Environmental Preferences and Sector Valuations

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Abstract

This paper examines the dynamic nature of pro-environmental preferences through the analysis of sector valuations in global equity markets from 2018 to 2021. We classify companies' business activities into three categories: green (e.g., renewables), neutral, and brown (e.g., fossil energy). We then test, based on panel regressions, whether being in the green or brown sectoral category affects stock valuations. We find that investors value sector affiliation, positively for green and negatively for brown, even after controlling for other firm-level financial and extra-financial characteristics. The effect is sizeable, as we report a 20% overvaluation of companies in green sectors and a 13% undervaluation of companies in brown sectors on average over the period compared to the rest of the market. In addition, companies belonging to green sectors have come under increased scrutiny by investors since 2018 and appear increasingly overvalued relative to the rest of the market, suggesting that pro-environmental preferences have become more prevalent among investors.

Keywords: Environmental preferences, Green bubble, Mispricing, Stock market, Stranded assets, Valuation ratios

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1 Introduction

> *"We believe that sustainability should be our new standard for investing."*
>
> Blackrock's 2020 letter to clients

> *"Central banks walk the talk, increasingly integrating sustainability aspects into the investment process, within the limits of their mandate."*
>
> Sabine Mauderer, Chair of the NGFS' "Scaling-up green finance" workstream

Greening financial portfolios have become a central topic of the financial community. Along with the recent pledge by many countries to reduce greenhouse gas emissions (UNEP, 2021), urgent environmental, climate, and biodiversity issues have prompted institutional investors to become more active in monitoring the environmental impact of their portfolios. Moreover, according to the surveys of Krueger et al. (2020) and Stroebel and Wurgler (2021), investors have begun to factor the financial implications of climate change into portfolio risk management. Against this background, an increasing number of financial institutions have formed coalitions to encourage companies to reduce their environmental footprint (e.g., Climate Action 100+) or have made net zero commitments (e.g., Glasgow Financial Alliance for Net Zero).

Nevertheless, the process of greening financial portfolios might be hampered by heterogeneous preferences among investors (Pedersen et al., 2021) and uncertainty in assessing the environmental status of companies. Some papers point out that financial markets seem to remain inefficient in forecasting environmental risks and tend to under-price them (e.g., Alok et al., 2020; Hong et al., 2019; Kruttli et al., 2021), which is a key concern for public authorities (e.g., IMF, 2020; NGFS, 2022). In addition, the uncertainty in assessing the environmental status of companies is illustrated by the significant disagreement among ESG scores (Berg et al., 2021; Billio et al., 2021; Gibson Brandon et al., 2021; Krueger et al., 2021) or debatable practice from data providers (Berg et al., 2020). Importantly, the lack of a common framework and reliable information on environmental assets creates several risks, namely (i) a dispersion of green investment flows towards non-sustainable assets (Billio et al., 2021), (ii) an incentive to green signaling by firms and funds that can lead to green washing (Bams & van der Kroft, 2022; Dumitrescu et al., 2022; Yang, 2022; Yu et al., 2020)[1], and (iii) over-investment in certain easily identifiable green companies (e.g., Bofinger et al., 2022; Bolton & Kacperczyk, 2021) that may support the emergence of a green bubble (e.g., Borio et al., 2023).[2]

[1] The risk of "green washing" prompted political initiatives to improve disclosure and compliance (NGFS, 2022)

[2] See also: The Economist, *A green bubble? We dissect the investment boom.* May 2021; Project Syndicate, *The Fallacy of Climate Financial Risk.* July 2021 (by John Cochrane).

Against this background, this paper examines the dynamic nature of pro-environmental preferences through the analysis of sector valuations in equity markets. We believe that the study of sector valuations is particularly appropriate given the absence of a reliable common definition of green and brown firms. Sector affiliation is arguably a more objective, consensual, and easily observable characteristic than other individual rankings based on environmental scores or carbon emissions, and less easily manipulated. Therefore, green and brown sectors are more likely to accurately reflect pro-environmental preferences than other metrics, providing a better framework for analysis. Furthermore, we focus on valuation ratios since equity prices need to be viewed against company fundamentals in order to determine whether they are overstretched, a key concept for analyzing the build-up of pro-environmental preferences and its implication on stock markets. It should be noted that we cannot discern whether the "mispricing" of green or brown sectors is driven by purely non-financial motives or whether investors try to hedge against a potential "green swan"[3] that would not be reflected in analyst earnings forecasts. For this reason, we use a broad definition of environmental preferences that incorporates both taste and potential disagreement about probability distributions of future payoffs on assets (e.g., Fama & French, 2007). The main hypothesis we test in the paper is that the development of environmental preferences has changed investor demand for green and brown stocks, leading to an increase in the valuation of green sectors and a decrease in the valuation of brown sectors, relative to the rest of the market. Next, we complement our findings by studying the degree of attention of investors about firms operating in green or brown sectors, based on equity turnover rates. We notably assume that the build-up of environmental preferences would lead to increased investor attention regarding both green and brown companies.

To test our main hypothesis, we study the effect of sector affiliation (i.e., operating in a green, neutral, or brown business activity) on stock valuation, after controlling for a large set of financial and extra-financial characteristics. We estimate this effect by running panel regressions, first over the entire sample period (2018–2021) and then separately for each year to detect possible changes in the coefficients. Dynamic estimations are useful to understand whether the valuation of green and brown sectors has evolved in recent years, a potential signal of the strengthening of pro-environmental preferences. Overall, this study can help assess whether investors use information on sector affiliation to evaluate the environmental status of companies, a critical element in designing a common taxonomy.[4] Moreover, our analysis assists in identifying where potential financial stability risks associated with overvaluation lie, which is particularly important given recent concerns about the emergence of a green bubble. Finally, our results provide some insight into the respective effects of positive and negative screenings in portfolio allocation strategies, defined as the inclusion or exclusion of some assets based on

[3]Bolton et al. (2020) define the green swan as "potentially extremely financially disruptive events that could be behind the next systemic financial crisis".

[4]Regulatory authorities are currently devoting resources to improve corporate environmental disclosure and to develop a common framework for identifying green assets (e.g., EU taxonomy for sustainable activities).

environmental characteristics, on the valuation of companies belonging to green and brown sectors.

Our empirical analysis is based on an international sample of listed firms included in the Datastream World portfolio that we track at a monthly frequency from 2018 to 2021. The study begins in 2018 due to numerous indications of significant growth in the sustainable asset management industry after this date (e.g., Aramonte & Zabai, 2021; Caramichael & Rapp, 2022). We also detect a sharp increase in internet searches for environmental, social and governance criteria after 2018, according to Google Trends (see Figure A1). We retrieve information on business activities for each company using The Refinitiv Business Classification (TRBC) system. Then, we use this information to classify firms into green, neutral or brown categories. Our baseline measure of equity valuation is a forward price/earnings ratio (PER) calculated with long-term earnings forecasts (three to five years ahead) by financial analysts from the Institutional Brokers' Estimate System (I.B.E.S).

Our selection of control variables is based on the asset pricing literature that ties cross-sectional stock return differences to firm characteristics (e.g., Harvey et al., 2016; Hou et al., 2020): we incorporate firm size (Fama & French, 1993), investment and past earnings profiles (Fama & French, 2015), leverage (Bhandari, 1988), illiquidity (Amihud, 2002), systematic risk and idiosyncratic volatility (Ang et al., 2006), and extreme downside risk (Huang et al., 2012). We also control for analyst attention, an indicator of the degree of public information dissemination (e.g., Brennan et al., 1993), and analyst forecast dispersion, which reflects the degree of heterogeneity in beliefs about stock fundamentals (Diether et al., 2002; Grinblatt et al., 2016). In addition, to mitigate the risk that the technology characteristics of the green sectors (see Henriques & Sadorsky, 2008, on the technological edge of companies in the renewable energy sector) bias our estimates, we design a control variable that measures the technology component of each firm using the sensitivity of individual stock returns to a portfolio of technology firms. Finally, we account for the effect of several extra-financial characteristics on asset prices, namely environmental scores (Görgen et al., 2020), environmental score disagreements (Billio et al., 2021), ESG controversies (Aouadi & Marsat, 2018), carbon emissions (Bolton & Kacperczyk, 2021), and physical risk scores (e.g., Acharya et al., 2022). All of these individual financial and extra-financial characteristics are collected from external sources, if available, or developed using the methods described in Section 2.

