change exposures may be bi-directional, given that previous literature has examined both directions. Hence, one may argue that the estimation of equation (2) in the main body of the paper may be subject to reverse causality concerns. In Appendix IE, we further investigate this and find that our results are not subject to a reverse causality concern.

A remark is in order at this point. The contemporaneous relation of portfolio weights and firm-level climate change exposures, as specified in equation (2) in the paper, is not an ad hoc choice. Instead, it is derived within the Koijen and Yogo (2019) theoretical setting. Following Hartzmark and Shue (2023), we use 2-digit SIC codes to construct a stock-specific instrument for firm-level climate change exposures. For each firm and each quarter, we construct the instrument by calculating the industry average of climate change exposures, excluding the focal firm. The constructed instrument is not subject to the reverse causality concern, as the portfolio weight of an individual stock can not affect the industry average (excluding the focal firm) of climate change exposures (see also Hartzmark and Shue (2023) for analogous reasoning). We use the constructed instrument to estimate the model (2) in the paper.

Once we estimate the coefficients $\beta_{0,i,t}$ and $\beta_{1,i,t}$, we calculate a new firm-level CCPP (termed instrumentalized CCPP) via (IC.9), which captures how changes in the industry average of climate change exposures affect the individual firm's stock prices. Figure IE.1, Panels (a)-(d), plots the cross-sectional average CCPP (instrumentalized CCPP) for S&P 500 constituent stocks over time, resulting from investors' portfolio rebalancing triggered by changes in the (industry average excluding the focal company) total, opportunity, regulatory, and physical exposures of companies, respectively. We can see that their patterns are very similar.

Next, we run the similar analysis as in Section 4.2 in the paper by regressing the option-implied cost of equity on the four instrumentalized CCPP, including the same control variables as in equation (4) in the paper. Table IE.1 confirms the robustness of the results in Section 4.2. The instrumentalized CCPP is significantly negatively correlated with the option-implied cost of equity.



(a) **(b)**

(c) **(d)**

Figure IE.1. Panels (a)-(d) plot the cross-sectional average CCPP (instrumentalized CCPP) of S&P 500 constituent stocks (before cross-sectional standardization), arising from investors' portfolio rebalancing triggered by changes in stocks' (industry average of) total, opportunity, regulatory, and physical climate change exposures, respectively. The CCPP is calculated by equation (IC.9). For CCPP stemming total (topic-based) climate change exposures, the sample period spans 2005:1-2021:4 (2008:1-2021:4), as dictated by the availability of climate change exposure data discussed in Sautner et al. (2023b).

Table IE.1. Effects of instrumentalized CCPP on firms' cost of equity: S&P 500 stocks

	One-month	One-quarter	Two-quarter	Three-quarter	One-year
Panel A: Effects on Martin and Wagner (2019) cost of equity					
InstrumentCCPP_total	-0.291***	-0.330***	-0.323***	-0.309***	-0.288***
	(-4.64)	(-5.82)	(-5.97)	(-4.66)	(-4.54)
N	39739	39735	39726	27506	26787
Adj.R^2	0.644	0.630	0.611	0.622	0.630
InstrumentCCPP_opp	-0.413***	-0.445***	-0.430***	-0.411***	-0.386***
	(-5.74)	(-6.84)	(-6.97)	(-5.36)	(-5.26)
N	32424	32423	32419	22178	21483
Adj.R^2	0.648	0.634	0.614	0.627	0.636
InstrumentCCPP_reg	-0.188**	-0.274***	-0.280***	-0.238***	-0.222***
	(-2.35)	(-3.77)	(-4.02)	(-2.71)	(-2.64)
N	32424	32423	32419	22178	21483
Adj.R^2	0.647	0.632	0.613	0.625	0.634
InstrumentCCPP_phy	-0.215***	-0.280***	-0.283***	-0.243***	-0.222***
	(-3.17)	(-4.58)	(-4.92)	(-3.68)	(-3.58)
N	32424	32423	32419	22178	21483
Adj.R^2	0.647	0.633	0.613	0.626	0.635
Panel B: Effects on Chabi-Yo et al. (2023) cost of equity					
InstrumentCCPP_total	-0.156***	-0.217***	-0.220***	-0.224***	-0.206***
	(-3.49)	(-6.87)	(-7.78)	(-6.46)	(-6.24)
N	39739	39735	39726	27506	26787
Adj.R^2	0.812	0.850	0.858	0.859	0.863
InstrumentCCPP_opp	-0.211***	-0.277***	-0.276***	-0.284***	-0.261***
	(-4.02)	(-7.54)	(-8.49)	(-7.06)	(-6.79)
N	32424	32423	32419	22178	21483
Adj.R^2	0.806	0.847	0.855	0.856	0.860
InstrumentCCPP_reg	-0.117**	-0.219***	-0.232***	-0.252***	-0.238***
	(-2.05)	(-5.53)	(-6.60)	(-5.82)	(-5.77)
N	32424	32423	32419	22178	21483
Adj.R^2	0.806	0.847	0.854	0.856	0.859
InstrumentCCPP_phy	-0.121**	-0.202***	-0.216***	-0.226***	-0.221***
	(-2.48)	(-5.85)	(-7.04)	(-6.46)	(-6.59)
N	32424	32423	32419	22178	21483
Adj.R^2	0.806	0.847	0.855	0.856	0.860
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Notes: This table reports panel regression results of firms' option-implied cost of equity on the instrumentalized CCPP and controls

