Green or Brown: Which Overpriced Stock to Short Sell?*

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Abstract

I document a negative relationship between firm's ESG performance and short selling demand among overpriced stocks. Such relationship is not driven by known short-sale constraints such as fewer lendable shares or higher lending fees. Instead, shorting overpriced stocks with high ESG scores is exposed to higher 1) synchronization risk—the long-side investors are reluctant to sell the overpriced stocks with better ESG performance; 2) short squeeze risks associated with ESG sentiment—high ESG stocks experience sentiment-driven positive price jumps when public attention to ESG spikes; and 3) ESG reputation risk—short sellers who publicly disclose large positions on high ESG stocks may get a bad reputation. I further document overpriced stocks with high ESG scores have more negative returns next month, partially due to insufficient short selling demand.

Keywords: ESG performance; short sell; market efficiency
JEL Classification: G12; G14; G23; G41

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1 Introduction

There is a growing interest in whether corporate environmental, social, and governance (ESG) performance matters for asset pricing and market efficiency. A number of institutions have broadened their perspectives, and incorporated a firm's ESG (environmental, social, and governance) performance into the investment decision making process. According to a 2020 report by the U.S. SIF Foundation, 33% of the professionally managed assets in the U.S. —$17.1 trillion or more in aggregate, are influenced by socially responsible investment principles.

Despite the fast growth of ESG investing, investors have different tastes for assets. The heterogeneity across firms in the ESG performances and across agents in the ESG preference have important implications for asset prices in the equilibrium (Pástor, Stambaugh, and Taylor (2020), Pedersen, Fitzgibbons, and Pomorski (2021)). In this paper, I examine whether short sellers have any preference for firms with different ESG performances. Short sellers are known as well-informed and sophisticated investors, and are important for stock market efficiency (e.g., Boehmer, Jones, and Zhang (2008), Christophe, Ferri, and Hsieh (2010), Boehmer and Wu (2013)). Theoretically, it is not clear whether short sellers would prefer shorting high or low ESG stocks given a similar level of overpricing. On one hand, as natural arbitrageurs, short sellers, compared with other investors have weaker than average ESG tastes. Following the model by Pástor, Stambaugh, and Taylor (2020), short sellers would take a brown tilt.[1] Therefore, short sellers may potentially short more green firms, all other things being equal. On the other hand, short sellers may face unconventional risk when they short overpriced high ESG stocks. For example, Cao, Titman, Zhan, and Zhang (2021) document that socially responsible institutions are less likely to sell overpriced stocks, especially high ESG stocks. Such trading behavior of the long-side investors increases the synchronization risk associated with short selling. Therefore, how the short seller views ESG performance of overpriced stocks is an important yet scarcely explored empirical question.

To start with, I examine how short selling activities vary with corporate ESG performance, among overpriced stocks.[2] Based on the score proposed by Stambaugh, Yu, and Yuan (2015) that captures relative mispricing levels, I sort all the stocks with ESG scores available into quintiles and classify those in the fifth quintile as most overpriced stocks. Among overpriced stocks, I find firms with high ESG scores have much lower short selling demand compared to other stocks, suggested by fewer shares on loan and lower utilization ratio. This relationship, however, is unlikely driven by the supply side of the lendable shares, as ESG scores have little impact on the percentage of lendable shares relative to the total shares outstanding. Furthermore, overpriced

[1] In this paper, "green (brown) firms" refer to those with good (bad) ESG performance in a broad sense, not limited to the environmental performance.

[2] My narrative is centered on overpriced stocks because short selling activities are most active among overpriced stocks.

stocks with high ESG scores are cheaper to borrow compared to their low ESG peers. These results suggest that among overpriced stocks, lower shares on loan associated with high ESG stock is likely due to the lower demand from short sellers, rather than severe short-sale constraints such as fewer lendable shares or higher borrowing fees.

To establish a causal relationship from corporate ESG performances to short sellers trading activities, I utilize the bi-annual FTSE4Good index reconstitution as an exogenous shock on firms perceived ESG performance. As FTSE4Good index specializes in corporate ESG issues, the inclusion enhances the ESG reputation of the newly added firms. I first match the included event firms with control firms according to several firm fundamental variables. Then I conduct a difference-in-differences regression analysis for the matched sample, and document that after the compared with control firms, treated firms that are included in FTSE4Good index have significantly lower short interests and utilization ratios, given the same level of overpricing. Such difference-in-differences analysis confirm my previous finding that short sellers are less likely to short high ESG stocks despite the overpricing. Since the comparison is made for the same firm shortly before and after the Index Inclusion events, the differences across short seller's trading can be attributed to their changed perceptions about firms' ESG profile. In addition to bi-annual FTSE4Good index reconstitution, I provide consistent evidence by examining another two exogenous shocks, i.e. the passage of close-call ESG shareholder proposals and the announcement of Paris Agreement.

After establishing the negative causal relation from corporate ESG performances to short selling demand among overpriced stocks, I attempt to study the underlying mechanisms. Specifically, I document that short sellers are less willing to short overpriced stocks with high ESG performances because of a higher synchronization risk, a higher short squeeze risk, and a reputation risk for shorting high ESG stocks.

Synchronization risk refers to the uncertainty about whether and when investors other than short sellers will exploit a common arbitrage opportunity by selling the shorted stocks (Abreu and Brunnermeier (2002)). Starks, Venkat and Zhu (2020) document that institutional investors, especially these with longer investment horizons, are more patient to firms with high ESG performances when there are negative earnings announcement. In a similar vein, Cao, Titman, Zhan, and Zhang (2021) find socially responsible institutions are less sensitive to quantitative mispricing signals.[3] The potential under-reaction from institutions that hold high ESG stocks imposes sizable explicit and implicit costs for short sellers. Despite a lower daily lending fee, short sellers may have to pay a higher borrowing fee as it takes longer for the other investors to coordinate and the overpricing to be corrected for high ESG stocks. Consequently, short sellers are less willing to accumulate shorting position of high ESG stocks even when these stocks are

[3]It is also possible that investors with an above average ESG preference model mispricing in a different way (Pedersen, Fitzgibbons, and Pomorski (2021)).

overpriced. By examining the ownership changes of active mutual funds and institutions from the Thomson Reuters 13F, I find corroborating evidence for the synchronic risk channel. Specifically, when an overpriced stock has better ESG performance, long-side investors are less likely to sell it.

Short squeeze risk, potentially associated with increased ESG awareness, also reduces the short selling activities of overpriced high-ESG stocks. Short squeeze refers to the unexpected rises in price for shorted stocks. When there is a price increase in shorted stocks, short sellers have to inject more capital into margin account, or cover their position following margin calls. Such exit from the short positions would further push up the prices of shorted stocks. Theoretically, short sellers can face unlimited losses when price rises. Does better ESG performance increase the short squeeze risk? To test such possibility, I first examine the relation between ESG performance and short squeeze risk, for overpriced stocks. Specifically, I construct four measures to capture the overall short squeeze risk, or the possibility of positive price jump: 1) realized skewness of daily stock return; 2) relative signed jump variation, which uses high-frequency intraday data, and is defined as the difference between the up and down semi-variance measures divided by the total return variance; 3) Option implied skewness, the difference between the implied volatilities of out-of-the-money (OTM) call options and at-the-money (ATM) call options; and 4) Upside slope, calculated as the slope of a function that relates right-tail implied volatility to moneyness (with moneyness being measured by the option's delta) of call options. The first two measures are constructed using realized return data and the other two measures are based on option prices, reflecting forward-looking information. I find the probability of a positive price jump is higher for high ESG stocks, which leads to a higher short squeeze risk faced by short sellers.

To quantify short-squeeze risks particularly caused by ESG attention, I calculate ESG sentiment beta as a proxy. I regress daily returns on the daily Google Search Volume Innovation of ESG related topics to get ESG sentiment beta, which captures how the stock return commoves with the ESG attention. By construction, stocks with higher ESG sentiment beta, will experience a price jump when the public suddenly pays more attention to ESG issues, therefore these stocks are more likely to suffer from short squeeze risks associated with ESG attention. I find high ESG stocks indeed have a higher ESG sentiment beta, thus short sellers may shy away from these stocks when they are overpriced.[4]

I also test whether short selling high ESG stocks potentially creates a reputation cost for short sellers. Although short sellers help improve price efficiency, they have earned a relatively more negative reputation as they tend to profit while other investors struggle.[5] Such reputation

[4]To further corroborate this argument, I use ten speeches of Greta Thunberg as exogenous shocks on public attention to ESG issues, and find cumulative abnormal return for high ESG stocks is 0.57% higher compared to other stocks. Correspondly, shares on loan of overpriced high ESG stocks decreases after Gret' speech. This is one example of sudden increased attention on ESG issues, and the results are reported in Internet Appendix IA3.

[5]For example, in certain cases, some have argued that short positions push down companies who otherwise would have prevailed, and thus taking short positions is almost unethical. Some reporters and fi-

loss could be potentially higher when shorting high ESG stocks, as some long side investors not only derive utility from the financial performances, but also the positive social impacts. Shorting brown assets, on the other hand, is reviewed as a way to be socially responsible and may improve the reputation of short sellers.[6] To provide suggestive evidence for this channel, I investigate the reactions from social media to public short selling campaigns by the major short sellers. If short sellers indeed perceive a higher reputation risk for shorting stocks with high ESG performances, in equilibrium, there would be fewer public campaigns against high ESG stocks, even short sellers are bearish on them. Moreover, one would expect more negative reactions from the social media.

Using data from Ljungqvist and Qian (2016), I identify major short sellers, and then collect data on short-sale positions by these short sellers reported on hedge fund websites and the *SeekingAlpha* website. For each campaign, I search related reports in *SeekingAlpha*, collect comments under the reports, manually read all the comments and for each comment, identify whether the tone is against or supportive to the short-sale position. I find there are indeed more negative comments when short sellers publicly disclose bearish positions on high ESG stocks. This evidence suggests that social pressures might discourage short sellers from initiating an active short selling position against stocks with high ESG performance.[7]

Finally, I investigate the impact of documented patterns on asset prices. I have shown that when the stocks are overpriced, short sellers are less willing to accumulate short positions for high ESG stocks. Therefore, these stocks should have more negative abnormal stock returns afterwards because the current short selling amount is not sufficient to correct the mispricing. I do find supporting evidence and the return predictability is concentrated in stocks with low short selling demand. In addition, after controlling for the short selling demand in the regression, the effect of ESG on future stock return gets attenuated, indicating the return predictability of ESG scores partially comes from its impacts on short selling demand.

To further lend support to the relationship between ESG performance and short selling activities, I perform several additional tests. If short selling risks and short sellers trading

nancial analysts partially attribute the fall of Bear Stearns and Lehman Brothers during the 2008 financial crisis to the intense pressure of short sellers' bear raids. https://mcgillbusinessreview.com/articles/short-sellers-market-traitors-or-balance-keepers

[6]For example, according to the Alternative Investment Management Association (AIMA) and international law firm Simmons & Simmons, alternative investment managers have a long and successful track record of discovering governance failures, as witnessed by the recent Wirecard scandal. They use this same expertise to expose environmental and social failings of issuers, creating more transparent, safer markets for investors around the world. https://www.aima.org/sound-practices/industry-guides/short-selling-and-responsible-investment.html

[7]To further explore how the reputation risks could affect short sellers' decision in general beyond those large short-sale campaigns, I examine a short selling regulation introduced in Europe markets on November 1, 2012, which requires public disclosure of short position if it reaches 0.5% of the outstanding amount of share capital. Using UK stocks as my test sample where ESG score is most available, I find after the regulation, short sellers decrease the short position of overpriced high ESG stocks, or accumulate short positions just below the applicable disclosure threshold, to avoid a negative impact on their ESG reputation. The results are reported in Internet Appendix IA4.

decision are indeed influenced by the ESG performances of the firm, the impacts should be more pronounced when the ESG performances are more relevant to the firms. To capture the heterogenous importance of ESG performance to a firm, I use socially responsible institutions ownership and the fraction of words mentioning climate change related topics in the earnings conference calls as two proxies. My documented results are indeed stronger for firms held by more socially responsible institutions, and when the climate change related words are more frequently mentioned in the earnings conference call.

Given the fact that the correlation of ESG scores among different data vendors is quite low (Gibson, Kruger, and Schmidt (2021)), I rely on alternative ESG scores from another two data providers, namely MSCI KLD ESG and Sustainalytics. The results using alternative ESG scores demonstrate similar patterns. In addition to using Stambaugh, Yu, and Yuan (2015) as the primary measure to identify overpriced stocks, I also consider the standardized unexpected earnings signal (SUE) as an alternative mispricing measure.[8] Consistently, among the firms experiencing the most negative SUE, stocks with high ESG scores have a lower short demand.

I also explore whether the trading of put options show up similar pattern, since they normally serve as a substitute for short selling when short-sale constraints are binding (Ramachandran and Tayal (2020)). Using net signed option volume as a proxy, I find the demand from option end-users is lower for overpriced high-ESG stocks, consistent with short sellers' trading behavior. In line with the lower demand for put options, implied volatility of put option and put-call implied volatility ratio are lower for put options of overpriced high-ESG stocks.

To the best of my knowledge, this is the first paper that investigates the effect of ESG performance on short selling activities, contributing to the fast growing literature about the impact of ESG performances on investors with different tastes and perspectives. Possibly because of the preferences of the clients[9], long-side institutions, especially the ones with stronger ESG preferences or longer investment horizons, have incorporated ESG performances in their portfolio choices. Such investor heterogeneity has a non-trivial impact on asset prices. For example, Starks, Venkat and Zhu (2020) document that socially responsible institutional investors tend to be more patient towards high ESG firms, e.g., they are less inclined to sell the stocks even after negative news or poor stock performance. Cao, Titman, Zhan, and Zhang (2021) show socially responsible investors react less towards quantitative signals. It is, however, unclear whether and through which channels ESG performances have an impact on the short sellers, who are important participants in the stock market and contribute to the market efficiency. My paper fills the gap, and enhances the understanding of ESG preferences or considerations for different

[8]For example, Foster, Olsen, and Shevlin (1984); Bernard and Thomas (1989).

[9]Using the release of Morningstar sustainability ratings, Hartzmark and Sussman (2019) find positive flows to mutual funds with good sustainability ratings and negative flows to mutual funds with poor ratings. See also, Ridel and Smeets (2017), who find that socially responsible investors are willing to forgo financial performance because of their preference for positive social impacts.

market participants.

Specifically, this paper points out corporate ESG performances at least affect two short selling risks. Synchronization risk, the uncertainty that other investors will exploit a common arbitrage opportunity (Abreu and Brunnermeier (2002)), increases with ESG performances, therefore reduces the short selling activities for overpriced high-ESG stocks. Though short sellers could publicly reveal their information to reduce the synchronization risks (Ljungqvist and Qian (2016)), they rarely do so for high-ESG stocks.[10] My empirical evidence suggests a reputation cost for publicly revealing a negative view on high ESG stocks. In addition, short squeeze risk, the possibility of large positive price jump, also increases with corporate ESG performances. Such sudden price increases potentially create unlimited losses for short sellers. Nevertheless, known short selling costs, such as lending fees, decrease with ESG performances. Therefore, this paper not only sheds light on an unexplored non-pecuniary dimension in affecting short selling activities, but also points out novel mechanisms.