Our results indicate that firms' green and brown sector affiliations are significantly priced in the global equity market. Companies operating in green business activities appear to be more valued, with a forward PER about 20% higher (3 PER points) than that of companies belonging to the neutral sectors. The effect is quite sizeable, since it represents 36% of the standard deviation of company valuations within neutral sectors. On the other hand, companies in brown sectors are undervalued by 13% (2 PER points; 24% of the standard deviation within neutral sectors) compared to neutral sectors, but this effect tends to fade once other extra-financial characteristics are taken into account, notably the carbon intensity of companies. Furthermore, our dynamic estimation shows that green firms have become increasingly overvalued relative to the rest of the market between 2018 and 2021, and vice versa for brown sectors. In 2021, the PER of green stocks was 42% higher (7 PER points; 74% of the standard deviation within neutral sectors in 2021) than that of neutral firms. We also find evidence that the equity turnover rate of both green and brown firms has increased over the last years. These findings imply that green and brown firms have sparked more interest recently and suggest that pro-environmental preferences have become more widespread among investors. Overall, our results are robust to different definitions of green and brown sectors and to several stock valuation measures. Our findings also remain consistent after dividing the sample into different regions.

Market-based evidence of interest and demand for green assets is mounting, from the rising prices of battery metals, such as lithium and cobalt, the integration of environmental considerations in the price of equity markets (e.g., Ardia et al., 2020; Bolton & Kacperczyk, 2021; Chini & Rubin, 2022; Choi et al., 2020; Engle et al., 2020; Jourde & Moreau, 2022; Pástor et al., 2020), CDS spreads (Blasberg et al., 2021), green bonds (e.g., Flammer, 2021; Zerbib, 2019), and real estate (e.g., Baldauf et al., 2020; Bernstein et al., 2019; Giglio et al., 2021), to the massive inflows into sustainable funds (e.g., GSIA, 2020; Hartzmark & Sussman, 2019) despite poor performance (El Ghoul & Karoui, 2017). These development supported the emergence of a green bubble narrative (e.g., Borio et al., 2023). However, we believe that prices need to be viewed against company fundamentals in order to determine whether they are overstretched.

Our main contributions to the literature are twofold. While some papers study the effect of ESG or climate characteristics on stock valuation (e.g., Bofinger et al., 2022; Bolton & Kacperczyk, 2021; Chava, 2014; Gao & Zhang, 2015; Giese et al., 2019; Krueger, 2015; Marsat et al., 2013; Pástor et al., 2022), our article is to our knowledge the first to analyze the valuation of stocks belonging to green and brown sectors. Since several definitions of green and brown can coexist, we consider that it is essential to fill this gap and test whether investors price the affiliation to green and brown sectors. Our interest for sector affiliation is related to the seminal work of Hong and Kacperczyk (2009), who analyze moral preferences through the lens of the valuation of "sin" companies belonging to the alcohol & tobacco or to the gaming sectors. As mentioned before, we believe that green and brown sectors are more consensual and easily observable than other environmental metrics, hence more likely to accurately reflect pro-environmental preferences. Another advantage of our framework is that we can disentangle investor preferences for green and brown assets, which, from an asset management perspective, helps to better understand the respective effects of positive and negative screening in asset allocation strategies. Finally, in contrast with previous studies, we account for potential correlation among green characteristics by incorporating several environmental variables as control in our model.[5] In some respects, this point is related to papers that examine

[5] Bolton and Kacperczyk (2021) shows that including industry fixed-effect in their model specification alters the effect of carbon emissions on stock prices. However, they do not examine whether green and brown industries tend to be over or undervalued in the market.

the effect of Corporate Social Responsibility (CSR) on stock valuation conditional on other variables, such as institutional ownership and economic conditions (Buchanan et al., 2018) or investor protection (Breuer et al., 2018). Wong and Zhang (2022) also find that market reactions to adverse ESG disclosure is sector-dependant (e.g., no effect on "sin" stocks), but they do not distinguish between green, brown and neutral sectors as we do.

Second, we complement the literature by studying the dynamic nature of pro-environmental preferences, allowing us to capture potential paradigm shifts in investor behavior. This approach is also useful to identify the potential emergence of a green bubble. Our measure of overvaluation focuses on the valuation of the green and brown sectors relative to neutral sectors. It therefore differs from papers that identify speculative bubbles from time series, exploring the behavior of stock prices from a historical perspective (e.g., Jordà et al., 2015; Phillips et al., 2015) with applications to green indices (see Ghosh et al., 2022; Lehnert, 2022). We consider that our approach is better suited to examining sector valuation, as our diagnosis is less conditioned by the common factor structure of stock prices. In particular, given the overall rise in equity valuations after the COVID-19 crisis, it seems more appropriate to adopt a relative approach by comparing sector valuations at each date in cross-section, rather than analyzing the time series of valuations for each sector. In addition, we extend our main approach based on stock valuation to other features that reflect investors' attention to green and brown stocks, based on stock turnover rate. This approach relates to prior papers on the link between attention and mispricing. Hong and Stein (2007) highlight that "glamour" stocks (with high market value compared to fundamentals) have high turnover rates, especially during the Internet bubble. Xiong and Yu (2011) find similar evidence in the context of the Chinese warrants bubble.

The rest of the study is structured as follows: Section 2 describes the data and methodology; Section 3 presents the results of the empirical analysis; Section 4 details the robustness tests; Section 5 concludes.

2 Data and Methodology

2.1 Model

We study the effect of environmental preferences on sector valuation based on a panel regression framework. Our dependent variable is the valuation of each stock included in the Datastream World portfolio (approximately 6000 companies from 71 countries) between 2018 and 2021 at monthly frequency. We regress stock valuation ratios on dummy variables that indicate whether the firm operates in a green, neutral, or brown business activity and a set of controls based on financial and extra-financial firm characteristics (see Equation 1). This approach is related to the characteristic-based asset pricing model of Daniel and Titman (1997). We use the valuation ratios of the companies (see Equation 2) as dependent variable instead of returns, which seems more appropriate to determine whether equity prices are overstretched over a relatively short period of time. Our main model is determined by the following equation:

$$PER_{i,t} = \alpha + \beta_g Green_i + \beta_b Brown_i + \sum_{f=1}^{F} \lambda_f FIN_{i,t}^f + \sum_{e=1}^{E} \lambda_e ENV_{i,t}^e + \gamma_{country,i} + \gamma_t + \epsilon_{i,t} \tag{1}$$

where $Green_i$ and $Brown_i$ are dummy variables that takes the value 1 when the company operates in a green or brown business activity. The coefficients of interest are β_g and β_b, which are expressed in PER units and can be interpreted as the overvaluation or undervaluation associated with the firm's affiliation to a green or brown sector. FIN and ENV are all variables representing financial and environmental characteristics for each firm. Finally, α is the constant term, and $\gamma_{country,i}$ and γ_t represents country and time fixed effects. All non-binary variables are winsorized at the 5% level to mitigate the effect of potential outliers on our estimates. Following Petersen (2009) and Thompson (2011), we cluster the standard errors by firm and by time to control for simultaneous correlation across both dimensions. The variables and their construction are described in the rest of the section and summarized in Table A1.

2.2 Variables

2.2.1 Valuation and investors' attention measures

Our baseline measure of equity valuation is a long-term forward PER, such as:

$$PER_{i,t} = \frac{P_{i,t}}{E_{i,t}} \tag{2}$$

with $P_{i,t}$ the price of stock i at the end of month t and $E_{i,t}$ the average of the earnings forecasts by financial analysts 3 to 5 years ahead, retrieved from I.B.E.S. To test the robustness of our findings, we also build three alternative valuation measures: a short-term forward PER based on the average of the earnings forecasts over a 1-2 year horizon, a trailing PER that focuses on latest earnings, and a book-to-market ratio.

To explore investors' attention to environmental issues, we also compute the monthly turnover rate for each stock, which is based on the sum of daily traded volumes ($V_{i,t}$), the price of the stock at the end of the month ($P_{i,t}$) and its market value ($MV_{i,t}$), all expressed in US dollars, such as:

$$TR_{i,t} = \frac{V_{i,t}.P_{i,t}}{MV_{i,t}} \tag{3}$$

2.2.2 Sector affiliation

We collect information on sector affiliation for each company using the TRBC system. TRBC covers over 250,000 securities in 130 countries to 5 levels of granularity. The information comes from local language speaking analysts that utilize company filings, Reuters news, and corporate actions services to assign and maintain a company's activity. This is a key advantage over the NACE and NAICS classifications, in which the identification of the company's main activity is declared by the company itself, leaving space for more subjectivity that could affect our assessment of green and brown firms (Battiston et al., 2022).