$$CoE_{t,h}(n) = \alpha + \beta_1 InstrumentCCPP_t(n) + \boldsymbol{\gamma}'\mathbf{X}_t(n) + \delta_t + \phi_j + \epsilon_{t,h}(n),$$

where $CoE_{t,h}(n)$, is the nth stock Martin and Wagner (2019) (Panel A) and Chabi-Yo et al. (2023) (Panel B) option-implied cost of equity estimated at t over alternative horizons h=1 month, 1 quarter, 2 quarters, 3 quarters, and 1 year. We include the instrumentalized CCPP arising from investor portfolio rebalancing triggered by changes in industry average (excluding the focal company) of total ($InstrumentCCPP_t(n)$), opportunity ($InstrumentCCPPOpp_t(n)$), regulatory ($InstrumentCCPPReg_t(n)$), and physical climate change exposures ($InstrumentCCPPPhy_t(n)$), separately. The vector of control variables $X_t(n)$ for the nth stock includes the market beta, log market equity, book-to-market ratio, profitability, investment, dividends-to-book equity, firm-level climate change exposure, momentum, and institutional ownership. All independent variables are cross-sectionally standardized within each quarter across S&P 500 stocks. Year-quarter and industry fixed effects are included. Standard errors are clustered at the firm level and the corresponding t-statistics are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The S&P 500 sample period spans 2005:1-2021:4 (2008:1-2021:4) for the total (topic-based) climate change exposures. We multiply the estimated coefficients by 100 for display purposes.

IF An application of CCPP metrics: The case of Harvard University Endowment

Investor-level estimates of the sensitivity coefficients $\beta_{1,i,t}$ in equation (IC.5), which contribute to the CCPP estimation, can shed light on how investors' portfolio rebalancing aligns with their sustainability statements. We conduct a case study on Harvard University's endowment, the largest university endowment worldwide with \$53.2 billion assets under management in fiscal year 2024. The Harvard Management Company (HMC) manages the university's endowment. In the 13F database, HMC reports its holdings as an "other" type of institutional investor. As of March 2024, HMC reported that its fossil fuel investments had declined to below 2% of the total endowment, approximately \$1 billion. This reduction aligns with Harvard's pledge to divest from fossil fuels and reach net-zero emissions across its endowment by 2050.

We estimate equation (IC.5) for HMC by pooling its portfolio weight data on the U.S. common stocks across quarters. Table IF.1 reports the estimated β_1 coefficients on climate change exposures for HMC. On average, HMC underweights stocks with higher total, opportunity, and regulatory climate change exposures, while overweighting stocks with higher physical exposures. Hence, HMC contributes to a negative CCPP resulting from total, opportunity, and regulatory exposures, and absorbs the negative CCPP from physical exposures by being on the other side of the trade when portfolios are adjusted.

Table IF.1. Harvard Management Company: Estimated β_1 coefficients on climate change exposures

	Total	Opp	Reg	Phy
Coefficients	-0.061***	-0.339***	-0.339***	0.219***
	(0.001)	(0.001)	(0.001)	(0.001)
N	19669	9747	9747	9747
Controls	Yes	Yes	Yes	Yes

Notes: This table reports the estimated β_1 coefficients by GMM in equation (IC.5) for Harvard Management Company. We proxy climate change exposures by the total (*Total*), opportunity (*Opp*), regulatory (*Reg*), and physical (*Phy*) climate change exposures (Columns 1, 2, 3, and 4, respectively). We employ U.S. common stock portfolio holdings by Harvard Management Company. We use the same stock characteristics variables as in Koijen and Yogo (2019) (market beta, log market equity, log book equity, profitability, investment, and dividend to book equity). Following Koijen et al. (2024), we cross-sectionally standardize all characteristics, except log market equity and log book equity, within each quarter and across the U.S. common stocks. Standard errors clustered at the investor level are reported in brackets. One, two, and three asterisks denote the significance at the 10%, 5%, and 1% significance levels, respectively. The quarterly sample period is 2005:1 to 2021:4 (2008:1 to 2021:4) for total (topic-based) climate change exposures.