In addition, this paper also contributes to the literature studying the short selling activities. Past literature has documented the superior ability of short sellers in obtaining and making use of both public and private information (e.g., Karpoff and Lou (2010), Christophe, Ferri, and Hsieh (2010), Dechow, Hutton, Meulbroek, and Sloan (2001), Hirshleifer, Teoh, and Yu (2011), Drake, Rees and Swanson (2011), and McLean, Pontiff, and Reilly (2020)). Short-sale constraints such as high lending fee and limited lendable shares have been documented to limit the short sellers' arbitrage and lead to informational inefficiency (Reed (2002), and Saffi and Sigurdsson (2011)). Other risks and costs are only empirically investigated recently. My paper highlights the importance of corporate ESG performance on short selling risks, further on short selling activities and market efficiency.

More generally, my paper is related to the literature studying how ESG performance influences security prices. Empirical studies document mixed evidence on the relation between corproate social performance and future stock returns. For example, Hong and Kacperczyk (2009) find that "sin" stocks outperform other stocks. Using "100 Best Companies to Work for in America" as a measure for employee satisfaction, Edmans (2011) documents a positive relationship between employee satisfaction and long-run stock performance. Bolton and Kacperczyk (2021) find stocks of firms with higher total CO_2 emissions earn higher returns, because investors are demanding compensation for their exposures to carbon emission risks. I show that ESG performance could affect short sellers' decisions, which will further affect stock prices.

The rest of the paper proceeds as follows. Section 2 describes my data and measures. I present my main results in Section 3 and additional robustness tests in Section 4. Section 5 concludes.

[10] Ljungqvist and Qian (2016) document that when small arbitrageurs face short-sale constraints and noise trader risks, they will publicly reveal their information to induce the long-side investors to sell, thereby accelerating price discovery.

2 Data and key measures

2.1 Data

I collect data on firms' Environmental, Social, and Corporate Governance (ESG) performance from Asset4.[11] These data provide objective, relevant, and systematic environmental, social, and governance (ESG) information based on 250+ key performance indicators (KPIs) and 750+ individual data points, from three pillars.[12] Asset4 provides data on more than 3,000 firms globally, covering major indexes. In the U.S., Asset4 covered firms in the S&P 500 index only at the beginning of the sample period but has been expanded to firms in the Russell 1000 index in the later period.

Equity lending characteristics, including shares on loan, lendable supply and borrowing fee, are available at the stock level and are taken from Markit. Markit Securities Finance capture stock loan trading information from over 100 participants and approximately 85% of the OTC securities lending market. It provides information on a daily basis at a security level, including quantity of stock on loan, quantity of stock inventory available to lend, utilization ratio, borrowing fee etc.[13]

The analyst coverage and forecast data are from I/B/E/S. Stock returns, prices, and trading volumes are obtained from the Center for Research on Security Prices (CRSP). The accounting data are collected from COMPUSTAT. I obtain institutional holdings (13F) data from Thomson Reuters. I obtain the data on U.S. individual stock options from OptionMetrics and high-frequency trading data from TAQ. The monthly Fama-French factors and risk-free rates are from Kenneth French's data library. The sample period is from January 2006 to December 2019.

2.2 Key measures

2.2.1 Mispricing signals

I follow Stambaugh, Yu, and Yuan (2015), and consider a monthly updated composite quantitative signal (SYY score), constructed by combining each stock's rankings on 11 anomaly variables. The 11 anomalies are *Net Stock Issues, Composite Equity Issues, Accruals, Net Operating Assets, Asset Growth, Investment-to-Assets, Distress, O-score, Momentum, Gross Profitability Premium, and Return on Assets.* For each anomaly, the stocks are sorted into 100 groups and assigned

[11] Asset4 was acquired by Thomson Reuters in 2009 and it now goes by the name Thomson Reuters ESG Scores. However, since the name Asset4 is widely known so I use the old name for simplicity. Note that as of 2018, the ESG ratings data is part of Refinitiv, which is a company co-owned by Thomson Reuters (45%) and Blackstone Group LP (55%).

[12] Raw Asset4 score ranges from 0 to 100. To make the interpretation of regression coefficient easier, I divide the raw Asset4 score by 100.

[13] The frequency of the data points increases from weekly to daily (starting from 2006) as the Markit Securities Finance securities lending universes has grown over time.

a rank from 1 to 100; the highest rank is assigned to the stocks associated with the lowest average abnormal future return, as documented in the literature. The composite quantitative signal of a stock is the arithmetic average of its rankings on the 11 anomalies, ranging between 1 and 100. According to this measure, stocks with the highest SYY score are the most overpriced and the expected future returns are the most negative. Those with the lowest values are the most underpriced and are expected to have the highest future returns.

In addition, I follow Foster, Olsen, and Shevlin (1984) and Bernard and Thomas (1989) and use firms' standardized unexpected earnings (SUE) as an alternative mispricing signal, computed as the difference between their current quarter's earnings and the earnings four quarters ago, scaled by the standard deviation of unexpected earnings over the last eight quarters.

2.2.2 Short selling variables

The main dependent variables related to short selling activities in my study are defined as follows: loan quantity (*On loan*) is the daily average of shares on loan relative to the total shares outstanding; lendable supply (*Lendable shares*) is the daily average of shares available for lending relative to a firm's total shares outstanding; utilization rate (*Utilization ratio*) is the daily average of utilization ratio (short interest divided by lendable shares); borrowing fee (*Lending fee*) is the average transaction-weighted rate reported by Markit and expressed in percentage per annum. For each stock each month, I use the five trading days before the month-end and the first five trading days of next month to calculate the daily average of short selling activities.

2.3 Sample summary

Table 1 Panel A reports the descriptive statistics for the shorting activities in the equity lending market. On average, 26.52% of a firm's market capitalization is available for lending, with 3.88% being On loan and resulting in a utilization rate of 12.09%. The value of *On loan* and *Lendable shares* has quite large cross-sectional variation, with standard deviation of 4.95% and 6.91%, respectively. The 10-percentile and 90-percentile value of *Utilization ratio* is 0.86% and 32.26%, indicating some firms are more heavily borrowed while some are barely borrowed. The average annualized fee is 0.53%, implying that it is very cheap, on average, to borrow shares in my sample with ESG scores available.

[Insert Table 1 about here]

I report the summary statistics of ESG performance, short selling activities and other related variables in Panel B of Table 1. *Ln(ME)* is the logarithm of market capitalization and *Ln(BM)* is the logarithm of book-to-market ratio (Fama and French (1992)). *Institutional Ownership* is the aggregated shares held by 13F institutions at the end of most recent quarter. *Analyst* is

number of analysts following at the end of last month. *Leverage* is the total liabilities scaled by the total asset at the most recent fiscal year end. *Loss* is a dummy variable indicating a negative income. Idiosyncratic volatility (*IVOL*), as in Ang, Hodrick, Xing, and Zhang (2006), is computed as the standard deviation of the residuals of the Fama and French (1993) three-factor model estimated using the daily stock returns over the previous month. *ESG score* has a mean of 0.63 and its standard deviation is 0.25. Such a large cross-sectional variation of ESG scores is useful to better estimate the effect of social performance on short selling activities from equity lending market.[14] *SYY* score is 45.02 on average, indicating the stocks in our sample is slightly underpriced compared to the original sample covered by Stambaugh, Yu, and Yuan (2015). Each month, I divide stocks into quintiles based on SYY score, and those in the fifth quintile are classified as "overpriced" stocks. By construction, *overpriced dummy* has mean of 0.2. In addition, these stocks are quite large, with 79% shares held by institutions and followed by 15.26 analyst on average. In summary, these stocks are quite large, liquid and easy to borrow.

I report the time-series average of the cross-sectional Pearson correlations and Spearman correlations of short-selling related variables, *ESG score*, *SYY score*, *overpriced dummy* and other relevant variables in Panel C of Table 1. Correlation between *ESG score* and *SYY score*, *overpriced dummy* is only -0.09 and -0.1, showing ESG performance does not contribute much to my mispricing measure ex-ante. However, I observe *ESG score* tends to have high correlations with *Ln(ME)* and *Analyst*, which I further control in the multivariate regression analyses.

3 Empirical results

3.1 Overpriced stocks, ESG Performance and short selling activities

I start my analysis by examining how the ESG performance of the firms will affect short selling activities conditional on mispricing. I conjecture that investors use mispricing score as their primary identification variable and overpriced stocks will have higher short demand from short sellers.[15] In this section, I investigate whether short sellers consider the ESG performance of the firms when they make the shorting decisions. Specifically, I sort all the stocks into quintiles using SYY mispricing score at the end of month, and focus on those most overpriced stocks because short selling activities should be concentrated on these stocks. I use the full sample rather than overpriced stocks only. Including "fairly priced" stock in my sample helps to control for the direct effect of ESG performance on the stock valuation. To start with, I run the following panel

[14] Another popular ESG database used in the literature is MSCI KLD, which has larger sample coverage. However, MSCI KLD ESG score is updated annually, is sticky over time, and has a smaller cross-sectional deviation as the distribution is clustered around zero.

[15] In Appendix Table A1, I find shares on loan, utilization ratio and lending fee is significantly higher for stocks with higher SYY scores, or stocks with overpriced dummy equaling one, all at 1% significance level.

regression:

$$\begin{aligned} Short\,Selling\,Activities_{it} = \alpha + \beta_1 ESG_{it-1} \times Overpriced\,Dummy_{it} + \\ \beta_2 ESG_{it-1} + \beta_3 Overpriced\,Dummy_{it} + \beta_4 X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{1}$$

where $Overpriced\,Dummy_{it}$ equals to one for overpriced stocks identified at the end of month t. I sort all the stocks based on SYY score into quintiles, and those with the highest SYY score are defined as overpriced stocks. $Short\,Selling\,Activities_{it}$ is the average of daily short selling activities during (-5, +5) days around the end of month t, including shares on loan, lendable shares, utilization, and lending fee.[16] ESG_{it-1} is the ESG performance at the end of last month. X_{it-1} are the control variables including market capitalization, book-to-market ratio, institutional ownership, analyst coverage, firm leverage, loss dummy, and idiosyncratic volatility. γ_t is the time fixed effect, and θ_i is the stock fixed effects. Coefficient on the interaction term β_1 captures the incremental effect of ESG performance on different short selling activities, for overpriced stocks compared to other stocks. The results are tabulated in Table 2. In column (1), the coefficient on $Overpriced\,Dummy_{it}$ is statistically positive, which also shows short sellers do utilize the information contained in the SYY score and make the short selling decision accordingly. The coefficient on the interaction term β_1 is significantly negative, indicating that among overpriced stocks, higher ESG performance is associated with a lower short selling demand compared to other stocks, proxied by shares on loan. Taken together, I find a negative relationship between ESG and shares on loan for overpriced stocks, relative to other fairly priced stocks. After controlling for a bunch of firm characteristics, when ESG score increases for one standard deviation (0.25), shares on loan decrease by 0.40%, which is equivalent to 10.4% of the average shares on loan, or 8.2% of the standard deviation of shares on loan. The economic magnitude is non-trivial.Consistent with the results of fewer shares on loan for overpriced high-ESG stocks, I find utilization ratio is lower correspondingly, significant at 1% level.

[Insert Table 2 about here]

Columns (3) and (4) report the results of lendable shares. It measures the willingness of shareholders to lend out the shares. The coefficient on the interaction term is not significantly different from zero, suggesting the fewer shares on loan for overpriced high-ESG stocks are not due to the lower supply of shares available to borrow. In addition, I find the lending fee is even lower for overpriced high-ESG stocks, showing borrowing cost is not a concern for short sellers here. Taken together, there are lower short selling demand for overpriced high-ESG stocks, while this is not due fewer lendable shares or higher lending fee.

[16] I include five trading days before the monthly SYY mispricing score becomes available, to capture the potential inside information of short sellers. The results are similar using different calculation windows and are discussed in Section 4.4.

3.2 Causality between ESG performance and short sellers' demand

To establish a causal relationship between firms' ESG performance and short sellers' trading activities among overpriced stocks, I consider a shock that changes a firms' ESG reputation from the viewpoint of market participants. The shock I examine is the FTSE4Good Index biannual reconstitution in which a firm is added from the Index due to a re-assessment of the firm's ESG performance relative to other firms, by FTSE-Russell. Launched in 2001, the FTSE4Good Index Series is a series of benchmark and tradable indexes for ESG (Environmental, Social and Governance) investors. Criteria are developed using an extensive market consultation process and are approved by an independent committee of experts.[17] Since FTSE4Good is an established index that specializes in corporate ESG issues, I expect the inclusion events carry information concerning firms ESG reputation perceived by the market participants. I want to test after the stocks are included in FTSE4Good index, whether short sellers treat them differently when these stocks are overpriced. One-to-one control groups are matched by firms ESG score, firm size, book to market value, number of analyst following and institutional ownership. The event window is (-6, +6) month excluding the event month for the following regression:

$$\begin{aligned} Short\,Selling\,Activities_{it} = \alpha + \beta_1 Treat_{it} \times Post_{it} \times Overpriced_{it} + \beta_2 Treat_{it} \times Post_{it} \\ +\beta_3 Post_{it} \times Overpriced_{it} + \beta_4 Treat_{it} \times Overpriced_{it} + \beta_5 Overpriced_{it} \\ +\beta_6 Post_{it} + \beta_7 Treat_{it} + \beta_8' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{2}$$

where $Treat_{it}$ represents the stocks that are included in the FTSE4Good index, $Post_{it}$ is the dummy for the 6 months after the event. β_1 captures how short selling activities change after the stock is included in the FTSE4Good index, compared to its peers. The results are reported in Table 3.

[Insert Table 3 about here]

After the stocks are included in an index that specializes in ESG issues, shares on loan for short selling decreases by 0.91% if the stock is overpriced. On the other hand, supply for short selling seems to decrease a little bit, while it is not statistically significant. Correspondingly, the utilization ratio decreases. Though the number of events is quite limited, it suggests a casual impact of ESG performance on the short selling activities, among overpriced stocks.

Prior studies suggest that the trading associated with index-linked products, such as index futures, index options, ETFs, could potentially affect the price discovery for the underlying stocks. For example, Hasbrouck (2003) documents ETFs help to improve intraday price discovery

[17] More information could be found on the FTSE4Good Index Factsheet: https://research.ftserussell.com/Analytics/FactSheets/temp/506aa4aa-8612-4ec6-ac2f-3f6c4c721141.pdf

using index futures. Glosten, Nallareddy, and Zou (2021) show that ETF activity increases short-run informational efficiency for stocks with weak information environments. On the contrast, Israeli, Lee, and Sridharan (2017) show the pricing efficiency decreases after an increase in ETF ownership. One may concern that my finding is due to increased passive ownership or ETF ownership when a stock is included in an index, thus short sellers are less willing to short them. To mitigate this concern, I perform a placebo test using reconstruction of the Russell 1000 index.