We classify firms into green, neutral and brown categories based on the most granular TRBC classification that contains more than 600 business activities. First, we define two baseline lists of green and brown business activities (see Tables A2 and A3). These lists are quite restrictive, as they are intended to focus on business activities that are most easily identified by investors as green or brown. Our baseline lists include only business activities in two key economic sectors for the ecological transition[6], namely the energy and utilities sectors. Specifically, we exploit intrasectoral divergences by classifying business activities as green (e.g., renewable energy and alternative electric utilities) or brown (e.g., oil & gas and fossil fuel electric utilities) within the same economic sectors. This approach facilitates comparison of results for green and brown firms and allows us to alleviate the risk that our results are affected by a structural difference in valuation across economic sectors. Our baseline lists identify 63 green companies, 279 brown companies and 5714 neutral companies.

As a robustness test, we propose two extensions to these initial lists. The first one classifies business activities within the basic materials sector: paper and forest products are considered green, while metals and mining and construction materials are defined as brown. Based on this definition, 36 and 282 additional companies are considered green and brown, respectively. The second extension incorporates electric vehicles and environmental services as green, whereas it defines automobiles and truck manufacturers and some transportation services as brown. It leads us to add 31 and 96 firms to our initial lists of green and brown companies, respectively.

Our classification is related to the Sustainable Industry Classification System (SICS) of the Sustainability Accounting Standards Board, which classifies companies based on common sustainability issues. Our brown list matches closely with the Extractives & Minerals Processing SICS category and our green list shares strong similarities with the Renewable Resources & Alternative Energy SICS category. Note that we do not directly rely on the Climate Policy Relevant Sectors of Battiston et al. (2017) for two reasons: they do not distinguish between green and brown business activities and they may not be easily identified by investors since the list of sectors is quite extensive. However, following their approach, we classify the finance, health, or technology sectors as neutral. While these sectors are not carbon-intensive, the financial sector is heavily involved in financing polluting companies, and the health and technology sectors are unlikely to be considered as key economic sectors for the ecological transition by investors.

[6]see e.g., IPCC (Intergovernmental Panel on Climate Change) (2022). Climate Change 2022: Impacts, Adaptations and Vulnerability. Working Group II Contribution to the IPCC Sixth Assessment report.

2.2.3 Financial characteristics

We collect a large set of financial variables based on the characteristics that are associated with cross-sectional stock return differences (e.g., Harvey et al., 2016; Hou et al., 2020). To control for firm size, we use the logarithm of the market capitalization of firms, denominated in USD. Following Fama and French (2015), firm investment is calculated as the annual growth rate in total assets and profitability as the firms' net income after preferred dividends divided by common equity. Firm leverage is proxied by the total debt of the company divided by common equity. We estimate analyst attention by the total number of analyst estimates for expected earnings per share. Finally, the analyst forecast dispersion is based on the standard deviation of the expected earnings per share.

We also build several market-based variables for each stock, including several measures of risk. We use the Amihud indicator to measure stock illiquidity. For each trading day, we calculate the ratio of the absolute value of the daily return of each stock ($r_{i,t}$) to the daily traded volume of that same stock ($V_{i,t}$, expressed in dollars). For each stock, we aggregate the data by month based on the median value to deal with potential outliers in daily volumes.

$$ILLIQ_{i,t} = median_{t=1}^{T} \frac{|r_{i,t}|}{V_{i,t}} \tag{4}$$

Then, we estimate dynamic measures of systematic risk and idiosyncratic volatility (see Equation 5). We regress the daily returns of each stock on the returns of the global market portfolio from Refinitiv Datastream. We estimate the model dynamically based on a rolling-window framework. The systematic risk at month t is $\beta_{i,t}^{M}$ estimated over the twelve past months. We use weighted regressions based on an exponentially decaying factor that gives more weight to the more recent observations. The idiosyncratic risk measure at month t is computed from the standard deviation of $\epsilon_{i,t}$ over the estimation period.

$$r_{i,t} = \alpha_{i,t} + \beta_{i,t}^{M} MKT_t + \epsilon_{i,t} \tag{5}$$

Given the apparent link between environmental profile and extreme risk reduction (Ilhan et al., 2021; Lins et al., 2017), we construct a measure of extreme risk based on a monthly 5% parametric Value-at-Risk (VaR, see Equation 6). To account for non-normality of returns, we estimate the VaR using the Cornish and Fisher (1937, see Equation 7) expansion that adjusts the traditional parametric normal VaR for the skewness and kurtosis of the empirical distribution:

$$VaR = \mu + \Omega(\alpha) * \sigma \tag{6}$$

$$\Omega(\alpha) = z(\alpha) + \frac{1}{6}(z(\alpha)^2 - 1)S + \frac{1}{24}(z(\alpha)^3 - 3z(\alpha))K - \frac{1}{36}(2z(\alpha)^3 - 5z(\alpha))S^2 \tag{7}$$

where μ is the mean, σ is the standard deviation of the returns over the entire period, and $\Omega(\alpha)$ is the critical value based on the loss probability level, skewness, and kurtosis (Equation 7). Specifically, $z(\alpha)$ is the critical value from the normal distribution for probability (1-α), S is the skewness, and K is the excess kurtosis. We set the parameter α to 5%. For the sake of consistency with other risk measures, we modify the sign of VaR so that a high value means that the company is exposed to a substantial downside risk.

Finally, to account for the effect of the technology characteristics of the green firms (see Henriques & Sadorsky, 2008) on stock valuation, we design a control variable that captures the technology component of each firm using the sensitivity of individual stock returns to a portfolio of technology firms. The technology portfolio is based on the world technology index of Refinitiv Datastream. We regress the daily returns of each stock on the returns of the technology portfolio and those of the global market portfolio from 2018 to 2021. We approximate the technology component of each firm by the coefficient associated with the returns of the technology portfolio using a framework similar to that presented in Equation (5).

2.2.4 Environmental characteristics

We collect additional environmental variables to control for the effect of various extra-financial characteristics on stock returns (see e.g., Acharya et al., 2022; Aouadi & Marsat, 2018; Billio et al., 2021; Bolton & Kacperczyk, 2021; Görgen et al., 2020) and potential correlation among green characteristics. We construct a composite environmental measure based on "E" (from ESG) scores from four data providers: CDP, Refinitiv ESG, S&P Global, and Sustainalytics. More specifically, we put all scores on a single scale, ranging from 0 to 100, and then calculate the cross-sectional average of the scores for each company. A high environmental score means that the company outperforms its peers in terms of ecological responsibility. Based on these data, we also construct a measure of environmental score disagreement for each company using the standard deviation between the scores of the different data providers.

Then, we download ESG controversies from Refinitiv Datastream, which measures a company's exposure to environmental, social and governance controversies and negative events reflected in global media. The score is ranged between 0 and 100, with the upper bound indicating that the firm is not subject to ESG controversies. We also design a carbon intensity measure for each firm based on both reported and estimated emissions, Scopes 1 & 2, divided by net sales, from Refinitiv Datastream. Finally, we use the physical risk score of ISS-ESG, which represents the fraction of the value of each company susceptible of being lost due to physical climate risks by 2050 in a likely climate-change scenario.

2.2.5 Descriptive statistics

We compare the average value of various financial and extra-financial characteristics for our baseline lists of green, brown, and neutral companies (see Table A4). First, based on all valuation measures, we observe that the stock valuation of green firms is higher than that of neutral firms, while brown companies appear less valued than the rest of the market. However, this finding might be driven by structural differences between the characteristics of green, brown and neutral firms.

Regarding financial characteristics, we show that green firms tend to be smaller, invest more, have more debt and are more exposed to technology shocks than neutral firms. The inverse holds for brown companies. Furthermore, both green and brown stocks are more illiquid and volatile than neutral companies. Regarding extra-financial characteristics, while firms in green sectors surprisingly have a slightly lower environmental score than the rest of the market, they also appear to be less concerned by environmental controversies and less exposed to physical risks. Finally, companies in both green and brown sectors are more carbon-intensive than neutral firms.