However, we expect that divestment by a *single* endowment alone is unlikely to have an impact on the prices of the divested companies, even in the case of the largest endowment, such as HMC. The previous literature has outlined the theoretical conditions under which such an effect can exist, namely the vast proportion of investors in the economy needs to be "green" and the correlation between the returns of green and brown stocks needs to be low (Heinkel et al. (2001), Berk and van Binsbergen (2025)). Considering the vast scale of the global fossil fuel industry, Harvard's holdings represent a minuscule fraction of the market. For example, major oil companies like ExxonMobil have market capitalizations exceeding $400 billion. Therefore, while Harvard's divestment is symbolically significant, it is unlikely to have a direct financial impact on the stock prices of these large firms. However, the symbolic and reputational effects of such divestments can be substantial. Harvard's decision may influence other institutions and investors to reconsider their positions on fossil fuel investments, potentially contributing to broader shifts in investment patterns over time. Aligning endowment investment strategies with climate goals also reinforcesthe university's wider educational and research missions.

We also examine whether our estimated coefficients $\beta_{1,i,t}$ for HMC are consistent with statements made by its top management on its divestment policy from fossil fuels, as well as related actions by Harvard's affiliates over time.[6] We estimate equation (IC.5) using HMC's quarterly cross-sectional portfolio weights on U.S. common stocks and examine the time series evolution of the estimated $\beta_{1,i,t}$ coefficients. Figure IF.1, Panels (a)-(d), plots the time series of HMC's $\beta_{1,i,t}$ coefficients on total, opportunity, regulatory, and physical climate change exposures, respectively. We can see that HMC's sensitivity to climate-related exposures is predominantly negative over the sample period, aligning with Harvard's commitment to endowment divestment and the related initiatives.

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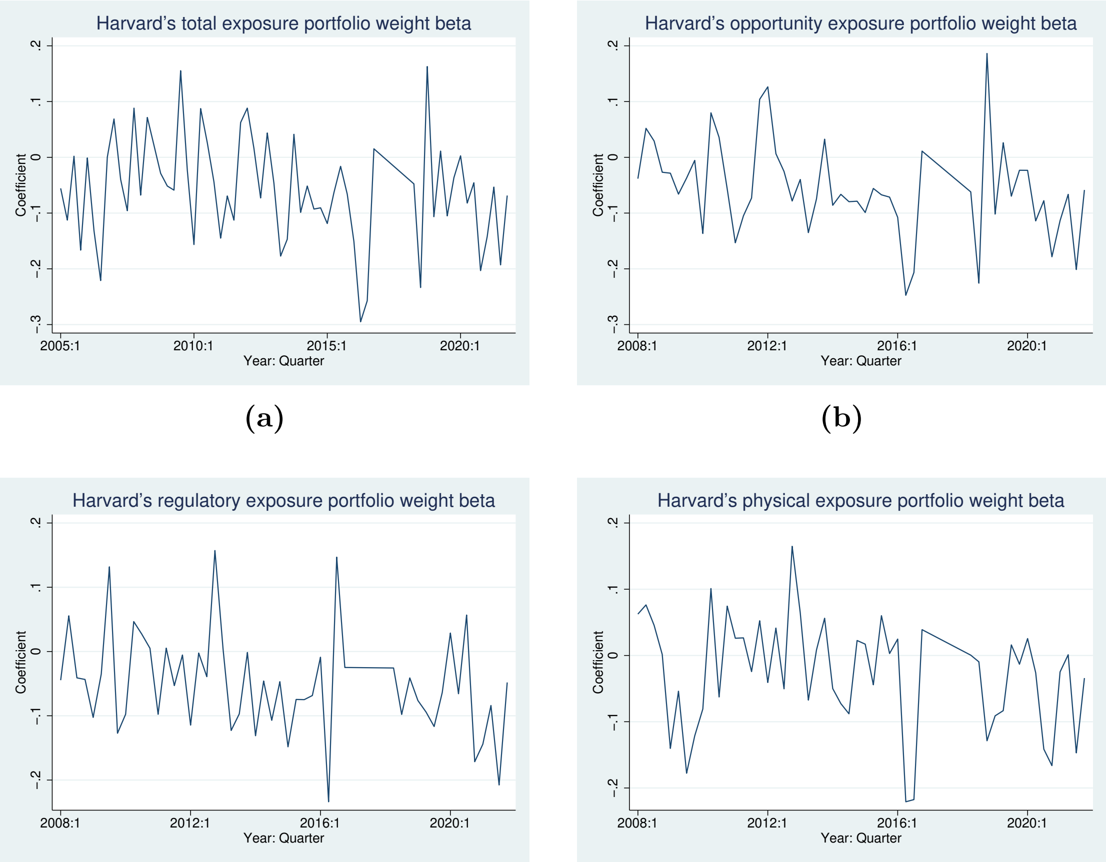
[6] HMC signed UNPRI on 25 April 2014, demonstrating its commitment to responsible investment. In February 2018, Harvard became the first university endowment to commit to achieving net-zero greenhouse gas emissions across its entire investment portfolio by 2050. To this end, HMC divested from companies engaged in the exploration or development of fossil fuel reserves and has reduced its exposure to fossil fuels from approximately 11% in 2008 to less than 2% of the endowment by fiscal year 2020, https://www.harvard.edu/president/news-and-statements-by-president-bacow/2021/climate-change-update-on-harvard-action/. Over time, Harvard has taken active steps toward endowment divestment. For example, Fossil Fuel Divest Harvard, a coalition of students, alumni, and faculty, advocates for a just and sustainable future (https://divestharvard.com/). In addition, Harvard Faculty for Divestment, a group of over 1,000 faculty members from the university, has played a key role in pushing for fossil fuel divestment and has continued to support broader decarbonization initiatives. A timeline of their efforts can be found at https://www.harvardfacultydivest.com/resources/timeline.