A stock's index assignment has an important impact on its portfolio weight in that index, as each Russell Index is value-weighted such that firms at the top of either index receive the highest weight. Therefore, the 1000th largest stock at the end of May, which is just included in the Russell 1000, has a trivial portfolio weight, whereas the 1001st largest stock just included in Russell 2000 will be given a large index weight. Therefore, the largest firms in the Russell 2000 Index are likely to be widely held by any funds or ETFs tracking the Russell 2000, whereas funds tracking the Russell 1000 would hold almost none of the smallest firms in the Russell 1000. Following Appel, Gormley and Keim (2016) and Chen, Dong, and Lin (2020), I use the inclusion of Russell 2000 as an exogenous shock on the ETF ownership or institutional ownership. I use this event as a placebo test, and investigate how the short selling activities of the first 100 stocks that are included in the Russell 2000 index differ from the last 100 stocks included in Russell 1000 index when they are overpriced.

The results are tabulated in Appendix Table A2. Consistent with Glosten, Nallareddy, and Zou (2021), I find there is more short selling demand for 100 largest stocks in Russell 2000 index when they are overpriced, compared to the 100 smallest stocks in Russell 1000 index, which should lead to a higher price efficiency. This placebo test helps to rule out the alternative that my results are driven by the inclusion of a general index.

In addition, I also examine another two alternative shocks to provide further evidence of the causality. Specifically, I use the passage of ESG related shareholder proposals as a shock to firms policy that would change firms' future ESG performance, and the announcement of the Paris Agreement as a shock that strengthens investors' ESG awareness. I provide related analysis and results in the Internet Appendix IA1 and IA2.

3.3 ESG performance and short selling risks

3.3.1 Synchronization risk

Abreu and Brunnermeier (2002) argue that arbitrage is limited if rational traders face uncertainty about when their peers will exploit a common arbitrage opportunity, which they called synchronization risk. If the mispricing correction process of their peers is delayed, arbitragers will face both explicit and implicit holding cost. Starks, Venkat and Zhu (2020) document that investors are more patient towards high ESG firms and sell less after negative earnings surprises.

It is therefore possible that among overpriced stocks, those with high ESG scores are associated with higher synchronization risks because short sellers' peers, who hold the stocks will delay the selling decision because investors are more patient towards them or holding high ESG stocks could attract fund inflow Hartzmark and Sussman (2019). Therefore, considering this, short sellers are less willing to accumulate short position on these stocks even when they are overpriced, to avoid holding costs, which could be tremendous sometimes. For example, short sellers must hold the short-sale proceeds in a margin account that pays minimal or no interest. In addition, arbitrageurs also face implicit holding costs. For instance, they cannot fully hedge their arbitrage strategy in a world where a perfect substitute for the mispriced asset does not exist. Other examples include the relative performance evaluation of fund managers in the short term and the risk that the lender of security might recall the asset.

To investigate this possibility, I examine whether long-side institutions will respond differently to stocks with different ESG performances when they are identified as overpriced. Specifically, I relate the change in the quarterly holdings of the mutual funds and all the 13f institutions at the end of a given quarter to overpriced stocks with different ESG performances. To identify overpriced stocks, I calculate the average of a stock's SYY score in the last month of the previous quarter and the first two months of the current quarter. Then I sort stocks into quintiles based on this average SYY score and assign an *Overpriced Dummy* to stocks in the quintile with the highest quarterly SYY scores. The change in holdings is calculated in two different ways, for both mutual funds and 13F institutions. First, I calculate log changes in the number of institutions holding the shares, since previous research suggests that the number of institutions holding a stock, rather than the amount that they hold, is more informative (Sias, Starks, and Titman (2006), Khan, Kogan, and Serafeim (2012), Edelen, Ince, and Kadlec (2016)). In addition, I calculate the change in the percentage of shares held by mutual funds and 13F institutions. Then I run the following regression on a quarterly basis:

$$\begin{aligned} Holding\,Changes_{it} &= \alpha + \beta_1 ESG_{it-1} \times Overpriced\,Dummy_{it} \\ &+ \beta_2 ESG_{it-1} + \beta_3 Overpriced\,Dummy_{it} + \beta_4' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{3}$$

where $Holding\,Changes_{it}$ is measured by four variables: log change of mutual funds number, change of mutual fund ownership, log change of 13F institution number, and change of institutional ownership. X_{it-1} are the control variables at the end of last quarter, including market capitalization, book-to-market ratio, institutional ownership, analyst coverage, firm leverage, loss dummy, and idiosyncratic volatility. I include quarter fixed effect and firm fixed effect.

[Insert Table 4 about here]

The results are tabulated in Table 4. Dependent variables in Columns (1) and (2), Columns (3) and (4) are mutual funds number change and mutual fund ownership change, respectively.

The coefficient of $Overpriced\,Dummy_{it}$ is significantly negative, suggesting the mutual funds decrease their holdings after the stock is identified as overpriced. Among overpriced stocks, fewer mutual funds dump the stocks with higher ESG stocks. When ESG score increases from Q1 to Q3 (0.46), the decrease of mutual funds ownership is mitigated by 0.24% when the stocks are overpriced. The results of 13F institution number change and institutional ownership change in Columns (5) to (8) reveal the same pattern, which suggests that investors who hold the stocks with high ESG performance delay the selling decision when the stocks are overpriced. Therefore, short sellers are more likely to avoid overpriced stocks with high ESG performance because of higher synchronization risk.

Mutual funds managers treat overpriced firms with various ESG performances differently, maybe because they want to maintain a high fund ESG performance to attract more flows (Hartzmark and Sussman (2019)). Alternatively, fund managers are likely to keep high ESG stocks to hedge climate risks even when they are relatively overpriced at the moment (Engle, Giglio, Kelly, Lee, and Stroebel (2020), Pástor, Stambaugh, and Taylor (2020)). If high synchronization risk associated with high ESG stock is indeed one essential consideration for short sellers, then when the demand for climate risk hedging is higher and investors' awareness on sustainability is higher, fund managers are more likely to hold overpriced high-ESG stocks and delay the selling. Therefore, I would expect the relationship between ESG performance and synchronization risk should be stronger after Paris Agreement. Indeed, in the unreported results, I do find institutions become more patient towards overpriced stocks with high ESG and further delay the selling after the Paris Agreement, which echoes with the results in Internet Appendix IA2 that the impact of ESG on short sellers trading is magnified after Paris Agreement.

3.3.2 Short squeeze risks and ESG sentiment

There is another type of risk that is essential for short sellers. The activity of behavioral noise traders might lead to temporary price movements, which will reduce the value of the arbitrage portfolio if the price moves even further away from the fundamental value. If arbitrageurs are compelled to liquidate their positions in the intermediate term, then they are forced to take losses exactly when the arbitrage opportunity is greatest. De Long et al. (1990) call this noise trader risk. There are many reasons why arbitrageurs have to liquidate their position before the arbitrage profit finally pays off. Short sellers are worried about temporary price increase instead of price drop, and, it might trigger short sellers to cover their positions following margin calls and further push up the price, which is modeled as short squeeze risks in Xu and Zheng (2016). If a short seller is squeezed out of his short position prematurely amid the price hike (that is, if the seller bumps up against his capital constraint), he will incur a loss even if the stock price eventually falls below the price at which he has initially sold the stock short. Clearly, if arbitrageurs are short-lived, as in models with overlapping generations, they only care about

the price at which they will sell the asset in their final period of consumption. In practice, professional fund managers have relatively short horizons because their clients evaluate them on short-term performance and relatively poor performance leads to an outflow of funds (Shleifer and Vishny (1997)). In addition, extra capital needs to be put in the short-sale margin account if the stock price goes up, which could be rather risky for relatively capital constrained short sellers. Therefore, because of short squeeze risk, short sellers might find it optimal to (partially) liquidate their position early in an incomplete market setting when the investment opportunity set changes, or just avoid the securities with higher short squeeze risks in the first place.

Given the popularity of ESG investing, it is reasonable to expect these "Good citizens" might suddenly experience a large buying pressure when the temporary attention for the ESG related topic is high, causing a short-term surge in the stock price. For example, Choi, Gao and Jiang (2020) find that when the local exchange city is abnormal warmer in that month, the google search volume related to global warming is higher and less carbon-intensive firms earn higher stock returns compared to other firms. Therefore, I hypothesize that short sellers may be less willing to short overpriced high ESG stocks because they have higher upside jump probabilities, which could partially come from ESG related attention/sentiment.

To test whether high ESG stocks have higher total short squeeze risks, I use four measures to proxy for the upside jump probabilities. First, I calculate realized skewness using daily stock returns in a month. Second, following Bollerslev, Li, and Zhao (2020), I use high-frequency intraday data, and construct relative signed jump variation, which is defined as the difference between the up and down semi-variance measures divided by the total return variance. Third, motivated by Xing, Zhang, and Zhao (2010), I calculate implied skewness from option prices, which is the difference between the implied volatilities of out-of-the-money (OTM) call options and the implied volatilities of at-the-money (ATM) call options. Following Kelly, Pastor, and Veronesi (2016), I use upside slope as the fourth measure, calculated as the slope of a function that relates right-tail implied volatility to moneyness (with moneyness being measured by the option's delta) of call options.[18] In addition to using the information contained in the realized returns, the last two measures capture the perceived positive jump possibility by investors based on the forward-looking information contained in the option prices. Then I investigate the relationship between four upside jump probability measures and ESG scores, and report the results in Table 5. Consistent with the hypothesis, I find high ESG stocks have both higher realized upside jump probability and perceived upside jump probability.

[Insert Table 5 about here]

[18] A lower upside slope is associated with higher positive jump probability perceived by the investors, meaning a more expensive OTM call options relative to ATM call options, since OTM call options has lower delta. To make it easier to interpret and consistent with other three measures, I take the negative value of upside slope.

To further test whether ESG attention/sentiment is one potential source for high upside jump probability associated with high ESG stocks, which is becoming progressively important for short sellers recently, I propose a measure, called ESG sentiment beta, capturing the movement of daily stock returns with Google Search Volume Innovations. Following a similar procedure of Huynh and Xia (2020), for each stock in each month, I estimate an ESG sentiment beta (β_{ESG}) from the daily rolling regression of stock excess returns on innovations in the daily Google Search Index Volume (DSVI) of ESG related topics over a 252-day window with a minimum of 120 valid daily return observations. In addition, I use 60 days of daily return to estimate a short-term ESG sentiment beta, requiring a minimum of 24 valid observations. I control for Fama-French three factors as follows.

$$RET_{it} = \alpha + \beta_{ESG} DSVI_{it} + \beta_2 Mkt\_rf_{it} + \beta_3 SMB_{it} + \beta_4 HML_{it} + e_{it}, \tag{4}$$

where $DSVI_{it}$ is the innovation of Google Search Volume of two topics, "Climate Change", and "Environmental, Social, and Corporate Governance". RET_{it} is the daily excess return of the stocks. Mkt_rf_{it}, SMB_{it}, HML_{it} are daily factors obtained from Kenneth French's data library. The β_{ESG} estimated captures a stock's covariance with innovation in the investors' attention towards ESG related topics on daily basis. By construction, a greater β_{ESG} indicates an increase in the stock price as innovation in the public's ESG attention/sentiment increases. Then I investigate the relationship between ESG sentiment beta and a firm's ESG performance.

[Insert Table 6 about here]

The results are reported in Table 6. Dependent variables in Columns (1) and (2) are ESG sentiment beta estimated based on the DSVI of the topic "Climate Change", on a 60-day window and 252-day window respectively. ESG performance is positively associated with ESG sentiment beta, after controlling various firm characteristics. Results in Columns (3) to (4), which are based on the DSVI of the topic "Environmental, Social, and Corporate Governance" show a similar pattern. When there is an attention increase on ESG related topics, stocks with higher ESG scores may experience a sudden price increase, which will make short sellers less incentivized to target those stocks even when they are overpriced.[19]

3.3.3 Potential ESG reputation risk

Although short sellers help improve price efficiency, they have earned a relatively more negative reputation since they tend to profit while other investors struggle. In certain cases, some

[19] To further elaborate the relationship between sudden surge of ESG sentiment and price increases of high ESG stocks, I utilize ten speeches of Greta Thunberg as exogenous shocks on public attention to ESG related issues, and find cumulative abnormal return (CAR) is higher for high ESG stocks and short selling demand decreases for overpriced high-ESG stocks after her speeches. The results are reported in Internet Appendix IA3.

have argued that short positions push down companies who otherwise would have prevailed, and thus taking short positions is almost unethical. It is concerned that short sellers may often attempt to illegally manipulate stock prices.[20] According to the current regulation under Regulation SHO, investors are not required to disclose any short position to the public. Imagine if the short sellers are suddenly required to disclose short selling positions above a certain threshold like European countries, those taking a large short position on "good citizens" might be worried about their reputations, which could further affect the future investor flows. In Capgemini's World Wealth Report 2020, more than a quarter (27%) of high net worth individuals (HNWIs) those with investible assets of $1 million or more said they were interested in sustainable products.[21] They should be less likely to put money into the funds that severely short stocks with good ESG performance, while at the same time they are the major investors of the hedge funds. Therefore, I hypothesize that short sellers might consider ESG performance before making short selling decisions, because a bad ESG reputation may lead to fund outflow or lower future fund inflow.

To test this possibility, I examine 1) the choice of short sellers to disclose their short-sale position publicly, 2) social pressure faced by short sellers when they take positions that effectively bet against high ESG stocks. Specifically, I ask if a stock has a high ESG score, are short sellers less likely to disclose the short position publicly even they have accumulated large short positions? And when a short seller publicly discloses a short position, whether the reaction of investors on social media is more adverse if the underlying firm has better ESG performance. Using data provided by Ljungqvist and Qian (2016) along with the information I collected about the publicly disclosed short-sale position/report from hedge funds websites and *SeekingAlpha* over a period from 2006 to 2019.[22] I identified 205 publicly disclosed short-sale campaigns. However, these targets are generally mid-cap stocks, with an average market capitalization of $9,124 million, which is in the 69 percentile of the distribution of CRSP firms.[23] Only several stocks have non-missing ESG scores from the Asset4 database, because it mainly covers large

[20]See generally the Commission's 2010 release adopting the short sale circuit breaker price test, Exchange Act Release No. 61595 (Feb. 26, 2010), 75 FR 11232, 11235-37 (Mar. 10, 2010) (discussing past and present concerns of market participants about manipulative short sale activity). A number of commenters noted concerns with potential trade manipulation, see, e.g., letter from Judith Scott, General Counsel, Portfolio Recovery Associates (Jun. 24, 2011) ("Portfolio Recovery Associates").

[21]Detailed report could be found: https://worldwealthreport.com/

[22]There are 31 arbitrageurs in Ljungqvist and Qian (2016). Among them, 17 arbitrageurs release multiple reports and 14 arbitrageurs release one report. I focus on the 17 arbitrageurs, which include Citron Research, Bronte Capital, GeoInvesting, Ian Bezek, ShareholderWatchdog, Alfred Little, MuddyWaters, Kerrisdale Capital, Asensio & Co., Spruce Point, Chimin Sang, Prescience Investment, Absaroka Capital Management, Chinese Company Analyst, The Forensic Factor, Glaucus Research, and OLP Global.