3 Results

3.1 The pricing of pro-environmental preferences in sector valuation

In this section, we explore whether being in the green or brown sector category affects firm valuations in global equity markets. We use panel regressions based on the overall sample and proceed in two steps. First, we regress the firm-specific PER on the green and brown sector dummies and company financial characteristics. Second, we add the extra-financial variables as control variables to assess if the information on green and brown sectors is priced above and beyond other firm-level environmental characteristics (environmental scores, carbon intensity, etc.).

Our first regression, estimated from 2018 to 2021, is therefore:

$$PER_{i,t} = \alpha + \beta_g Green_i + \beta_b Brown_i + \sum_{f=1}^{F} \lambda_f FIN_{i,t}^{f} + \gamma_{country,i} + \gamma_t + \epsilon_{i,t} \quad (8)$$

The results are presented in Table 1. One finding that stands out from the analysis is that the coefficient associated with the green sector is significantly positive in all four distinct specifications. The magnitude of the effect is substantial: operating in a green sector increases the PER of firms by 2.5 to 3.2 points (+20%) compared to the average PER of the neutral sectors (14.8). Symmetrically, the coefficient related to the brown sector appears significantly negative in all specifications. Although the scale of the discount for brown sectors is smaller in absolute terms than the premium for green sectors, it is still sizeable. Operating in a brown business activity reduces firms' PER by 1.6 to 2.5 points (approximately -13%) compared to neutral sectors.

With regard to financial variables, we show that companies with high market capitalization, high investment and low debt tend to be more valued in equity markets. Furthermore, market-based risk indicators give contrasting results. Companies exposed to liquidity, systematic or extreme risks are negatively valued, while those exposed to idiosyncratic (or diversifiable) risks benefit from higher valuations. In line with the resale option theory, we find that stocks with greater analyst coverage tend to be cheaper, since analyst coverage can help coordinate investors' beliefs (Andrade et al., 2013; Scheinkman & Xiong, 2003). Finally, as expected, the technological component of companies tends to drive their valuations higher.

The R-squared of the regressions is between 13% and 26%, which is in line with the related literature (e.g., Bolton & Kacperczyk, 2021). However, one potential limitation of this approach is the omission of certain extra-financial variables that could be correlated with the classification of companies in green or brown sectors (see Table A4). Indeed, alternative environmental characteristics, namely "E" (from ESG) scores, "E" score disagreements, ESG controversies, carbon emission intensity, and physical risk scores, have been found to have significant effects on stock returns or valuations (see e.g., Acharya et al., 2022; Aouadi & Marsat, 2018; Billio et al., 2021; Bolton & Kacperczyk, 2021; Görgen et al., 2020). To take these characteristics into account, we add the corresponding variables as covariates, and estimate the regression detailed in Equation 1. We report the results in Table 2.

We find that the green sector premium outlined above is robust to the inclusion of the various extra-financial variables. In the five different specifications, the coefficient associated with the green sector dummy is significantly positive, and of the same order of magnitude as in Table 1. Additionally, in three out of five specifications, the coefficient for brown sectors is, as before, significantly negative. Interestingly, the effect of brown sectors on equity valuation becomes non-significant after controlling for firms' carbon emission intensity. This suggests that investors prioritize detailed information on carbon emissions by companies over the brown sector affiliation when they value firms. Nevertheless, we show in a dynamic setting that the coefficient associated with brown sectors turns significantly negative at the end of the period, even after controlling for all alternative environmental characteristics (see Section 3.2).

After including additional extra-financial variables, the R-squared of the estimations increases from 26% to 27%–31%. Overall, the results for alternative environmental characteristics indicate that firms with high carbon emission intensity, high exposure to physical risk and subject to ESG controversies tend to exhibit lower valuation in equity markets. Interestingly, high "E" scores are associated with lower PER, which is consistent with the analysis of Jourde and Stalla-Bourdillon (2021). Indeed, a high environmental score may reflect lower future profitability, especially if the firm's management prioritises other goals over the maximization of returns (e.g., Gillan et al., 2021). In addition, difficulties in assessing firms' environmental performances and the risk of "greenwashing" result in a high rate of disagreement between environmental scores, which can in turn dilute green investment flows (see e.g., Afota et al., 2021; Billio et al., 2021).

Table 1: PER on sectoral and financial variables

	(1)	(2)	(3)	(4)
Green sector	2.503**	3.090***	3.195***	2.847**
	(1.135)	(1.152)	(1.101)	(1.119)
Brown sector	−2.509***	−2.414***	−2.000***	−1.557***
	(0.377)	(0.383)	(0.407)	(0.418)
Market value		0.789***	0.897***	1.962***
		(0.091)	(0.110)	(0.133)
Investment		9.635***	8.977***	8.062***
		(0.585)	(0.562)	(0.580)
Leverage		−0.015***	−0.014***	−0.013***
		(0.001)	(0.001)	(0.001)
Illiquidity			−0.001***	−0.001***
			(0.0004)	(0.0005)
Idio. risk			10.003***	9.984***
			(1.349)	(1.289)
Syst. risk			−3.641***	−3.423***
			(0.290)	(0.275)
Extreme risk			-12.007***	-11.812***
			(1.520)	(1.600)
Profitability				−0.208
				(0.722)
Analyst disp.				−0.0004
				(0.009)
Analyst cov.				−0.294***
				(0.022)
Technology				2.168***
				(0.291)
Constant	8.365***	4.578***	8.422***	2.334
	(0.543)	(0.939)	(1.440)	(1.638)
Observations	218,387	218,147	209,139	190,301
R^2	0.131	0.195	0.219	0.261
Adjusted R^2	0.131	0.195	0.219	0.260
FE: Country & Time	Yes	Yes	Yes	Yes

Note: This table presents estimates of the effect of sectoral affiliation on firms' long term PER. The control variables are detailed in Table A1. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels and are reported in parentheses.

Table 2: PER on sectoral, financial and extra-financial variables

	(1)	(2)	(3)	(4)	(5)
Green sector	2.696^{**}	3.629^{***}	3.279^{**}	2.864^{**}	3.379^{**}
	(1.104)	(1.194)	(1.294)	(1.192)	(1.356)
Brown sector	-1.632^{***}	-0.589	-0.845^{*}	-1.094^{**}	-0.254
	(0.438)	(0.477)	(0.457)	(0.475)	(0.521)
Environ. score	-0.046^{***}				-0.044^{***}
	(0.006)				(0.007)
Environ. disag.	-0.008				-0.015
	(0.012)				(0.014)
Carbon intensity		-1.540^{***}			-1.045^{***}
		(0.210)			(0.235)
Physical risk			-0.324^{***}		-0.247^{***}
			(0.046)		(0.053)
ESG controv.				0.047^{***}	0.038^{***}
				(0.004)	(0.004)
Market value	2.346^{***}	1.907^{***}	1.889^{***}	2.202^{***}	2.355^{***}
	(0.153)	(0.151)	(0.139)	(0.158)	(0.174)
Investment	7.722^{***}	7.926^{***}	8.953^{***}	7.728^{***}	7.743^{***}
	(0.583)	(0.630)	(0.654)	(0.618)	(0.674)
Leverage	-0.012^{***}	-0.013^{***}	-0.013^{***}	-0.011^{***}	-0.011^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Illiquidity	-0.001^{***}	-0.001^{**}	-0.001^{**}	-0.001^{**}	-0.001^{**}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Idio. risk	9.680^{***}	8.200^{***}	10.869^{***}	8.830^{***}	9.219^{***}
	(1.264)	(1.315)	(1.338)	(1.293)	(1.343)
Syst. risk	-3.375^{***}	-3.366^{***}	-3.342^{***}	-3.320^{***}	-3.216^{***}
	(0.272)	(0.287)	(0.297)	(0.280)	(0.296)
Extreme risk	-10.872^{***}	-12.546^{***}	-11.741^{***}	-11.931^{***}	-11.339^{***}
	(1.637)	(1.798)	(1.812)	(1.747)	(1.978)
Profitability	-0.657	-1.425^{*}	-0.048	-1.749^{**}	-1.160
	(0.732)	(0.776)	(0.796)	(0.764)	(0.825)
Analyst disp.	-0.001	-0.002	0.065^{**}	0.003	0.057^{**}
	(0.010)	(0.008)	(0.027)	(0.007)	(0.029)
Analyst cov.	-0.258^{***}	-0.292^{***}	-0.307^{***}	-0.265^{***}	-0.249^{***}
	(0.022)	(0.023)	(0.023)	(0.023)	(0.025)
Technology	2.194^{***}	2.729^{***}	2.452^{***}	2.780^{***}	2.879^{***}
	(0.285)	(0.327)	(0.320)	(0.317)	(0.334)
Constant	1.215	5.121^{***}	3.539^{**}	-3.051	-0.562
	(1.749)	(1.803)	(1.591)	(1.998)	(2.015)
Observations	185,900	153,221	158,020	155,867	131,556
R^2	0.271	0.279	0.278	0.287	0.309
Adjusted R^2	0.270	0.279	0.278	0.286	0.308
FE: Country & Time	Yes	Yes	Yes	Yes	Yes

Note: This table presents estimates of the effect of sectoral affiliation on firms' long-term PER. The control variables are detailed in Table A1. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels and are reported in parentheses.