(a) **(b)**

(c) **(d)**

Figure IF.1. Panels (a)-(d) plot the time-series evolution of Harvard Management Company’s sensitivity of relative portfolio weights with respect to total, opportunity, regulatory, and physical exposures, respectively (i.e., $\beta_{1,i,t}$ estimated from equation (IC.5)). We employ U.S. common stock portfolio holdings by Harvard Management Company. We use the same stock characteristics variables as in Koijen and Yogo (2019) (Market beta, log market equity, log book equity, profitability, investment, and dividend to book equity). Following Koijen et al. (2024), we cross-sectionally standardize all characteristics, except log market equity and log book equity, within each quarter and across U.S. common stocks. The coefficients on the total (topic-based) climate change exposures are estimated over the period 2005:1-2021:4 (2008:1-2021:4), as dictated by the availability of climate change exposure data discussed in Sautner et al. (2023b).

References

Ardia, D., Bluteau, K., Boudt, K., and Inghelbrecht, K. (2023). Climate Change Concerns and the Performance of Green Versus Brown Stocks. *Management Science*, 69(12):7607–7632.

Berk, J. B. and van Binsbergen, J. H. (2025). The Impact of Impact Investing. *Journal of Financial Economics*, 164:103972.

Black, F. and Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy*, 81(3):637–657.

Chabi-Yo, F., Dim, C., and Vilkov, G. (2023). Generalized Bounds on the Conditional Expected Excess Return on Individual Stocks. *Management Science*, 69(2):922–939.

Faccini, R., Matin, R., and Skiadopoulos, G. (2023). Dissecting Climate Risks: Are They Reflected in Stock Prices? *Journal of Banking and Finance*, 155:106948.

Hartzmark, S. M. and Shue, K. (2023). Counterproductive Sustainable Investing: The Impact Elasticity of Brown and Green Firms. Working paper, Boston College.

Heinkel, R., Kraus, A., and Zechner, J. (2001). The Effect of Green Investment on Corporate Behavior. *Journal of Financial and Quantitative Analysis*, 36(4):431–449.

Koijen, R. S. J., Richmond, R. J., and Yogo, M. (2024). Which Investors Matter for Equity Valuations and Expected Returns? *Review of Economic Studies*, 91:2387–2424.

Koijen, R. S. J. and Yogo, M. (2019). A Demand System Approach to Asset Pricing. *Journal of Political Economy*, 127(4):1475–1515.

Martin, I. W. and Wagner, C. (2019). What Is the Expected Return on a Stock? *Journal of Finance*, 74(4):1887–1929.

Sautner, Z., van Lent, L., Vilkov, G., and Zhang, R. (2023a). Firm-Level Climate Change Exposure. *Journal of Finance*, 78(3):1227–1831.

Sautner, Z., van Lent, L., Vilkov, G., and Zhang, R. (2023b). Pricing Climate Change Exposure. *Management Science*, 69(12):7540–7561.

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