[23]The average market capitalization of short-sale targets in Ljungqvist and Qian (2016) is $969.3 million, 54th percentile of the distribution of CRSP firms, from 2006 to 2011. The targets are larger in terms of CRSP distribution and much larger in absolute market value, because firms are growing over time and short-sellers seem to target some large firms recently.

stocks in major indexes. To supplement the information of ESG performance for these short-sale targets, I utilize ESG scores from two other alternative databases in this particular test, KLD and MSCI IVA databases.[24] Following Brandon, Krueger, and Mitali (2021), I calculate the ESG score as follows:

$$ESG\_combined_{it} = \frac{1_{KLD_{it}} \times z_t\,(KLD) + 1_{IVA_{it}} \times z_t\,(IVA)}{1_{KLD_{it}} + 1_{IVA_{it}}} \tag{5}$$

where $1_{KLD_{it}}$ ($1_{IVA_{it}}$) is a dummy variable indicating if the KLD (IVA) score is available for stock i in period t, $z_t\,(KLD)$ and $z_t\,(IVA)$ is the standardized ESG score with a mean of zero and a standard deviation of one. This approach consists of using an average standardized score whenever both KLD and IVA scores are available, and using only the available standardized score whenever a stock is covered by one data provider only.[25] By doing so, I have identified 110 events with ESG scores available.

To investigate whether the short sellers are less willing to disclose their short position publicly if the firm has good ESG performance, I run a logit regression and examine the probability of being targeted. Column (2) in Panel A, Table 7 shows that after controlling for the short selling demand (proxied by shares on loan and utilization ratio), high ESG firms are less likely to be the targets of the public short-sale campaigns. One step further, I perform a one-to-one propensity score matching based on shares on loan, utilization ratio and other firm characteristics. In Columns (3) and (4) of Table 7 Panel A, I compare two stocks that have been equally shorted and have similar firm characteristics, and find short sellers are less willing to tell public about their short position if they are going to violate social norms, i.e., short sell firms with good ESG performance.

[Insert Table 7 about here]

The next question is when short sellers take positions that effectively bet against high ESG stocks publicly, are they more subject to social pressures? I use the tone of online comments to infer investors' attitudes towards the public short-sale campaigns. For each campaign, I search the related reports in *SeekingAlpha* and collect comments under the reports, summing up to 5,277 comments. I choose *SeekingAlpha* because the users are more sophisticated in terms of investment knowledge than users of general social media such as *Twitter*.

I read all the comments, and for each comment, I assign an *Agreement Score* and an *ESG*

[24] These two databases have larger coverage compared to Asset4. However, the ESG performance is sticky over time and has smaller standard deviation.

[25] This approach has two advantages. First, even though ESG ratings can disagree, taking average could be a better estimation of true ESG performance. Second, this allows us to obtain the largest possible sample with non-missing ESG performance, as targets of short-sale campaigns are usually midcap stocks. I also show my results are robust to alternative ESG database, which will be discussed later.

dummy. Specifically, the *Agreement Score* of a comment is equal to -1 if the comment is against the short-sale activity, +1 if the comment is supportive for the short-sale activity, and 0 if it is neutral.[26] The *ESG dummy* equals 1 if the comment mentions ESG related topics, and 0 otherwise.[27]

Then I run comment level panel regression with year fixed effect and the results are reported in Table 7 Panel B. I examine the following two questions: 1) whether the tone from public is more negative towards short-sale campaign if the stock has a higher ESG score; 2) whether there are more ESG related comments if the stock has a higher ESG score. I find the *Agreement Score* is more negative for high ESG stocks, indicating there is more pressure from social media if short sellers publicly disclose their short position on high ESG stocks. Moreover, it is likely that such adverse reactions are related to the ESG performance of the firms, indicated by a positive relationship between ESG score and ESG dummy.

Publicly disclosed short-sale activities are rare in numbers and special in nature. Short sellers' consideration could be far different from general short sellers. To explore how the reputation risks associated with ESG performance of targets could affect short sellers' decisions in general, I examine a short selling regulation introduced in European markets on November 1, 2012, which requires a certain level of public disclosure of short position. I find after the regulation came into force, short selling demand of high ESG firms decreases among overpriced stocks, which suggests short sellers care about their ESG reputations and try to hide some short position on high ESG stocks.[28]

Nevertheless, I need to admit that ESG reputation risk channel does not contribute much to my findings because short sellers are not required to disclose their short positions at this moment in the United States. However, there is a growing demand for higher transparency of funds' short selling activities. Recently, SEC has adopted new rules and forms to modernize the reporting and disclosure of information by registered investment companies.[29] It requires financial statements to include specific holding information related to derivatives, including options, futures, swaps

[26]For example, when Citron Research disclosed a bearish view on Monster Beverage (Ticker: MNST) in 2016, there is one comment saying, "I happen to be a retailer of many retail products, Monster happens to be one of them. Just happen to look at an invoice for a delivery this week, Monster energy was over half the bill. Monster has added a number of items, and entered new categories, and all of them sell. This is quite rare. Over the years, all I hear is how health conscious people are and they want to point to the dropping consumption of cola and carbonated. Its down has been more than replaced by Energy, fully sweet teas, and item extensions like Mountain Dew kick start...Does any of this matter to the valuation, maybe not, but if it drops all the way to $80 I will be buying all the way there." I assign an agreement score of -1 for this particular comment.

[27]I use 28 important ESG issues identified by RepRisk, one news-based ESG data vendor. Environmental issues include climate change, local pollution, waste issues etc. Social issues include discrimination in employment, local participation issues, occupational health and safety issues etc. Governance issues include executive compensation issues, fraud, tax optimizations etc.

[28]Detailed test results are reported in Internet Appendix IA4.

[29]More details about amendments and new rules could be found:https://www.sec.gov/divisions/investment/guidance/secg-investment-company-reporting-modernization-rules.htm

and others. Put options are often treated as a substitution of short selling. If all the option holding positions are required to be disclosed to the public, I would expect there is a reasonable chance that short selling position will be required to be disclosed shortly, just like other countries (Europe, Australia, and Japan, etc.).

3.4 Impact on stock returns

Short selling could help to improve the price efficiency (Saffi and Sigurdsson (2011), and Boehmer and Wu (2013)). In this section, I investigate the implication of documented trading behavior of short sellers on stock prices. When stocks are overpriced and there are not enough short selling to correct the mispricing for high ESG stocks, I expect the return of overpriced stocks should be more negative for high ESG stocks afterwards, as the mispricing gets corrected gradually. To test this hypothesis, I calculate the daily cumulative return from the sixth trading day to the end of month and then run the Fama and MacBeth (1973) regression.

[Insert Table 8 about here]

Columns (1) and (2) in Table 8 Panel A show the results. Among overpriced stocks, an increase in one standard deviation of ESG score is associated with 0.26% lower return in the following month. To further that more negative return associated with overpriced high-ESG stock is due to limited short selling demand, I next examine whether the return predictability is concentrated in stocks with low short selling demand. Specifically, I use shares on loan and utilization ratio to proxy for short demand. Within each SYY mispricing quintile, I divide stocks into two groups based on shares on loan and utilization ratio, and I expect the return predictability of ESG performance among overpriced stocks should be stronger when there is not enough short selling demand. Columns (3) and (4) in Table 8 Panel A report the results for stocks with low shares on loan and stocks with high shares on loan, showing the return predictability only exists among stocks with lower short selling demand.

The aforementioned results are consistent with the story that short sellers are less willing to short overpriced high ESG stocks, leading to a more negative return afterwards. To lend more support to this argument, I next examine the impact of short selling demand on the return predictability by controlling the short selling demand in the regression. If overpriced high-ESG stocks have more negative returns because there is not enough short demand, then the impact of ESG score on the returns should become less significant when short selling demand is controlled. The results are reported in Panel B Table 8. Among overpriced stocks, lower shares on loan are associated with more negative stock returns, showing insufficient short demand will delay the process of mispricing correction. Short selling demand indeed plays a key role in explaining the negative relation between overpriced high ESG stocks and stock returns. After controlling for

the short selling demand proxies, the magnitude of the ESG coefficient is reduced by 30%, from -0.924 (Column (2)) to -0.652 (Column (6)) and T-stat drops. However, the impact of ESG score is still marginal significant, showing that insufficient short selling demand may not be the only reason for the return predictability documented.

4 Robustness tests and discussions

4.1 Additional cross-sectional results

So far, I have documented that ESG performance affects short selling demand when the stocks are overpriced. I also provide three potential mechanisms. Short sellers are less willing to short overpriced high-ESG stocks because of higher synchronization risks, higher short squeeze risks, and ESG reputation risks. In this section, I further explore the heterogeneity across stocks, and investigate the impact of social performance conditional on different institution ownership structures and investors ESG awareness.

4.1.1 Different institution ownership structures

One reason that short sellers are less willing to sell overpriced high ESG stocks, comes from the uncertainty of long-side investors' selling decision, or synchronization risks, because institutions are more patient towards these "good citizens". Naturally, one would expect that socially responsible institutions, which have stronger ESG preferences, would be further patient to high ESG stocks. Therefore, the aforementioned relationship between ESG score and short selling demand among overpriced stocks should be stronger when the shares are held by more socially responsible investors. To test this hypothesis, I first identify these socially responsible institutions. Specifically, I follow Cao, Titman, Zhan, and Zhang (2021) and sort financial institutions in the Thomson Reuters 13F filing database into three groups, based on the average ESG score of firms in their portfolio holdings, where the top tercile contains institutions with the highest average portfolio ESGSCORE and the bottom tercile consists of institutions with the lowest average portfolio ESGSCORE. Institutions in the top tercile are deemed socially responsible. For each firm, I calculate the fraction of socially responsible institutions (SRIO) as the number of shares held by socially responsible institutions, divided by the total number of shares held by all the institutions. Then I test whether the relationship between ESG and short selling demand is stronger for the stocks held by more socially responsible institutions, by running the following

regression:

$$
\begin{aligned}
Short\,Selling\,Activities_{it} = \alpha &+ \beta_1 ESG_{it-1} \times Overpriced_{it} \times High\_SRIO_{it-1} \\
&+ \beta_2 ESG_{it-1} \times High\_SRIO_{it-1} + \beta_3 Overpriced_{it} \times High\_SRIO_{it-1} \\
&+ \beta_4 ESG_{it-1} \times Overpriced_{it} + \beta_5 Overpriced_{it} + \beta_6 High\_SRIO_{it-1} \\
&+ \beta_7 ESG_{it-1} + \beta_8' X_{it-1} + \gamma_t + \theta_i + e_{it},
\end{aligned} \tag{6}
$$

I divide all the stocks into two groups based on $SRIO$ at the end of last quarter, and $High\_SRIO_{it-1}$ is dummy representing stocks with $SRIO$ above the medium. All the regressions include firm fixed effect and time fixed effect.

[Insert Table 9 about here]

Panel A, Table 9 reports the results. β_1 is statistically significant negative for shares on loan, utilization ratio and lending fee, indicating when the stocks are more held by the socially responsible institutions, the documented relationship between ESG scores and short selling activities is even stronger.

4.1.2 Different attention on ESG performance

I document short sellers are less willing to short overpriced high-ESG stock, compared to its peers. I expect the importance of the ESG performance should vary with investors' attention. When there is more attention on a firm's ESG performance, the negative relationship between ESG and short selling demand should be magnified. To capture investors' attention on individual firms, I employ a text-based measure, *Climate Change Exposure* (*CC_Expo*) constructed by Sautner, Van Lent, Vilkov and Zhang (2021) that extracts information from quarterly earnings conference calls. The method adopts a machine learning keyword discovery algorithm to count the frequency of climate change related bigrams in a transcript, scaled by the total number of bigrams. It captures overall attention on climate change exposure of the firms, including both risks and opportunities. I conjecture that when the analysts and managers talk more about climate related topics during the conference call, investors pay more attention to firms' ESG performance, therefore its impact on short sellers' trading activities should be stronger. I divide the whole sample into two based on the *CC_Expo* of the firm last quarter, then then test whether the results are more significant among firms with higher *CC_Expo*.

The results are reported in Panel B, Table 9. The coefficient on the triple interaction term is significantly negative for shares on loan and utilization ratio. The effect of ESG performance on short selling demand in the high *CC_Expo* group is much stronger compared to that in the low *CC_Expo* group, while ESG score is still negatively related with short selling demand among

overpriced stocks in the low CC_Expo group. The results indicate when the attention is higher on a firm's climate exposures, ESG performance becomes a more relevant factor that short sellers would take into consideration.

4.2 Alternative ESG score

Through my empirical analysis, I mainly rely on one data vendor of ESG performance, the Thomson Reuters Asset4 ESG database. There are other popular ESG databases. For example, the MSCI KLD database is commonly used in the literature[30], which has larger sample coverage. However, the MSCI KLD ESG score is updated annually, sticky over time, and has a smaller cross-sectional deviation as the distribution is clustered around zero. More than 50% of the universe has a net KLD score of -1, 0, and 1. In addition, different data vendors may choose different factors to construct ESG scores and have different methodologies, thus capturing different aspects of ESG performance. Gibson, Kruger, and Schmidt (2021) find that correlations of ESG scores from different vendors are not very high.

[Insert Table 10 about here]

Therefore, as a robustness check, I further utilize the ESG score provided by two alternative data vendors, the MSCI KLD ESG database and Sustainalytics. For MSCI KLD ESG data, a large portion of the firms have ESG scores of -1, 0, and 1, I therefore apply more extreme values as cut-off points and classify my sample firms into Low ($ESG\_rank = 1$), Medium ($ESG\_rank = 2$), and High ESG groups ($ESG\_rank = 3$), using the 15th percentile and the 85th percentile as my breakpoints. ESG score from Sustainalytics is updated monthly, has more time-series and cross-sectional variation, and is available from September 2009. Using these two alternative ESG data, I repeat my baseline regression and report the results in Table 10, Panel A for ESG score from MSCI KLD ESG and Panel B for ESG score from Sustainalytics. The pattern is consistent with my baseline result that among the overpriced stocks, those with better social performance have lower short selling demand, while the supply for lendable shares is not affected, after controlling for multiple firm characteristics. Although different ESG data vendors have a different assessment for a firm's ESG performance, my results are robust to different ESG data vendors.

4.3 Alternative mispricing signals

I use the mispricing score in Stambaugh, Yu, and Yuan (2015) as my primary measure to identify the overpriced stocks because it is widely used in the literature as a proxy for mispricing. For example, Akbas et al. (2015) document dumb money appears to exacerbate cross-sectional mis-

[30] Deng, Kang and Low (2013), Krüger (2015), and Lins, Servaes and Tamayo (2017)

pricing and smart money appears to attenuate aggregate mispricing. Engelberg, Joseph, Adam and Matthew (2018) find that MISP measure predicts return strongly among firms with high short-selling risk.[31] However, there might be different interpretations of this measure. As a robustness check, I use standardized unexpected earnings (SUE) as another mispricing measure. Specifically, I follow Foster, Olsen, and Shevlin (1984) and Bernard and Thomas (1989) and compute SUE as the difference between their current quarter's earnings and the earnings four quarters ago, scaled by the standard deviation of unexpected earnings over the last eight quarters. Each month, all the stocks are divided into quintiles based on the most recent SUE. Firms with the most positive SUE are expected to have higher returns and firms with the most negative SUE are expected to have the most negative returns, which are identified as overpriced stocks. Then I examine whether the relationship between short selling activities and SUE quintiles vary with ESG scores of the firm. I run the following regression:

$$\begin{aligned} Short\,Selling\,Activities_{it} &= \alpha + \beta_1 ESG_{it-1} \times Overpriced\,Dummy_{it} \\ &+ \beta_2 ESG_{it-1} + \beta_3 Overpriced\,Dummy_{it} + \beta_4' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{7}$$

The patterns reported in Appendix Table A3 are consistent with the aforementioned results. For stocks with the most negative SUE thus the most negative expected return, there are more shares on loan, lower lendable shares, higher utilization ratio, and higher lending fees. Among these overpriced stocks, ESG performance has a negative impact on the short selling demand.