3.2 The build-up of pro-environmental preferences

The previous analysis is conducted over the entire period covered by our dataset (2018-2021). To evaluate whether investors' environmental preferences have strengthened over time, we split our monthly dataset year by year and run the estimations again. Our main regression reflects Equation 1 and includes all our financial and extra-financial covariates, as in the last column of Table 2. Figure 1 depicts the coefficients associated with the green and brown sector dummies along with the corresponding confidence intervals at the 90% confidence levels.

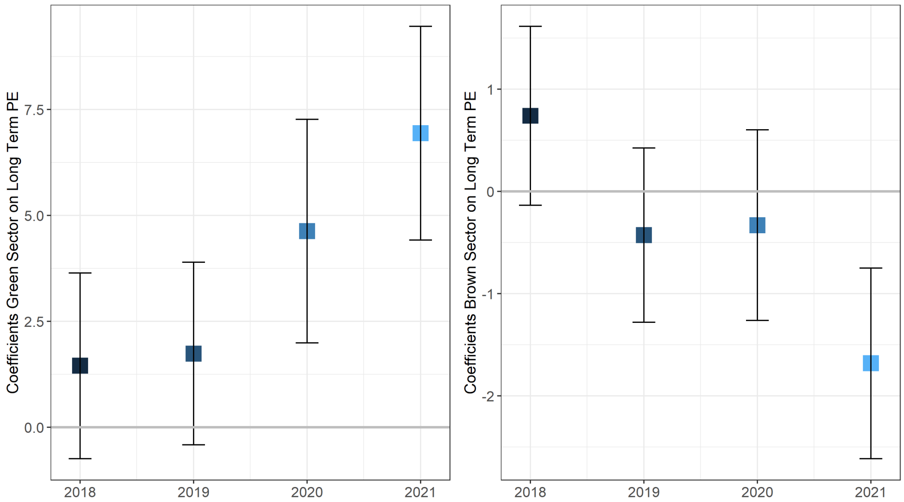
Our dynamic framework highlights a sharp increase over time in the valuation of firms operating in green business activities. Although non-significant at the beginning of the sample, the coefficient associated with the green sector dummy turns significant in the years 2020 and 2021. Moreover, the effect becomes quite sizeable at the end of the period. Belonging to the green sectors in 2021 increases a company's PER by nearly 7.5 points compared with an average PER of 16.8 for neutral sectors (about 42% higher). For brown sectors, the coefficient appears positive in 2018, then slowly falls into negative territory in subsequent years. While the coefficient remains non-significant on the first three years, it becomes significantly negative in the year 2021, despite the inclusion of carbon intensity as independent variable in the underlying regression. This finding contrasts with the results of the static regressions (see Table 2) and underlines that there is a material discount for firms belonging to brown sectors, but only at the end of the period.

These two results suggest that the green premium and the brown discount documented in Tables 1 and 2 are especially strong in the most recent years. Overall, we conclude that both green and brown sector characteristics are priced by investors. Given that we control for other extra-financial variables, such as environmental scores or carbon emissions at the firm level, our findings indicate that investors take sector affiliation into account over and above other environmental criteria. The emergence of both a green premium and a brown discount also suggests that the need for investors to "green" financial portfolios manifests itself in both positive and negative screenings in asset allocation strategies, namely the inclusion of green sectors and the exclusion of brown sectors in financial portfolios.

Finally, in order to better grasp the growing attention of investors for firms operating in green and brown business activities, we complement the above findings with similar regressions using the firm-specific turnover rates as dependent variable. Turnover rates are defined as the volumes traded for a stock divided by the outstanding shares. We believe that this metric usefully complement our core approach based on valuation measures in order to capture the degree of interest in green and brown sector characteristics. The results are presented in Figure 2. Again, the underlying regressions include all our financial and extra-financial variables as regressors.

We find that the coefficient associated with the green sector dummy is non-significant in the first years of the sample, but turns significantly positive in 2021. This finding underlines that investors' attention for firms operating in green

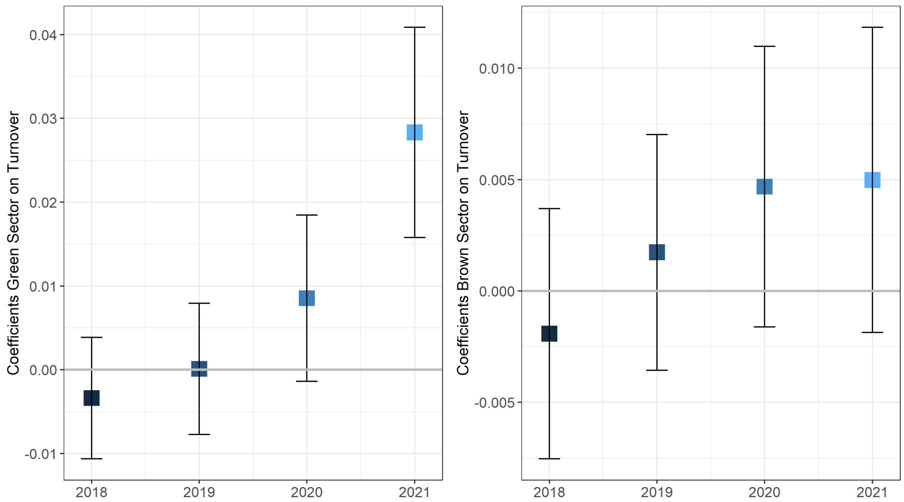
Fig. 1: The dynamic effect of sector affiliation on long term PER



Note: The figure depicts the coefficients associated with the green and brown sector dummies from Equation (1), estimated dynamically on a yearly basis. The regressions include all financial and extra-financial covariates, as in the last column of Table 2. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels. Vertical bars represent the confidence intervals at the 90% confidence levels.

business activities has increased over time. This result can be compared with those of Hong and Stein (2007) and Xiong and Yu (2011), which highlight high turnover rates for certain stocks during the Internet bubble and the Chinese warrant bubble, respectively. This increase in the turnover rate of green and brown stocks is also consistent with the theory of Pedersen et al. (2021), which assumes the co-existence of different types of investors with heterogeneous (environmental) preferences. Based on the resale option theory (Scheinkman & Xiong, 2003), such a divergence in investor preferences can also help to drive up the price of green stocks. While we do not consider this to be sufficient evidence to clearly support the thesis of a green bubble in the equity markets, it is a further sign of the rapid build-up of pro-environmental preferences among investors. Conversely, although it tends to increase over time, the coefficient associated with the brown sector dummy remains non-significant, even at the end of the sample. The fact that we find no significant relationship between firms' affiliation to brown sectors and turnover rates may explain why evidence of a brown discount is less salient than for the green premium in previous analyses.

Fig. 2: The dynamic effect of sector affiliation on turnover rate



Note: The figure depicts the coefficients associated with the green and brown sector dummies from Equation (1), estimated dynamically on a yearly basis. The dependent variable is the firm-specific turnover rate instead of PER. The regressions include all financial and extra-financial covariates, as in the last column of Table 2. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels. Vertical bars represent the confidence intervals at the 90% confidence levels.

4 Robustness tests and extensions

4.1 Valuation metrics

Our main conclusions are based on a long-term forward PER defined, in Section 2.2.1, as the ratio of the current price of the stock divided by the earning forecasts over a 3-5 year horizon. As the earning forecasts made by I.B.E.S analysts may be biased, we replicate the same analysis with different valuation ratios. More specifically, we test the robustness of our findings to the use of a short-term forward PER (with earning forecasts over a 1-2 year horizon), a trailing PER (with, as denominator, the latest earnings of the company), and a book-to-market ratio. We perform the same analysis as in Figure 1 but with the aforementioned alternative valuation ratios. The results are outlined in Figures B2 to B4.

For green sectors, our results appear robust to alternative valuation measures. In all three cases, the coefficient associated with the green sector dummy increases over time (or decreases in the case of the book-to-market ratio) and is significantly positive (negative) in the last year of the sample. In contrast, for brown sectors, the coefficient declines over time in all cases (or increases in the case of the book-to-market ratio). However, the coefficients are not significant in 2021 for the short-term forward PER and the trailing PER. This indicates, in line with our previous analysis, that the brown discount is probably less pronounced, and thus harder to detect, than the green premium.

4.2 Definitions of green and brown sectors

As indicated in Section 2.2.2, selecting business activities to build the lists of green and brown sectors remains, to some extent, arbitrary, as there is no consensual classification of this sort in the literature. Our main specification, that we label "Main list", is the most restrictive one and focuses only on the energy and utilities sectors. We also consider two potential extensions of this list. The first one classifies business activities within the basic materials sector: paper and forest products are considered green, while metals and mining and construction materials are defined as brown. The second extension incorporates electric vehicles and environmental services as green, whereas it defines automobiles and truck manufacturers and some transportation services as brown. More details on these two extensions, "Extended 1" and "Extended 2", can be found in Tables A2 and A3 in the Appendix.

We check whether our main results are robust to variations in the definition of green or brown sectors. To that end, we try to consider as many potential definitions as possible, and replicate our analysis with three different classifications: Main list with Extension 1, Main list with Extension 2 and Main list with Extensions 1 and 2. We report in Table B5 the results of the different regressions using the long-term forward PER as dependent variable, and, as regressors, the sector, financial and extra-financial variables (as in the last column of Table 2). In all the different cases, we observe a gradual build-up over time of a green premium on the one hand and brown discount on the other. Indeed, for the three alternative sectoral definitions, the coefficient associated with the green (brown) sector dummy tends to increase (decrease) as time goes by and becomes significantly positive (negative) in year 2021. This finding highlights that our results do not depend on a specific sector classification.

4.3 Regional analysis

A natural extension of our analysis is to combine our sectoral focus with a geographical dimension. To that aim, we split our sample into three regions, Asia, Europe and North America. These three different regions cover close to 90% of the companies in our sample. We replicate in Table B6 the same exercise as in Section 2.2.2 and evaluate whether our results are sensible to specific geographical locations.

We confirm that the green premium documented above is present in each of the three regions. Although the magnitudes may vary across areas, all three coefficients associated with the green sector dummy increase over time and are significantly positive at least in the last year of our sample. Quite counter-intuitively, the size of this effect appears higher in North America compared to Europe. This contrasts with Amel-Zadeh and Serafeim (2018), who highlights that European investors tend to have stronger environmental concerns than their US counterparts.[7] Nevertheless, European investors also invest to a large extent in US securities, which could push up the valuation of green stocks in North America.

Regarding brown sectors, we find that the corresponding coefficients decline over time in all three regions. European and Asian coefficients are, as expected, significantly negative in year 2021. However the coefficient for North America, although negative in that year, is not significantly different from zero. This latter result may also contribute to explain why the evidence of the brown discount appears more mixed in the previous analyses.

5 Conclusion

In this paper, we explore the dynamic nature of pro-environmental preferences among investors through the lens of sector valuations in global equity markets from 2018 to 2021. We argue that sector affiliation is a more objective, consensual, and easily observable characteristic than other environmental measures. Therefore, sector valuation are likely to provide a reliable framework to explore the development of environmental preferences.

Understanding whether pro-environmental preferences are priced at the sector level is essential for financial practitioners and regulatory authorities. First, it can provide important insights on the effect of positive and negative screenings in portfolio allocation strategies on equity valuations. Second, this research question is important for policy-makers developing classification systems aimed at channelling public and private investment towards environmentally sustainable economic activities, particularly in Europe where corporate alignment with taxonomy is based on business activities. Finally, our analysis can help identify potential financial stability risks associated with the emergence of a green bubble or a negative reassessment in the value of brown securities.

Based on panel regressions, we find that firms' green and brown sector affiliations are significantly priced in the global equity market, positively for green sectors and negatively for brown sectors. Furthermore, companies operating in green sectors have become increasingly overvalued relative to the rest of the market between 2018 and 2021, and vice versa for those operating in brown sectors, implying that pro-environmental preferences have become more prevalent among investors. In addition, the turnover rate of both green and brown companies has increased over the last years, which also suggests that investors have become more concerned by environmental issues. However, despite these evidence, we believe that the green bubble narrative is probably overstated, given that the overvaluation of companies operating in green business activities is quite substantial, but not extreme. In the same vein, while firms belonging to brown sectors appear slightly undervalued, they are still far from becoming stranded assets.

[7] See also the 2021 report from the Global Alliance for Sustainable Investment. The proportion of sustainable investments (relative to total assets under management) has been consistently higher in Europe than in the US over the 2014–2020 period.

Since our baseline valuation measure is based on long-term analyst forecasts, our results suggest that the mispricing of green or brown sectors is driven by purely non-financial motives. However, we cannot exclude the fact that investors demand for green firms is intended to hedge against a potential “green swan”. It might also reflect a divergence between the beliefs of investors and financial analysts. Such divergence could stem from the uncertainty surrounding the effect of environmental risks or opportunities on future earnings profiles. We believe that discerning between these effects is a promising avenue for future research.

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Appendix A Variables

Table A1: Variable description

Type	Variables	Definition	Sources
Valuation measures	Long-term PER	Stock price divided by expected earnings per share (EPS3MN, EPS4MN, EPS5MN)	Refinitiv Datastream, I.B.E.S, authors' computation
	Short-term PER	Stock price divided by expected earnings per share (EPS1MN, EPS2MN)	Refinitiv Datastream, I.B.E.S, authors' computation
	Trailing PER	Stock price divided by current earnings per share (EPS1TR12)	Refinitiv Datastream, authors' computation
	Market-to-book ratio	Market capitalization (MV) of firms divided by common equity (WC03501)	Refinitiv Datastream, authors' computation
Financial variables	Market value	Market capitalization (MV) of firms, denominated in USD	Refinitiv Datastream
	Investment	Annual growth in total assets (WC02999)	Refinitiv Datastream, authors' computation
	Profitability	Net income after prefered dividends (WC01706) divided by common equity (WC03501)	Refinitiv Datastream, authors' computation
	Leverage	Total debt of the company divided by common equity, expressed in percentage (WC08231)	Refinitiv Datastream
	Analyst coverage	Total number of analyst estimates for expected earnings per share (EPS1NE)	Refinitiv Datastream, I.B.E.S
	Analyst dispersion	Standard deviation of the expected earnings per share (EPS3SD, EPS4SD, EPS5SD)	Refinitiv Datastream, I.B.E.S, authors' computation
	Illiquidity	Amihud indicator; ratio of the absolute value of the daily return of each stock to the daily traded volume (VO) of that same stock	Refinitiv Datastream, authors' computation
	Turnover rate	Sum of daily traded volumes in amount (VO*P) divided by the market value (MV)	Refinitiv Datastream, authors' computation
	Systematic risk	Dynamic beta from the regression of firm returns on market returns (TOTMKWD)	Refinitiv Datastream, authors' computation
	Idiosyncratic risk	Standard deviation of the residual of the regression used to estimate the systematic risk	Refinitiv Datastream, authors' computation
	Extreme risk	Cornish-Fisher 5% monthly Value-at-Risk	Refinitiv Datastream, authors' computation
	Technology component	Beta from the regression of firm returns on the returns of a technology portfolio (TECNOWD)	Refinitiv Datastream, authors' computation
Environmental variables	Environmental score	Measure based on the "E" scores of four data providers	CDP, Refinitiv ESG, S&P Global, and Sustainalytics, authors' computation
	Environmental disagreement	Standard deviation between the environmental scores of the different data providers	CDP, Refinitiv ESG, S&P Global, and Sustainalytics, authors' computation
	ESG controversies	Company's exposure to environmental, social and governance controversies and negative events reflected in global media (TRESGCCS)	Refinitiv Datastream
	Carbon intensity	A carbon intensity measure for each firm based on both reported and estimated emissions, Scopes 1 & 2 (ENERDP123), divided by net sales (WC01001)	Refinitiv Datastream, authors' computation
	Physical risk score	The physical risk score represents the fraction of each issuer value susceptible of being lost due to physical climate risks by 2050 in a likely climate-change scenario.	ISS-ESG