4.4 Alternative period for short selling activities calculation

In my baseline analysis, based on the mispricing at the end of the month I investigate the average daily short selling activities around the month-end in the window of (-5, +5) days, because previous studies document that short sellers have private information (Karpoff and Lou (2010), Christophe, Ferri, and Hsieh (2010)) and they may make the short selling decision before the monthly SYY score is available. In addition, among 11 anomalies that Stambaugh, Yu, and Yuan (2015) use to construct SYY score, some are updated annually and are known to the investors before the end of month. As a robustness check, I also use alternative windows to calculate short selling demand. I repeat the baseline analysis, and calculate the average of daily short selling activities of (0, +10) trading day window and (-10, +10) trading day window around the month-end. For example, for the $Overpriced\,Dummy_{it}$ identified at the end of March, (0, +10) day window refers to the short selling activities starting from the first trading day of April through the 10th trading day in April. Again, I find similar results, which are tabulated in Appendix Table A5. It may indicate short sellers trade on both private information and public signal such

[31] Other published work, including Jacobs (2016), Wang, Yan, and Yu (2017), Liu, Stambaugh, and Yuan (2018), Chen, Da, and Huang (2019), and Guo, Li, and Wei (2020) and among the others, either uses the MISP directly or each anomaly separately to study stock market mispricing.

as SYY score.

4.5 Do investors buy put options instead?

Investors are more likely to use options to express a bearish view on overpriced stocks than they are to express a bullish view on underpriced stocks because of short-sale constraints (Easley, O'Hara, and Srinivas (2002), Johnson and So (2012)). If the arbitragers are less willing to short overpriced high ESG stocks because these stocks have severe short-sale constraints, then investors may turn to the option market and buy put options, which will influence put option prices (Ramachandran and Tayal (2020)). In the contrast, I show my results are not due to traditional short-sale constraints, therefore the option trading pattern is expected to be similar to that of short sellers. And indeed, I find option traders also buy fewer put options of overpriced high-ESG stocks. Detailed analyses are reported in the Internet Appendix IA5.

5 Conclusion

With the increasing awareness of ESG issues in recent years, more and more investors take ESG information into consideration. Do the short sellers, who are the natural arbitragers, consider the ESG performance when making short selling decisions? My analysis suggests that when a stock is overpriced, short sellers will shy away from it if the stock has good social performance. I use the inclusion of FTSE4Good Index inclusion, passage of close-call ESG proposal, and Paris Agreement to establish the causal relationship between short selling demand and ESG performance, conditional on mispricing level. I further find the lower demand for overpriced high-ESG stock is neither due to fewer lendable shares nor higher borrowing costs. Three potential explanations are proposed, including synchronization risks, short squeeze risks, and ESG reputation risks. First, short sellers face higher uncertainty about whether and when the "long side" investors will sell the overpriced high-ESG stocks. Second, high ESG stocks have a higher probability of upside price jump, and may experience a sudden price increase when the attention to ESG spikes. Third, short sellers who care about their ESG reputations may be reluctant to short overpriced high-ESG stocks. Finally, the negative relationship between ESG performance and short selling demand among overpriced stocks has a considerable implication on stock returns. Overpriced stocks with high ESG scores have more negative stock returns afterwards.

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Table 1. Summary statistics

This table reports descriptive statistics of short selling activities, stock characteristics and correlation matrix. Panel A reports the stock-month summary statistics of short selling activities. Panel B reports summary statistics of ESG score, logarithm of market capitalization, the logarithm of book to market value, institutional ownership of most recent quarter-end, analyst coverage, firm leverage, loss dummy indicating negative earnings last year, and AXHZ (2006) idiosyncratic risk (IVOL) of last month. The statistics are the time-series average of cross-sectional distributions. *On loan* is the daily average of shares on loan relative to the total shares outstanding. *Lendable shares* is the daily average of shares available for lending on a given day relative to a firm's total shares outstanding. *Utilization ratio* is *on loan* divided by *Lendable shares*. *Lending Fee* is the daily average of transaction-weighted rate reported by Markit and expressed in percentage per annum. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100. *SYY* score for a stock is the mispricing score in Stambaugh, Yu, and Yuan (2015). Each month, I divide stocks into five quintiles based on SYY score, and *Overpriced Dummy* is a dummy for stocks with the highest SYY score. *Ln(ME)* is the logarithm of market capitalization. *Ln(BM)* is the logarithm of book to market ratio. *Institutional ownership* is the percentage of common stocks owned by institutions in the previous quarter. *Analyst coverage* is the number of analysts following the firm in the previous month. *Leverage* is the total liabilities scaled by the total asset at the most recent fiscal year end. *Loss* is a dummy variable indicating a negative income. *IVOL* is the annualized idiosyncratic volatility computed as in Ang, Hodrick, Xing, and Zhang (2006). Panel C reports the time-series average of cross-sectional correlations among different short selling activities, ESG scores, and other firm characteristics. The Pearson correlations are shown below the diagonal together with Spearman correlations above the diagonal. The sample period is from January 2006 to December 2019.

Panel A: Short selling activities							
Jan 2006 – Dec 2019	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
On loan (%)	3.88	4.95	0.36	0.77	1.99	4.97	10.12
Lendable shares (%)	26.52	6.91	18.51	22.48	26.82	30.86	34.57
Utilization ratio (%)	12.09	14.96	0.86	2.13	6.19	16.20	32.26
Lending fee (%)	0.53	1.53	0.35	0.36	0.37	0.38	0.43

Panel B: Stock characteristics							
Jan 2006 – Dec 2019	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
ESG score	0.63	0.25	0.28	0.41	0.64	0.87	0.94
SYY	45.02	11.82	30.46	36.54	44.10	52.60	60.77
Overprice	0.20	0.40	0	0	0	0	1
Ln(ME)	8.97	1.20	7.62	8.12	8.81	9.68	10.61
Ln(BM)	-0.90	0.79	-1.84	-1.35	-0.85	-0.34	0.02
Institutional ownership	0.79	0.16	0.59	0.70	0.81	0.90	0.96
Analyst	15.26	7.51	5.84	9.66	14.65	20.11	25.51
Leverage	0.26	0.20	0.03	0.13	0.24	0.36	0.50
Loss dummy	0.12	0.32	0	0	0	0.01	0.61
IVOL	0.07	0.04	0.03	0.04	0.06	0.08	0.11

Panel C. Correlations among short selling activities and stock characteristics

Pearson \ Spearman	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Var9	Var10	Var11	Var12	Var13	Var14
On loan	1.00	0.17	0.95	0.17	-0.28	0.17	0.16	-0.42	0.02	0.32	-0.10	0.07	0.18	0.28
Lendable shares	0.21	1.00	-0.01	-0.10	-0.03	-0.05	-0.04	-0.23	0.08	0.59	0.00	-0.12	0.00	0.13
Utilization ratio	0.89	-0.08	1.00	0.19	-0.30	0.18	0.17	-0.41	0.01	0.20	-0.13	0.09	0.18	0.27
Lending fee	0.28	-0.12	0.41	1.00	-0.09	0.07	0.08	-0.08	0.02	0.02	-0.03	0.06	0.10	0.12
ESG	-0.24	0.03	-0.27	-0.08	1.00	-0.10	-0.11	0.51	-0.09	-0.22	0.26	0.06	-0.14	-0.21
SYY	0.15	-0.07	0.18	0.06	-0.09	1.00	0.69	-0.17	0.31	0.01	-0.12	0.25	0.23	0.19
Overprice	0.15	-0.04	0.17	0.06	-0.10	0.74	1.00	-0.12	0.19	0.02	-0.06	0.20	0.22	0.17
Ln(ME)	-0.36	-0.21	-0.35	-0.10	0.50	-0.19	-0.12	1.00	-0.21	-0.31	0.58	0.03	-0.18	-0.28
Ln(BM)	0.02	0.07	0.00	0.02	-0.07	0.27	0.17	-0.20	1.00	-0.01	-0.19	-0.02	0.14	0.04
Institutional ownership	0.34	0.64	0.13	0.01	-0.13	0.00	0.01	-0.27	-0.01	1.00	-0.02	-0.03	0.10	0.25
Analyst	-0.08	0.02	-0.10	-0.07	0.25	-0.12	-0.05	0.56	-0.18	0.01	1.00	-0.11	-0.08	0.00
Leverage	0.09	-0.12	0.13	0.07	-0.02	0.22	0.18	0.01	-0.08	0.00	-0.12	1.00	0.10	0.00
Loss dummy	0.19	-0.01	0.20	0.11	-0.13	0.25	0.22	-0.18	0.12	0.08	-0.07	0.10	1.00	0.24
IVOL	0.28	0.05	0.30	0.18	-0.19	0.20	0.17	-0.27	0.04	0.16	-0.01	0.04	0.26	1.00

Table 2. Overpriced dummy, ESG performance and short selling activities

The table displays the panel regression of shares on loan, lendable shares, utilization ratio and lending fee as a function of ESG performance and overpriced dummy, and other control variables for U.S. firms. The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Columns (1) to (2), Columns (3) to (4), Columns (5) to (6), and Columns (7) to (8), respectively. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG	-1.144**	-1.615***	0.874*	0.617	-5.523***	-6.382***	-0.273***	-0.226***
	(-2.18)	(-3.69)	(1.84)	(1.41)	(-3.45)	(-4.59)	(-2.88)	(-2.79)
Overpriced dummy	1.745***	1.677***	-0.924***	-0.751***	6.554***	5.945***	0.280***	0.211***
	(5.16)	(5.86)	(-2.99)	(-2.67)	(6.09)	(6.39)	(3.88)	(3.50)
ESG	-0.663	0.099	0.394	0.515	-2.507**	-0.546	-0.025	0.054
	(-1.37)	(0.25)	(0.68)	(0.94)	(-1.97)	(-0.47)	(-0.54)	(1.17)
Ln(ME)		-2.212***		-0.651***		-6.303***		-0.187***
		(-11.65)		(-3.46)		(-11.58)		(-3.84)
Ln(BM)		0.010		0.375**		-0.712		-0.017
		(0.07)		(2.06)		(-1.51)		(-0.64)
Institutional ownership		19.504***		15.774***		43.577***		0.849***
		(14.48)		(16.52)		(11.75)		(3.64)
Analyst		0.045***		0.045***		0.147***		0.003
		(3.51)		(3.10)		(3.39)		(1.06)
Leverage		4.694***		-0.900		12.890***		0.103
		(6.31)		(-1.14)		(5.44)		(0.59)
Loss dummy		0.731***		-0.492***		2.403***		0.049**
		(7.14)		(-4.48)		(7.30)		(2.02)
IVOL		9.248***		-2.599***		31.770***		1.754***
		(11.51)		(-2.89)		(12.56)		(6.36)
Firm fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.495	0.628	0.771	0.796	0.547	0.630	0.334	0.335
Observations	106,665	95,658	106,665	95,658	106,665	95,658	106,665	95,658

Table 3. Short selling activities around FTSE4Good US Index inclusion event

This table reports panel regression results of different short selling activities around the FTSE4Good US Index inclusion events, including *On loan*, *Lendable shares*, *Utilization ratio*, and *Lending fee*. The event window is (-6, +6) months excluding the event month. The treated group refers to those stocks included in FTSE4Good US Index in that quarter. At the end of each month, all available stocks are sorted into five quintiles based on the Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. The control group is identified via propensity score matching of the firms based on ESG score, size, book to market ratio, stock return in the prior month, momentum, and idiosyncratic volatility. *Post* equals one after the stocks are included in the Index. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post x Treat x Overprice	-1.047***	-0.905**	-0.357	-0.210	-2.579**	-2.226**	-0.023	-0.017
	(-2.87)	(-2.10)	(-1.12)	(-0.56)	(-2.48)	(-1.99)	(-0.66)	(-0.46)
Post x Treat	0.017	0.037	-0.028	-0.031	-0.099	-0.058	0.032	0.032
	(0.29)	(0.68)	(-0.40)	(-0.44)	(-0.48)	(-0.29)	(0.97)	(0.97)
Post x Overprice	0.282**	0.208*	0.193	0.148	0.759	0.507	0.029	0.031
	(2.12)	(1.76)	(1.37)	(1.03)	(1.14)	(0.81)	(1.40)	(1.33)
Treat x Overprice	0.396	0.307	-0.057	-0.149	1.286	1.143	0.027*	0.027*
	(1.02)	(0.77)	(-0.22)	(-0.57)	(1.31)	(1.16)	(1.68)	(1.75)
Overprice	0.044	0.136	-0.058	0.010	-0.052	0.180	-0.023	-0.031
	(0.16)	(0.61)	(-0.30)	(0.05)	(-0.07)	(0.30)	(-1.41)	(-1.48)
Post	0.067	0.058	0.073	0.072	0.230	0.249	-0.032	-0.034
	(1.43)	(1.23)	(1.22)	(1.26)	(1.35)	(1.42)	(-1.06)	(-1.05)
Treat	-0.091	-0.104	-0.020	0.023	-0.173	-0.210	-0.016	-0.015
	(-0.63)	(-0.71)	(-0.13)	(0.16)	(-0.41)	(-0.50)	(-1.15)	(-1.08)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.728	0.745	0.959	0.959	0.758	0.768	0.478	0.477
Observations	5,040	4,864	5,042	4,866	5,042	4,866	5,040	4,864

Table 4. Investors' trading behavior, overpriced stocks and ESG performance

This table reports the panel regression of quarterly trading behavior of mutual funds and institutions, towards overpriced stocks with different ESG scores. In Columns (1) and (2), *mutual funds number change* is defined as the difference between logarithm of mutual funds holding the stock this quarter and last quarter. In Columns (3) and (4), *mutual funds ownership change* is defined as the difference between total mutual fund ownership this quarter and last quarter. In Columns (5) and (6), *institution number change* is defined as the difference between logarithm of institution numbers holding the stock this quarter and last quarter. In Columns (7) and (8), *institutional ownership change* is defined as the difference between total institutional ownership this quarter and last quarter. One month before the end of each quarter, I calculate the average Stambaugh, Yu, and Yuan (2015) mispricing score of the preceding three months for each stock. Then all the available stocks are sorted into five SYY quintiles. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last quarter. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	Mutual funds		Mutual fund		Institution		Institutional	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG	1.361**	1.115*	0.513***	0.502***	3.421***	2.902**	0.905***	0.979***
	(2.27)	(1.76)	(3.95)	(3.62)	(2.96)	(2.36)	(2.87)	(2.82)
Overpriced dummy	-1.988***	-1.545***	-0.164*	-0.172*	-3.140***	-2.520***	-0.371*	-0.383*
	(-5.13)	(-3.56)	(-1.69)	(-1.65)	(-5.00)	(-3.64)	(-1.92)	(-1.79)
ESG	0.577	0.714	-0.205**	-0.162	4.777***	5.122***	0.137	0.106
	(1.09)	(1.29)	(-2.09)	(-1.60)	(4.47)	(4.62)	(0.57)	(0.38)
Ln(ME)		-2.241***		-0.004		-2.248***		-0.084
		(-8.27)		(-0.10)		(-4.63)		(-0.69)
Ln(BM)		-0.272		0.042		0.817*		0.240**
		(-1.17)		(1.14)		(1.84)		(2.19)
Institutional ownership		11.842***		-1.955***		-1.617		-13.388***
		(7.51)		(-9.55)		(-0.80)		(-17.46)
Analyst		-0.053**		0.004		0.005		0.027***
		(-2.55)		(0.99)		(0.13)		(2.73)
Leverage		0.417		0.504***		-0.245		0.561
		(0.41)		(3.03)		(-0.11)		(1.03)
Loss dummy		-1.610***		0.013		-0.935**		0.098
		(-7.61)		(0.27)		(-2.42)		(0.81)
IVOL		-18.156***		0.157		-14.688***		-2.024
		(-5.37)		(0.26)		(-3.15)		(-1.39)
Firm fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.398	0.419	0.826	0.833	0.457	0.469	0.271	0.301
Observations	35,184	31,906	35,184	31,906	34,652	31,443	34,649	31,441

Table 5. Upside jump probability and ESG performance

The table displays the panel regression of several jump risks measures, which proxy for the short squeeze risks, as a function of ESG performance and other control variables for U.S. firms. The dependent variable is realized skewness, relative signed jump variation, option implied skewness and upside slope in Column (1) to (4), respectively. Realized skewness is the skewness calculated using the previous month's daily stock returns. Following Bollerslevm Li and Zhao (2019) and using high-frequency intraday data, relative signed jump variation is defined as the difference between the up and down semi-variance measures divided by the total return variation. Option implied skewness is the difference between the implied volatilities of out-of-the-money (OTM) call options and at-the-money (ATM) call options. Upside slope is calculated as the slope of a function that relates right-tail implied volatility to moneyness (with moneyness being measured by the option's delta) of call options. To make it easier to interpret, I take the negative value of the upside slope. *ESG* score is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	(1) Realized skewness	(2) Relative signed jump variation	(3) Option implied skewness	(4) Upside slope
ESG	8.302***	0.357**	0.212**	1.391***
	(2.88)	(2.28)	(2.06)	(2.88)
Ln(ME)	-11.932***	-0.692***	-0.125***	-1.595***
	(-11.44)	(-10.65)	(-2.70)	(-6.96)
Ln(BM)	-0.851	-0.049	-0.084**	0.329*
	(-0.87)	(-0.87)	(-2.31)	(1.70)
Institutional ownership	-3.264	-0.126	-0.390*	-1.061
	(-0.74)	(-0.48)	(-1.67)	(-0.93)
Analyst	-0.058	-0.008	0.005	0.046**
	(-0.58)	(-1.47)	(1.26)	(2.50)
Leverage	0.380	0.150	0.089	-0.438
	(0.08)	(0.60)	(0.45)	(-0.45)
Loss dummy	-3.334***	-0.308***	-0.094**	0.321
	(-2.85)	(-4.52)	(-2.15)	(1.53)
IVOL	47.146***	-0.663	-0.799*	8.590***
	(5.04)	(-1.29)	(-1.79)	(3.31)
Firm fixed Effect	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes
Adj R-squared	0.0476	0.160	0.307	0.337
Observations	95,644	95,284	84,710	72,885

Table 6. ESG sentiment beta and ESG performance

This table presents the panel regression results of ESG sentiment beta on ESG performance, and other firm characteristics. The ESG sentiment beta is estimated from the daily rolling regressions of individual stock excess returns on innovations in the Google Search Index of ESG related topics, after controlling for the daily Fama-French three-factor. In Columns (1) and (2), to calculate ESG sentiment beta, "Climate Change" is used as a topic and the estimation is based on a 60-day rolling window with a minimum requirement of 24 days, and a 252-day rolling window with a minimum requirement of 120 days. In Columns (3) and (4), "ESG" is used as a topic and the estimation is based on a 60-day rolling window with a minimum requirement of 24 days, and a 252-day rolling window with a minimum requirement of 120 days. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	DSVI: Climate Change		DSVI: ESG	
	60-day rolling window	252-day rolling window	60-day rolling window	252-day rolling window
	(1)	(2)	(3)	(4)
ESG	0.151**	0.232***	0.444**	0.359***
	(2.15)	(3.15)	(2.18)	(2.72)
Ln(ME)	-0.007	-0.165***	-0.138*	-0.120**
	(-0.23)	(-5.29)	(-1.71)	(-2.37)
Ln(BM)	0.040	0.003	-0.040	0.045
	(1.53)	(0.10)	(-0.55)	(0.98)
Institutional ownership	-0.088	-0.076	-0.056	0.015
	(-0.72)	(-0.62)	(-0.17)	(0.05)
Analyst	0.002	0.009***	0.008	0.004
	(0.99)	(3.93)	(1.09)	(1.06)
Leverage	0.095	0.094	-0.393	0.256
	(0.81)	(0.78)	(-1.18)	(1.23)
Loss dummy	0.045	-0.057**	0.022	-0.083
	(1.36)	(-2.30)	(0.25)	(-1.39)
IVOL	0.136	-0.235	0.264	0.442
	(0.45)	(-1.28)	(0.26)	(0.95)
Firm fixed Effect	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes
Adj R-squared	0.0223	0.102	0.0166	0.0123
Observations	95,658	95,658	95,658	95,658

Table 7. Short-sale campaigns

This table presents the probability of being targeted as short-sale targets in Panel A and comment level panel regression coefficients of agreement score and ESG dummy on ESG score and other control variables. In Panel A, Columns (1) and (2) show the logit regression results using full sample, and columns (3) and (4) show the logit regression results after propensity score matching based on On loan, Utilization ratio, logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. In Panel B, the dependent variable is the agreement score in columns (1) and (2), and ESG dummy in columns (3) and (4). Agreement score measures the level of agreement towards the short-sale campaign for each comment. It takes the value of -1 if the comment is against the short-sale campaign, +1 if the comment is supportive towards the short-sale campaign, and 0 if the comment is neutral. ESG dummy takes 1 if there are ESG related topics mentioned in the comment. ESG score is a combined score, whenever possible, using the average of standardized scores obtained from the KLD database and IVA database. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All the regressions control for year fixed effect. The t- statistics in the brackets are calculated from robust clustered standard errors by the event. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test.

Panel A. Probability of being targets of short-sale campaigns				
	(1)	(2)	(3)	(4)
	full sample		matched sample	
ESG score	-0.489***	-0.489***	-0.398**	-0.410**
	(-3.22)	(-3.30)	(-1.99)	(-1.99)
On loan		0.033		0.025
		(1.15)		(0.50)
Utilization ratio		0.027***		-0.009
		(2.82)		(-0.58)
Other Controls	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Adjusted R-squared	0.126	0.160	0.0402	0.0414
Observations	25,156	25,156	208	208

Panel B. Comment level analysis				
	(1)	(2)	(3)	(4)
	Agreement Score		ESG Dummy	
ESG score	-0.147***	-0.120***	0.020*	0.044***
	(-3.99)	(-3.14)	(1.66)	(2.89)
Controls	No	Yes	No	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Adjusted R-squared	0.0406	0.0577	0.0317	0.0324
Observations	5,277	4,634	5,277	4,634

Table 8. Impact on stock return

Panel A reports the Fama-MacBeth cross-sectional regressions of stock returns on overpriced dummy, ESG and other controls, for the full sample, stocks with low & high shares on loan, and stocks with low & high utilization ratio, in Columns (1) and (2), Columns (3) and (4), and Columns (5) and (6), respectively. Panel B reports the Fama-MacBeth cross-sectional regressions of stock returns on overpriced dummy, ESG and further controls shares on loan and utilization ratio. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. Within each SYY quintile, I further divide stocks into two groups based on utilization ratio. *ESG* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. I report Newey-West (1987) *t*-statistics in parentheses below the coefficients. The sample period is from January 2006 and December 2019.

Panel A. ESG, mispricing, short demand and stock returns						
	Full sample		On loan		Utilization	
			Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
Overprice x ESG	-0.586**	-0.924***	-0.975**	-0.440	-1.010**	-0.444
	(-1.98)	(-2.86)	(-2.49)	(-0.70)	(-2.50)	(-0.77)
Overpriced Dummy	-0.055	0.243	0.067	0.136	0.106	0.151
	(-0.27)	(1.15)	(0.23)	(0.38)	(0.36)	(0.48)
ESG	-0.122	0.433*	0.278	0.435*	0.316	0.459*
	(-0.71)	(1.85)	(1.17)	(1.70)	(1.14)	(1.97)
Controls	No	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.012	0.060	0.065	0.066	0.065	0.064
Observations	105,986	95,104	47,783	47,321	48,006	47,098
Panel B. Controlling short selling demand						
	(1)	(2)	(3)	(4)	(5)	(6)
Overprice x ESG	-0.586**	-0.924***	-0.447	-0.757*	-0.466	-0.652*
	(-1.98)	(-2.86)	(-1.14)	(-1.93)	(-1.09)	(-1.70)
Overpriced Dummy	-0.055	0.243	-0.202	0.037	-0.180	0.006
	(-0.27)	(1.15)	(-0.93)	(0.15)	(-0.78)	(0.02)
ESG	-0.122	0.433*	-0.170	0.393*	-0.176	0.381*
	(-0.71)	(1.85)	(-1.08)	(1.82)	(-1.09)	(1.72)
Overprice x On loan			0.021	0.036**		
			(1.23)	(2.22)		
On loan			-0.014	-0.025**		
			(-1.07)	(-2.19)		
Overprice x UT					0.008	0.014**
					(1.35)	(2.31)
UT					-0.006	-0.007**
					(-1.33)	(-1.99)
Controls	No	Yes	No	Yes	No	Yes
Adj R-squared	0.012	0.060	0.025	0.070	0.024	0.070
Observations	105,986	95,104	105,986	95,104	105,986	95,104

Table 9. ESG awareness, ESG attention and impact of ESG on short selling activities

This table reports the impact of socially responsible institutional ownership (SR_IO) on the relationship between short selling activities and ESG performance in Panel A, and the impact of climate change exposure on the relationship between short selling activities and ESG performance in Panel B. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. In Panel A, each quarter, I divided all the stocks into two groups based on socially responsible institutional ownership (SR_IO), following Cao, Titman, Zhan, and Zhang (2021). I first calculate value-weighted size-adjusted ESG score as the socially responsible score for all the institutions. Then I define socially responsible (SR) institutions (one-third of all) based on their score. SR_IO is the number of shares held by SR institutions divided by the total number of shares held by all the institutions. *High SR_IO* is a dummy for firms with SR_IO above medium last quarter. In Panel B, each quarter, I divided all the stocks into two groups based on Climate Change Exposure (CC_Expo), constructed by Sautner, Van Lent, Vilkov, and Zhang (2021), which captures overall attention on climate change exposure of the firms from earnings conference calls. *High CC_Expo* is a dummy for firms with CC_Expo above medium last quarter. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test.

Panel A: Impact of socially responsible institutional ownership (SR_IO)								
	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG x High SRIO	-2.404***	-1.739**	0.426	0.640	-5.968**	-3.703**	-0.240*	-0.246*
	(-2.80)	(-2.34)	(0.50)	(0.76)	(-2.37)	(-2.27)	(-1.77)	(-1.71)
Overprice x ESG	0.533	-0.284	0.413	0.153	-1.220	-3.651*	-0.486**	-0.426**
	(0.66)	(-0.41)	(0.48)	(0.18)	(-0.52)	(-1.76)	(-2.57)	(-2.30)
Overprice x High SRIO	1.463***	1.232***	0.029	-0.097	3.224**	2.382*	-0.129	-0.110
	(2.92)	(2.77)	(0.06)	(-0.21)	(2.07)	(1.68)	(-1.07)	(-0.93)
ESG x High SRIO	0.547	0.791	-0.059	-0.439	1.210	1.519	-0.113	-0.050
	(0.90)	(1.58)	(-0.09)	(-0.67)	(0.74)	(1.06)	(-1.02)	(-0.49)
High SRIO	-0.305	-0.180	-0.471	-0.296	-0.264	0.251	0.076	0.057
	(-0.80)	(-0.55)	(-1.23)	(-0.77)	(-0.25)	(0.26)	(1.02)	(0.84)
Overprice	0.842*	0.825**	-0.848*	-0.718*	4.473***	4.340***	0.388***	0.291**
	(1.85)	(2.02)	(-1.78)	(-1.65)	(3.15)	(3.35)	(3.06)	(2.46)
ESG	-2.463***	-1.363**	2.194***	2.861***	-9.983***	-6.680***	0.009	0.073
	(-3.62)	(-2.48)	(2.68)	(3.57)	(-5.22)	(-4.04)	(0.10)	(0.78)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.499	0.629	0.773	0.798	0.552	0.633	0.322	0.327
Observations	105,528	95,415	105,528	95,415	105,528	95,415	105,528	95,415

Panel B: Impact of climate change exposure								
	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG x High CC_Expo	-2.301***	-1.917***	0.355	0.767	-6.302***	-5.878***	-0.010	-0.007
	(-3.14)	(-3.30)	(0.54)	(1.22)	(-2.76)	(-3.06)	(-0.06)	(-0.04)
Overprice x ESG	-0.454	-0.955**	0.935*	0.529	-3.467**	-4.456***	-0.280**	-0.208*
	(-0.79)	(-2.07)	(1.88)	(1.15)	(-1.97)	(-3.16)	(-2.14)	(-1.67)
Overprice x High CC_Expo	1.302**	1.269***	-0.234	-0.303	3.928**	4.235***	-0.042	-0.037
	(2.57)	(3.09)	(-0.53)	(-0.73)	(2.38)	(2.92)	(-0.33)	(-0.28)
ESG x High CC_Expo	-0.026	-0.350	-0.177	-0.127	-0.546	-1.348	0.126	0.096
	(-0.07)	(-1.20)	(-0.48)	(-0.38)	(-0.52)	(-1.46)	(1.64)	(1.19)
High CC_Expo	-0.167	0.030	0.205	0.156	-0.280	0.187	-0.103*	-0.082
	(-0.62)	(0.14)	(0.74)	(0.62)	(-0.35)	(0.26)	(-1.69)	(-1.26)
Overprice	1.460***	1.327***	-1.013***	-0.816***	5.363***	4.643***	0.300***	0.211**
	(3.95)	(4.34)	(-3.15)	(-2.75)	(4.50)	(4.75)	(3.00)	(2.23)
ESG	-1.892***	-0.461	2.325***	2.565***	-8.517***	-4.643***	-0.147*	-0.025
	(-3.77)	(-1.12)	(4.10)	(4.90)	(-5.53)	(-3.45)	(-1.84)	(-0.33)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.500	0.631	0.762	0.789	0.553	0.635	0.320	0.326
Observations	101,005	91,467	101,005	91,467	101,005	91,467	101,005	91,467