Note: This table describes the variables we use in our empirical analysis. We report in parentheses the Datastream identifiers used to download or construct the main variables. Variables are grouped into three categories: valuation measures, financial variables and environmental variables. The construction of green and brown sector dummies is detailed in Tables A2 and A3

Table A2: List of green sectors

List	Business Sector	Industry Group	Industry	Business Activity	TRBC ID
	Renewable Energy				5020
		Renewable Energy			502010
			Equipment & Services	All	50201010
			Renewable Fuels	All	50201020
	Utilities				5910
		Electric Utilities & IPPs			591010
			Electric Utilities		59101010
Main list				Power Charging Stations	5910101014
				Alternative Electric Utilities	5910101020
				Hydroelectric & Tidal Utilities	5910101021
				Solar Electric Utilities	5910101022
				Wind Electric Utilities	5910101023
				Biomass & Waste to Energy	5910101024
				Geothermal Electric Utilities	5910101025
			Independent Power Producers		59101020
				Renewable IPPs	5910102012
	Applied Resources				5130
Extended 1		Paper & Forest Products			513010
			Forest & Wood Products	All	51301010
			Paper Products	All	51301020
	Automobiles & Auto Parts				5310
		Automobiles & Auto Parts			531010
			Auto & Truck Manufacturers		53101010
Extended 2				Electric (Alternative) Vehicles	5310101014
	Industrial & Comm Services				5220
		Pro & Comm Services			522030
			Environmental Serv. & Equip.	All	52203010

Note: This table describes the business activities included in our lists of green sectors. This selection is based on The Refinitiv Business Classification (TRBC) that contains more than 600 business activities. We define a main list based solely on business activities in the energy and utilities sector, as well as two extensions. The TRBC methodology used to assign an industry to firms is described here.

Table A3: List of brown sectors

List	Business Sector	Industry Group	Industry	Business Activity	TRBC ID
	Fossil Fuels				5010
		Coal			501010
			Coal	All	50101010
		Oil & Gas			501020
			Integrated Oil & Gas	All	50102010
			Oil & Gas Explo. and Prod.	All	50102020
			Oil & Gas Refin. and Mark.	All	50102030
		Oil & Gas Equip. & Serv.			501030
Main list			Oil & Gas Drilling	All	50103010
			Oil Related Serv. and Equip.	All	50103020
			Oil & Gas Transport. Serv.	All	50103030
	Utilities				5910
		Electric Utilities & IPPs			591010
			Electric Utilities		59101010
				Fossil Fuel Electric Utilities	5910101012
			Independent Power Producers		59101020
				Fossil Fuel IPPs	5910102011
		Natural Gas Utilities			591020
			Natural Gas Utilities	All	59102010
	Mineral Resources				5120
		Metals & Mining			512010
			Precious Metals & Minerals	All	51201010
			Iron & Steel	All	51201020
Extended 1			Aluminum	All	51201030
			Specialty Mining & Metals	All	51201050
			Diversified Mining	All	51201080
		Construction Materials			512020
			Construction Materials	All	51202010
	Automobiles				5310
		Automobiles & Auto Parts			531010
			Auto & Truck Manufac.	All (without Electric Vehicles)	53101010
	Transportation				5240
		Freight & Logistics Serv.			524050
Extended 2			Air Freight & others		52405010
				Air Freight	5240501012
			Ground Freight & Logis.		52405030
				Freight Trucking	5240503012
		Passenger Transport. Serv.			524060
			Airlines	All	52406010

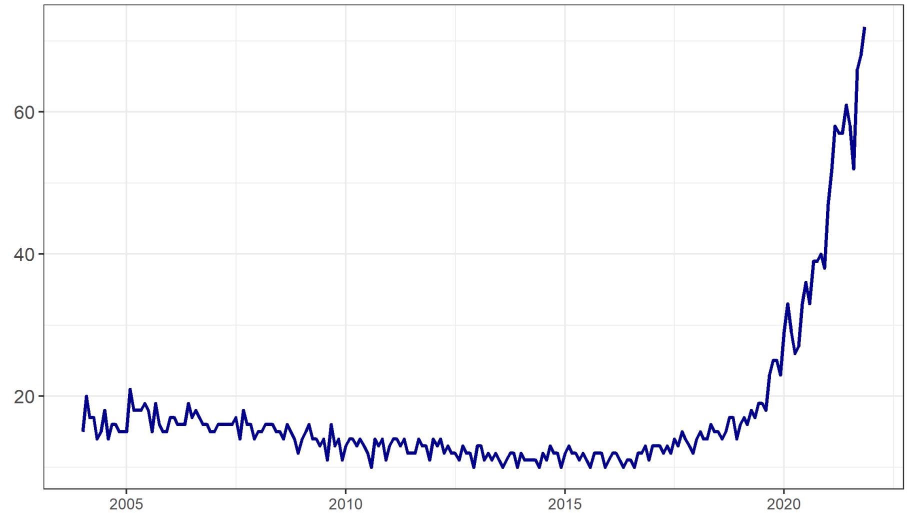
Note: This table describes the business activities included in our lists of brown sectors. This selection is based on The Refinitiv Business Classification (TRBC) that contains more than 600 business activities. We define a main list based solely on business activities in the energy and utilities sector, as well as two extensions. The TRBC methodology used to assign an industry to firms is described here.

Table A4: Descriptive statistics

Variables	Mean			St. dev		
	Green	Brown	Neutral	Green	Brown	Neutral
Long-term PER ratio	17.8	11.5	14.8	10.5	6.7	8.4
Short-term PER ratio	14.8	8.2	10.0	13.2	9.7	11.5
Trailing PER ratio	25.2	14.9	19.7	21.8	14.8	16.0
Book-to-Market	654	855	686	527	541	532
Market value	3,088	9,387	7,305	4,516	12,251	10,552
Investment	0.12	0.02	0.08	0.19	0.13	0.16
Profitability	0.08	0.08	0.10	0.14	0.15	0.13
Leverage	127	91	93	125	88	103
Analyst coverage	3.4	5.3	4.7	3.6	4.6	4.1
Analyst dispersion	0.21	0.46	0.48	0.29	0.94	6.3
Illiquidity	225	142	127	462	406	366
Turnover rate	0.071	0.068	0.071	0.089	0.073	0.074
Systematic risk	0.93	0.99	0.85	0.51	0.54	0.48
Idiosyncratic risk	0.39	0.36	0.34	0.15	0.13	0.13
Extreme risk	-0.22	-0.22	-0.19	0.11	0.09	0.08
Technology component	0.06	-0.35	-0.11	0.47	0.39	0.46
Environmental score	32.6	40.3	40.1	22.8	26.9	25.1
Environmental disagreement	16.8	14.8	14.8	7.4	6.9	7.0
ESG controversies	97.4	85.7	89.7	11.3	26.2	23.2
Carbon intensity	0.65	0.62	0.18	0.63	0.55	0.39
Physical risk	1.1	2.4	1.9	1.9	3.0	2.6

Note: This table reports the descriptive statistics for our baseline lists of green, neutral and brown sectors. We compute the mean and standard deviation for each of the variables we use in our empirical analysis.