Table 10. Alternative ESG scores

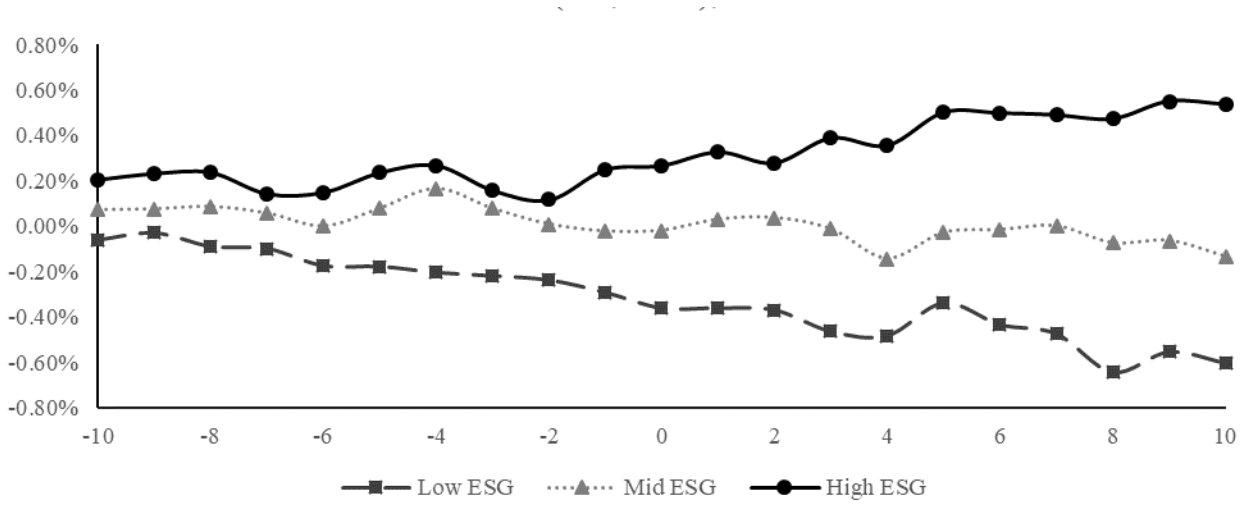
The table displays the panel regression of shares on loan, lendable shares, utilization ratio and lending fee as a function of overpriced dummy, and ESG score provided by two alternative data vendors. I report the result of ESG score provided by MSCI KLD database and Sustainalytics in Panel A and Panel B. In Panel A. each year, I divide all the stocks based on MSCI KLD ESG score into low, medium and high ESG groups, using the cutoff of 15% and 85%. *ESG rank* is 1, 2, and 3 for low, medium and high ESG groups. In Panel B, *SUS_ESG* is the raw ESG score from Sustainalytics divided by 100. The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Columns (1) and (2), Columns (3) and (4), Columns (5) and (6), and Columns (7) and (8), respectively. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019 in Panel A and January 2009 to December 2019 in Panel B.

Panel A: MSCI KLD ESG score								
	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG rank	-0.362**	-0.535***	0.331**	0.225	-1.904***	-2.338***	-0.013*	-0.016**
	(-2.22)	(-3.99)	(2.11)	(1.65)	(-4.27)	(-5.89)	(-1.82)	(-2.01)
Overpriced Dummy	1.947***	1.943***	-1.178***	-0.939***	7.673***	7.379***	0.076***	0.064***
	(5.35)	(6.33)	(-3.31)	(-2.99)	(7.12)	(7.66)	(4.17)	(3.26)
ESG rank	0.242**	0.286***	0.170	0.235**	0.826***	0.938***	0.006	0.006
	(2.22)	(3.02)	(1.46)	(2.15)	(2.59)	(3.29)	(1.07)	(1.12)
Ln(ME)		-2.228***		-0.465***		-6.393***		-0.087***
		(-11.61)		(-2.61)		(-11.67)		(-6.21)
Ln(BM)		0.011		0.374**		-0.739		-0.001
		(0.08)		(2.15)		(-1.59)		(-0.09)
Institutional ownership		19.242***		15.374***		42.585***		0.319***
		(14.20)		(17.02)		(11.04)		(4.48)
Analyst		0.043***		0.045***		0.144***		0.002*
		(3.40)		(3.23)		(3.38)		(1.90)
Leverage		4.699***		-0.718		12.822***		0.070
		(6.27)		(-0.96)		(5.35)		(1.18)
Loss dummy		0.721***		-0.460***		2.411***		0.027***
		(7.09)		(-4.45)		(7.28)		(3.18)
IVOL		8.629***		-2.814***		29.768***		0.608***
		(11.31)		(-3.42)		(12.18)		(7.83)
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.495	0.628	0.770	0.796	0.550	0.631	0.406	0.422
Observations	106,665	95,658	106,665	95,658	106,665	95,658	106,665	95,658

Panel B: Sustainalytics ESG score								
	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG	-1.988*	-4.022***	3.209***	1.463	-6.378*	-11.559***	-0.050*	-0.067**
	(-1.77)	(-4.31)	(2.75)	(1.41)	(-1.78)	(-3.66)	(-1.84)	(-2.48)
Overpriced Dummy	1.698***	2.651***	-2.350***	-1.324**	5.675***	7.986***	0.050***	0.053***
	(2.64)	(4.90)	(-3.40)	(-2.18)	(2.67)	(4.20)	(3.04)	(3.28)
ESG	-2.222	-0.319	0.336	1.088	-9.171*	-4.633	-0.053	-0.044
	(-1.35)	(-0.22)	(0.19)	(0.63)	(-1.93)	(-1.11)	(-1.51)	(-1.29)
Ln(ME)		-1.979***		-0.590***		-5.270***		-0.031***
		(-9.28)		(-2.61)		(-8.72)		(-4.90)
Ln(BM)		0.207		0.279		-0.034		0.004
		(1.33)		(1.32)		(-0.07)		(0.78)
Institutional ownership		18.246***		12.677***		43.834***		0.185***
		(11.03)		(10.31)		(9.85)		(5.07)
Analyst		0.066***		0.048***		0.213***		0.001*
		(4.87)		(3.09)		(4.40)		(1.93)
Leverage		3.872***		0.152		10.347***		0.048**
		(4.99)		(0.18)		(4.23)		(2.09)
Loss dummy		0.532***		-0.471***		1.724***		0.015***
		(5.40)		(-3.87)		(5.52)		(4.18)
IVOL		9.513***		-3.218***		28.182***		0.260***
		(8.65)		(-2.62)		(8.48)		(6.53)
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.562	0.672	0.814	0.830	0.601	0.672	0.525	0.533
Observations	70,635	63,837	70,635	63,837	70,635	63,837	70,635	63,837

Figure 1. Cumulative return

This figure plots the cumulative abnormal return for low, medium and high ESG stocks around Greta Thunberg's speeches in a window of (−10, +10) days. All the stocks are sorted into five quintiles based on ESG score at the end of last month. Low, medium, and high ESG group refers to first quintile, second to fourth quintile, and fifth quintiles of stocks. Cumulative abnormal return is calculated based on the FF-3 factor model.



Supplementary Appendix for

"Green or Brown: Which Overpriced Stock to Short Sell?"

Variable Definitions

Short Selling Activity Measures	
On loan	Daily average of shares on loan relative to the total shares outstanding within a month.
Lendable shares	Daily average of shares available for lending on a given day relative to a firm's total shares outstanding within a month.
Utilization ratio	Each day, I use shares on loan scale by lendable shares to get daily utilization ratio, then take average within a month.
Lending fee	Daily average of transaction-weighted rate reported by Markit and expressed in percentage per annum.
Mispricing Measures	
SYY score	SYY score, ranging between 1 and 100, is the composite mispricing measure in Stambaugh, Yu, and Yuan (2015). Stocks with the highest SYY values are most "overpriced" and those with the lowest values are most "underpriced". Updated monthly.
Overpriced dummy	At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. Overpriced dummy equals to one for stocks in the fifth quintile, referring to the most "overpriced" stocks.
SUE score	Standardized unexpected earnings score is computed as the difference between current quarter's earnings and the earnings four quarters ago, then divided by the standard deviation of unexpected earnings over the last eight quarters.
Corporate Social Performance (ESG) measures	
ESG score	ESG score is monthly updated from Asset4 database, based on 250+ key performance indicators (KPIs) and 750+ individual data points, from three pillars. The range of ESG score is between 0 and 1 after scaling by 100.
Institution Holding Change Measures	
Mutual funds number change	Difference between logarithm of mutual funds holding the stock this quarter and last quarter.
Mutual fund ownership change	Difference between total mutual fund ownership this quarter and last quarter.
Institution number change	Difference between logarithm of 13F institutions holding the stock this quarter and last quarter.
Institutional ownership change	Difference between total 13F institutional ownership this quarter and last quarter.

Stock Characteristics	
Ln(ME)	The natural logarithm of the market value of the firm's equity at the end of last year.
Ln(BM)	The natural logarithm of book equity for the fiscal year-end in a calendar year divided by market equity at the end of December of that year, as in Fama and French (1992).
Institutional ownership	The percentage of common stocks owned by institutions in the previous quarter.
Analyst	The number of analysts following the firm in the previous month.
Leverage	Total liabilities scaled by the total asset at the end of the most recent fiscal year.
Loss dummy	A dummy variable indicating a negative value of net income at the end of the most recent fiscal year.
IVOL	Idiosyncratic volatility, as in Ang, Hodrick, Xing, and Zhang (2006), computed as the standard deviation of the regression residual of individual stock returns on the Fama and French (1993) three factors using daily data in the previous month.
ESG sentiment beta	ESG sentiment beta is estimated from daily rolling regressions of individual stock excess returns on the innovation in the Google Search Index of two ESG related topics ("Climate Change" and "ESG"), after controlling for daily Fama-French three-factor. It is based on a 60-day rolling window with a minimum requirement of 24 days, or 252-day rolling window with a minimum requirement of 120 days.
Socially responsible institutional ownership	I first calculate value-weighted size-adjusted ESG score as socially responsible score for all the institutions. Then I define socially responsible (SR) institutions (one-third of all) based on their score. SR_IO is the number of shares held by SR institutions divided by the total number of shares held by all the institutions.
Climate change exposure	Constructed by Sautner, Van Lent, Vilkov, and Zhang (2021), this measure counts the frequency of certain climate change bigrams in a transcript, scaled by the total number of bigrams in that transcript, and captures overall attention on climate change exposure of the firms from earnings conference calls.

Table A1. Mispricing and short selling activities

The table displays the panel regression of shares on loan, lendable shares, utilization ratio and lending fee as a function of Stambaugh, Yu, and Yuan (2015) mispricing score (SYY) in Panel A and Overpriced dummy in Panel B, together with other control variables for U.S. firms. The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Columns (1) and (2), Columns (3) and (4), Columns (5) and (6), and Columns (7) and (8), respectively. SYY is Stambaugh, Yu, and Yuan (2015) mispricing score at the end of last month. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

Panel A: Short selling activities and Stambaugh, Yu, and Yuan (2015) mispricing score (SYY)								
	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SYY	0.049***	0.033***	-0.033***	-0.030***	0.157***	0.107***	0.006***	0.004***
	(7.80)	(6.69)	(-6.49)	(-6.16)	(8.55)	(7.12)	(4.49)	(3.18)
ESG	-0.807*	-0.125	0.495	0.583	-3.243**	-1.437	-0.063	0.022
	(-1.68)	(-0.32)	(0.86)	(1.07)	(-2.55)	(-1.26)	(-1.38)	(0.50)
Ln(ME)		-2.224***		-0.630***		-6.346***		-0.188***
		(-11.73)		(-3.36)		(-11.69)		(-3.85)
Ln(BM)		-0.015		0.395**		-0.805*		-0.020
		(-0.10)		(2.18)		(-1.72)		(-0.75)
Institutional Ownership		19.548***		15.741***		43.706***		0.853***
		(14.44)		(16.49)		(11.71)		(3.65)
Analyst		0.044***		0.046***		0.144***		0.003
		(3.45)		(3.17)		(3.32)		(1.03)
Leverage		4.416***		-0.475		11.903***		0.074
		(5.93)		(-0.60)		(5.01)		(0.42)
Loss dummy		0.699***		-0.432***		2.285***		0.046*
		(6.93)		(-3.98)		(7.04)		(1.88)
IVOL		8.804***		-1.991**		30.216***		1.706***
		(11.23)		(-2.25)		(12.14)		(6.24)
Firm fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.496	0.628	0.772	0.797	0.549	0.630	0.335	0.335
Observations	106,665	95,658	106,665	95,658	106,665	95,658	106,665	95,658

Panel B: Short selling activities and overpriced dummy								
	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overpriced dummy	1.170***	0.797***	-0.437***	-0.411***	3.578***	2.361***	0.122***	0.075***
	(9.07)	(7.42)	(-3.79)	(-3.89)	(9.71)	(7.46)	(4.74)	(3.34)
ESG	-0.804*	-0.122	0.513	0.597	-3.242**	-1.438	-0.063	0.022
	(-1.67)	(-0.31)	(0.89)	(1.09)	(-2.53)	(-1.25)	(-1.38)	(0.50)
Ln(ME)		-2.211***		-0.651***		-6.297***		-0.186***
		(-11.65)		(-3.46)		(-11.58)		(-3.83)
Ln(BM)		-0.004		0.379**		-0.766		-0.019
		(-0.03)		(2.09)		(-1.64)		(-0.70)
Institutional Ownership		19.481***		15.784***		43.501***		0.846***
		(14.43)		(16.54)		(11.68)		(3.63)
Analyst		0.045***		0.045***		0.146***		0.003
		(3.49)		(3.11)		(3.36)		(1.05)
Leverage		4.664***		-0.891		12.829***		0.107
		(6.27)		(-1.13)		(5.41)		(0.61)
Loss dummy		0.722***		-0.488***		2.382***		0.050**
		(7.08)		(-4.45)		(7.23)		(2.03)
IVOL		9.166***		-2.567***		31.550***		1.753***
		(11.40)		(-2.86)		(12.38)		(6.33)
Firm fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.495	0.628	0.771	0.796	0.547	0.629	0.334	0.335
Observations	106,665	95,658	106,665	95,658	106,665	95,658	106,665	95,658