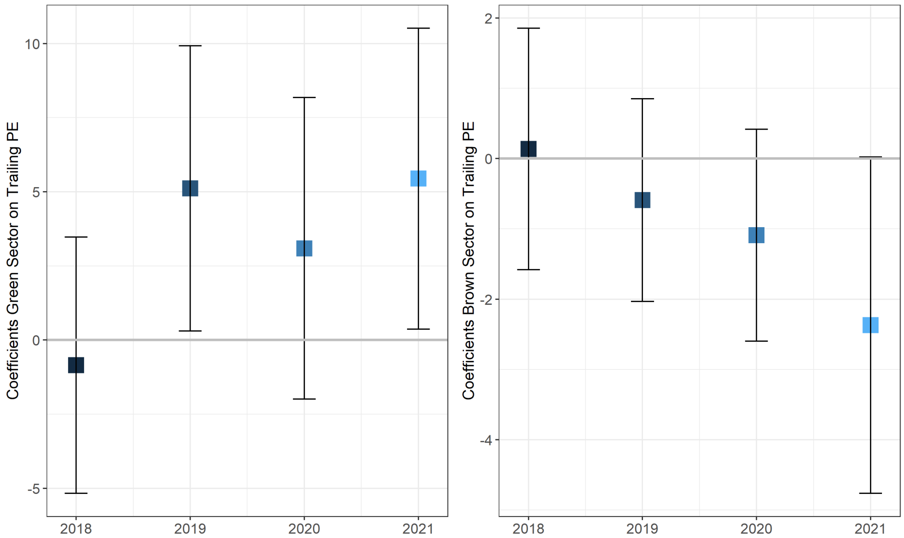
Fig. A1: Internet searches for environmental, social and governance criteria based on Google trends



Note: The figure shows the evolution of internet searches for ESG criteria based on Google trends from 2004 to 2023 at a monthly frequency. The score is normalized between 0 and 100, with the upper bound indicating a historically high level of internet searches.

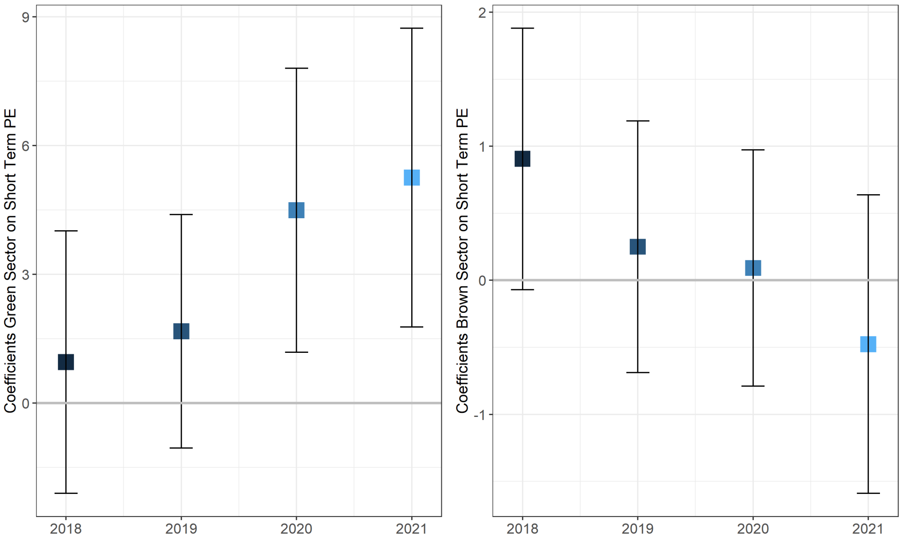
Appendix B Dynamic regressions

Fig. B2: The dynamic effect of sector affiliation on trailing PER



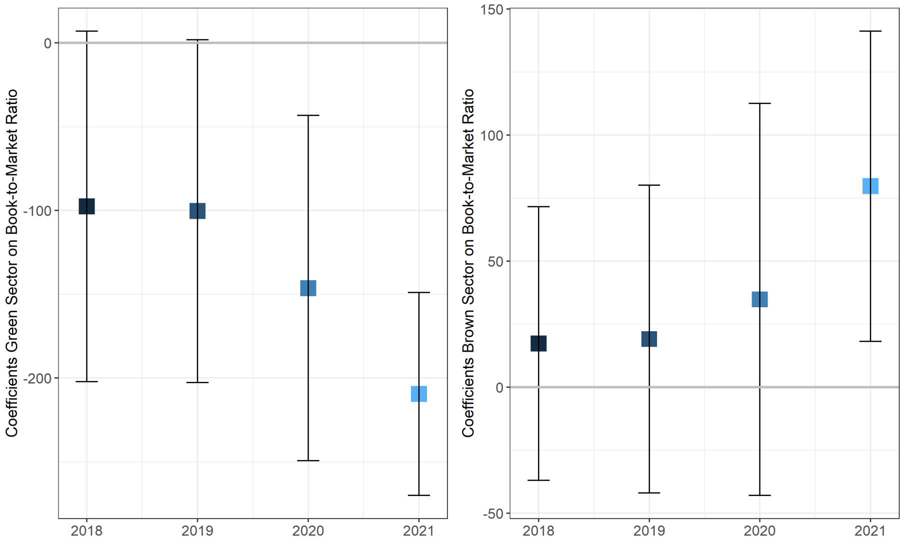
Note: The figure depicts the coefficients associated with the green and brown sector dummies from Equation (1), estimated dynamically on a yearly basis. The dependent variable is the firm-specific trailing PER. The regressions include all financial and extra-financial covariates, as in the last column of Table 2. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels. Vertical bars represent the confidence intervals at the 90% confidence levels.

Fig. B3: The dynamic effect of sector affiliation on short-term forward PER



Note: The figure depicts the coefficients associated with the green and brown sector dummies from Equation (1), estimated dynamically on a yearly basis. The dependent variable is the firm-specific short-term forward PER. The regressions include all financial and extra-financial covariates, as in the last column of Table 2. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels. Vertical bars represent the confidence intervals at the 90% confidence levels.

Fig. B4: The dynamic effect of sector affiliation on book-to-market ratio



Note: The figure depicts the coefficients associated with the green and brown sector dummies from Equation (1), estimated dynamically on a yearly basis. The dependent variable is the firm-specific book-to-market ratio. The regressions include all financial and extra-financial covariates, as in the last column of Table 2. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels. Vertical bars represent the confidence intervals at the 90% confidence levels.

Table B5: Dynamic regressions based on alternative sector definitions

	2018	2019	2020	2021
Green sector - Main with 1	0.076	0.831	1.399	2.966***
	(0.870)	(0.870)	(1.113)	(1.141)
Green sector - Main with 2	0.411	0.661	3.031***	5.102***
	(0.884)	(0.914)	(1.130)	(1.104)
Green sector - Main with 1 and 2	-0.365	-1.021	1.050	2.631***
	(0.681)	(0.726)	(0.881)	(0.903)
Brown sector - Main with 1	0.124	-0.424	-0.738	-1.477***
	(0.870)	(0.870)	(1.113)	(1.141)
Brown sector - Main with 2	-0.781	-1.313	-0.787***	-1.830***
	(0.884)	(0.914)	(1.130)	(1.104)
Brown sector - Main with 1 and 2	-0.868	-1.121	-1.041	-1.713***
	(0.681)	(0.726)	(0.881)	(0.903)

*Note: Each sectoral coefficient stems from a regression with, as dependent variable, the long-term forward PER, and, as independent variables, all the financial and extra-financial characteristics of our dataset, as in the last column of Table 2. The first column of the table indicates which definition is considered for the construction of the green and brown sectors. "Main with 1" refers to the Main list with Extension 1, as detailed in Table A2 and A3. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.*

Table B6: Dynamic regressions by regions

	2018	2019	2020	2021
Green sector - North America	2.275	2.917	8.786***	12.601***
	(2.619)	(2.622)	(2.772)	(1.807)
Green sector - Europe	-0.380	-0.712	3.773	4.195*
	(2.278)	(1.988)	(2.476)	(2.636)
Green sector - Asia	1.133	2.629*	1.790	5.927***
	(1.556)	(1.543)	(1.776)	(1.958)
Brown sector - North America	3.793***	2.994***	2.196**	-0.871
	(1.024)	(1.077)	(1.114)	(0.965)
Brown sector - Europe	1.074	-0.038	-0.325***	-1.351*
	(0.668)	(0.688)	(0.748)	(0.717)
Brown sector - Asia	-1.469	-2.324**	-2.093*	-2.343*
	(1.005)	(1.117)	(1.227)	(1.393)

*Note: Each sectoral coefficient stems from a regression with, as dependent variable, the long-term forward PER, and, as independent variables, all the financial and extra-financial characteristics of our dataset, as in the last column of Table 2. The first column of the table indicates which region is considered for the analysis. All regressions use country and month-year fixed effects. Standard errors are clustered at both firm and time levels and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.*