Table A2. Short selling activities around Russell 2000 inclusion event

This table reports panel regression results of different short selling activities around the Russell 2000 Index inclusion events, including *On loan*, *Lendable shares*, *Utilization ratio*, and *Lending fee*. The event window is (-6, +6) months excluding the event month. The treated group refers 1001st to 1100th stocks in terms of market capitalization at the end of May, which will be included in the Russell 2000 index. The control group refers 991st to 1000th stocks in terms of market capitalization at the end of May, which will be included in Russell 1000 index. At the end of each month, all available stocks are sorted into five quintiles based on the Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. The control group is identified via propensity score matching of the firms based on ESG score, size, book to market ratio, stock return in the prior month, momentum, and idiosyncratic volatility. *Post* equals one after the stocks are included in the Index. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post x Treat x Overprice	1.097**	0.797*	0.627	0.590	3.564**	2.368*	0.177	0.146
	(2.47)	(1.78)	(1.41)	(1.21)	(2.26)	(1.70)	(1.57)	(1.28)
Post x Treat	-0.235	-0.134	-0.092	0.094	-0.919*	-0.847*	-0.048	-0.074
	(-1.55)	(-0.91)	(-0.55)	(0.58)	(-1.96)	(-1.82)	(-0.92)	(-1.35)
Post x Overprice	-0.184	-0.274	-0.341	-0.408	-0.236	-0.368	-0.048	-0.030
	(-0.57)	(-0.81)	(-1.05)	(-1.17)	(-0.23)	(-0.37)	(-0.76)	(-0.54)
Treat x Overprice	-1.159**	-0.757	-0.633	-0.974**	-3.879**	-2.108	-0.136	-0.054
	(-2.37)	(-1.52)	(-1.36)	(-1.99)	(-2.41)	(-1.45)	(-1.32)	(-0.71)
Overprice	1.110***	0.901**	-0.172	0.270	4.064***	2.461**	0.069	-0.000
	(2.80)	(2.18)	(-0.45)	(0.74)	(3.05)	(1.99)	(1.15)	(-0.01)
Post	0.054	0.072	-0.322**	-0.351**	0.095	0.237	0.007	0.017
	(0.44)	(0.57)	(-2.25)	(-2.50)	(0.25)	(0.62)	(0.14)	(0.32)
Treat	-0.437**	-0.263	-0.259	-0.267	-1.239*	-0.556	0.006	0.037
	(-2.05)	(-1.27)	(-1.14)	(-1.17)	(-1.86)	(-0.84)	(0.15)	(0.88)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.663	0.709	0.858	0.870	0.683	0.711	0.520	0.530
Observations	20,561	17,680	20,561	17,680	20,561	17,680	20,561	17,680

Table A3. Alternative mispricing proxy: standardized unexpected earnings (SUE)

The table displays the panel regression of short interest, lendable shares, utilization ratio and lending fee as a function of ESG performance and overpriced dummy, together with other control variables in between January 2006 and December 2019 for U.S. firms. The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Column (1) and (2), Column (3) and (4), Column (5) and (6), and Column (7) and (8). They are calculated as the daily average of short selling activities of next month. Each month, all the stocks are sorted into quintiles based on the standardized unexpected earnings (SUE) in the most recent quarter. *Overpriced dummy* equals one for stocks in the most negative SUE quintile, referring to the most "overpriced" stocks. *ESG* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of the last quarter. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG	-1.209***	-0.766***	0.156	0.342	-3.445***	-2.406***	-0.327***	-0.260***
	(-3.56)	(-2.69)	(0.54)	(1.16)	(-3.65)	(-2.97)	(-3.47)	(-3.31)
Overpriced dummy	1.798***	1.079***	-0.374*	-0.564***	5.153***	3.325***	0.306***	0.223***
	(7.29)	(5.36)	(-1.76)	(-2.63)	(7.60)	(5.85)	(4.24)	(3.81)
ESG	-0.643	-0.048	0.510	0.571	-2.799**	-1.197	-0.007	0.064
	(-1.35)	(-0.12)	(0.88)	(1.04)	(-2.19)	(-1.03)	(-0.16)	(1.50)
Ln(ME)		-2.163***		-0.677***		-6.155***		-0.181***
		(-11.38)		(-3.59)		(-11.30)		(-3.75)
Ln(BM)		-0.018		0.389**		-0.809*		-0.020
		(-0.12)		(2.14)		(-1.73)		(-0.75)
Institutional ownership		19.468***		15.793***		43.457***		0.843***
		(14.35)		(16.53)		(11.63)		(3.61)
Analyst		0.046***		0.044***		0.150***		0.003
		(3.60)		(3.05)		(3.45)		(1.09)
Leverage		5.046***		-1.084		13.954***		0.139
		(6.77)		(-1.39)		(5.90)		(0.80)
Loss dummy		0.670***		-0.453***		2.220***		0.043*
		(6.37)		(-4.11)		(6.46)		(1.76)
IVOL		9.357***		-2.641***		32.080***		1.760***
		(11.53)		(-2.90)		(12.37)		(6.34)
Firm fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.496	0.627	0.771	0.796	0.548	0.629	0.335	0.335
Observations	106,665	95,658	106,665	95,658	106,665	95,658	106,665	95,658

Table A4. Mispricing, ESG performance and short selling activities

The table displays the panel regression of shares on loan, lendable shares, utilization ratio and lending fee as a function of ESG performance, Stambaugh, Yu, and Yuan (2015) mispricing score (SYY), and other control variables for U.S. firms. The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Columns (1) and (2), Columns (3) and (4), Columns (5) and (6), and Columns (7) and (8), respectively. SYY is Stambaugh, Yu, and Yuan (2015) mispricing score at the end of last month. *ESG* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SYY x ESG	-0.038*	-0.067***	0.077***	0.053***	-0.246***	-0.316***	-0.013***	-0.013***
	(-1.80)	(-4.01)	(4.22)	(3.22)	(-3.81)	(-5.68)	(-3.29)	(-3.20)
SYY	0.070***	0.074***	-0.078***	-0.062***	0.299***	0.299***	0.013***	0.011***
	(4.67)	(6.21)	(-6.33)	(-5.45)	(6.21)	(7.26)	(4.07)	(3.58)
ESG	-0.476	2.129**	-1.365	0.122	1.430	8.059***	0.481**	0.584***
	(-0.43)	(2.40)	(-1.35)	(0.13)	(0.44)	(2.81)	(2.46)	(2.86)
Ln(ME)		-2.191***		-0.701***		-6.149***		-0.186***
		(-11.57)		(-3.76)		(-11.39)		(-3.80)
Ln(BM)		0.020		0.356**		-0.631		-0.015
		(0.13)		(1.98)		(-1.35)		(-0.56)
Institutional Ownership		19.649***		15.675***		44.150***		0.873***
		(14.58)		(16.55)		(11.97)		(3.73)
Analyst		0.044***		0.046***		0.143***		0.003
		(3.46)		(3.19)		(3.37)		(1.00)
Leverage		4.322***		-0.312		11.364***		0.065
		(5.85)		(-0.40)		(4.87)		(0.37)
Loss dummy		0.663***		-0.359***		2.068***		0.044*
		(6.60)		(-3.31)		(6.51)		(1.77)
IVOL		8.661***		-1.762**		29.444***		1.691***
		(11.14)		(-1.99)		(12.22)		(6.26)
Firm fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.499	0.630	0.774	0.799	0.555	0.635	0.336	0.336
Observations	106,665	95,658	106,665	95,658	106,665	95,658	106,665	95,658

Table A5. Different windows of short selling activities

The table displays the panel regression of shares on loan, lendable shares, utilization ratio and lending fee as a function of ESG performance and overpriced dummy, and other control variables for U.S. firms. . Instead of using the daily average of *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month, I calculate them in the window of (0, +10) trading days, and (-10, +10) trading days around month end in Columns (1) to (4), Columns (5) to (8), respectively. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by the firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	(0, +10) days around month end				(-10, +10) days around month end			
	On loan	Lendable shares	Utilization ratio	Lending fee	On loan	Lendable shares	Utilization ratio	Lending fee
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG	-1.685***	0.786*	-6.508***	-0.183**	-1.716***	0.792*	-6.578***	-0.189**
	(-4.24)	(1.84)	(-4.87)	(-2.30)	(-4.29)	(1.83)	(-4.96)	(-2.33)
Overpriced dummy	1.646***	-0.865***	5.920***	0.174***	1.674***	-0.863***	5.995***	0.180***
	(6.15)	(-3.11)	(6.72)	(2.88)	(6.19)	(-3.04)	(6.82)	(2.94)
ESG	-0.702*	1.524***	-4.398***	0.010	-0.717*	1.521***	-4.360***	0.013
	(-1.90)	(2.93)	(-3.20)	(0.16)	(-1.94)	(2.90)	(-3.18)	(0.21)
Ln(ME)	-2.023***	-0.527**	-6.097***	-0.155***	-2.025***	-0.571***	-6.028***	-0.155***
	(-9.93)	(-2.48)	(-9.66)	(-3.08)	(-9.90)	(-2.64)	(-9.58)	(-3.05)
Ln(BM)	-0.259	-0.050	-1.006*	-0.012	-0.263*	-0.066	-1.042*	-0.014
	(-1.64)	(-0.26)	(-1.89)	(-0.44)	(-1.65)	(-0.34)	(-1.95)	(-0.50)
Institutional Ownership	19.717***	18.073***	44.793***	1.135***	19.491***	18.090***	43.783***	1.144***
	(13.14)	(16.67)	(10.68)	(3.72)	(13.07)	(16.46)	(10.51)	(3.77)
Analyst	0.045***	0.042***	0.138***	0.002	0.043***	0.041***	0.135***	0.002
	(3.21)	(2.84)	(2.99)	(0.74)	(3.12)	(2.79)	(2.93)	(0.75)
Leverage	3.844***	-0.906	11.980***	0.042	3.873***	-0.875	11.862***	0.055
	(4.71)	(-1.02)	(4.59)	(0.23)	(4.72)	(-0.97)	(4.55)	(0.29)
Loss dummy	0.607***	-0.246**	2.224***	0.036	0.611***	-0.248**	2.208***	0.036
	(4.87)	(-1.99)	(5.53)	(1.32)	(4.89)	(-1.98)	(5.51)	(1.33)
IVOL	8.624***	0.568	28.695***	1.674***	8.679***	0.653	28.817***	1.694***
	(9.88)	(0.65)	(10.71)	(5.67)	(10.03)	(0.74)	(10.90)	(5.61)
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.622	0.798	0.618	0.318	0.619	0.788	0.616	0.317
Observations	95,658	95,658	95,658	95,658	95,658	95,658	95,658	95,658

Internet Appendix for
Green or Brown: Which Overpriced Stock to Short Sell?

IA1. Short selling activities around the passage of ESG proposal

I rely on a regression discontinuity design approach as the identification strategy and investigate the effect of the close-call passage of a firm's ESG proposal on its short selling activities. I obtain the data on shareholder proposal voting results from ISS. Proposals related to social/environmental issues or corporate governance issues are classified as ESG proposals. Following Flammer (2015) and Cao, Liang, and Zhan (2019), I use a voting firm's random passage of ESG proposals as identification, assuming the passage of an ESG proposal to be a randomly assigned variable with regard to firms other characteristics. Intuitively, there is no reason to expect any systematic difference between a company for which an ESG proposal passes with 50.1% of the votes and a company for which a similar proposal fails with 49.9% of the votes. However, if a company passes an ESG proposal, it would probably have better ESG performance in the future compared to its peers that fail with a similar voting rate (Cao, Liang, and Zhan (2019)). As a result, I conjecture that among overpriced stocks, the short selling demand would be lower if a firm passes a close-call ESG proposal compared to another firm just fails an ESG proposal. To test this hypothesis, I run the following regression for the event window of (-6, +6) months:

$$\begin{aligned} Short\,Selling\,Activities_{it} = \alpha + \beta_1 Treat_{it} \times Post_{it} \times Overpriced_{it} + \beta_2 Treat_{it} \\ \times Post_{it} + \beta_3 Post_{it} \times Overpriced_{it} + \beta_4 Treat_{it} \times Overpriced_{it} + \beta_5 Treat_{it} \\ + \beta_6 Post_{it} + \beta_7 Overpriced_{it} + \beta_8' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{IA1}$$

where $Treat_{it}$ represents the firms pass an ESG proposal with a supporting rate lower than 55%. The Control group includes firms that reject an ESG proposal with a supporting rate higher than 45%. $Post_{it}$ is the dummy for the 6 months after the event.[32]

Results in Table IA1 are consistent with the hypothesis. If a firm passes a close-call ESG proposal, its ESG performance is expected to be improved compared to its peers that just reject an ESG proposal. Shares on loan and utilization ratio decrease significantly and lending fee also decreases, though it is not statistically significant. It indicates when the ESG score of a firm is expected to increase after the passage of an ESG proposal, short sellers are less willing to short it, especially for overpriced stocks.

[32] I exclude the month when ESG proposal is passed, because Flammer (2015) and Cao, Liang, and Zhan (2019) document a positive CAR associated with close-call pass of ESG proposal, which might also affect short sellers decision.

IA2. Short selling activities around Paris Agreement

The third event I utilize is the Paris Agreement. On December 12, 2015, the Paris Agreement was announced at the 21st Conference of the Parties (or COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris. The PA is broadly considered as a landmark step for global climate change mitigation and adaptation action, and more importantly, it came as a surprise. For the first time, most UN countries agreed on the need to limit global temperature increase "well below 2 Degress" above pre-industrial levels (Art 2.1(a)), to strengthen the ability of countries to deal with the impacts of climate change (Art 2.1(b)), and to commit to "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (Art 2.1(c)).[33] After the announcement of Paris Agreement, investors ESG awareness and their attention on ESG related issues would increase. Climate risks, including regulatory risks and litigation risks would increase, through the adoption of a carbon tax for instance. As a result, after the PA was announced, investors become more aware of ESG issues, and climate risk have a higher probability to be materialized, I expect the effect of ESG performance on short selling activities of overpriced stocks to be magnified.

Specifically, I look at a short window of (-6, +6) months around the announcement of Paris Agreement. In particular, I hypothesize that after Paris Agreement, investors ESG awareness will be magnified, and the effect of ESG performance on short selling demand will become stronger as a result. I run the following regression and report the results are in Table IA2.

$$\begin{aligned} Short\,Selling\,Activities_{it} = \alpha &+ \beta_1 ESG_{it-1} \times Overpriced_{it} \times Post_t \\ &+ \beta_2 Overpriced_{it} \times ESG_{it-1} + \beta_3 Overpriced_{it} \times Post_t \\ &+ \beta_4 ESG_{it-1} \times Post_t + \beta_5 Overpriced_{it} \\ &+ \beta_6 ESG_{it-1} + \beta_7 Post_t + \beta_8' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{IA2}$$

where $Post_t$ is a dummy representing "post period (four quarters) after Paris Agreement. Consistent with our conjecture, there is are even lower shares on loan for overpriced high ESG stocks after Paris Agreement, together with a lower utilization ratio and lower lending fees. On the contrary, there is not much difference in lendable shares, suggesting the lower short selling activities comes from demand side rather than the supply side.

IA3. Impact of Greta's speeches

To further elaborate the relationship between sudden surge of ESG sentiment and price increases of high ESG stocks, I utilize ten speeches of Greta Thunberg as exogenous shocks on public

[33] Complete texts of the Paris Agreement can be found at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement/key-aspects-of-the-paris-agreement

attention to ESG related issues, and investigate whether there is a return difference between stocks with high ESG stocks and other stocks around her speeches. I divide my sample firms into ESG quintiles and investigate how the cumulative abnormal return (CAR) of high ESG stocks differs from other stocks. Figure 1 provides an informal view about the impact of Greta's speeches by plotting the CAR for low ESG stocks, medium ESG stock and high ESG stocks in a window of twenty days. Visual inspection shows that high (low) ESG stocks have a positive (negative) return drift after Greta's speeches, yet the reaction is quite a short term. For a more formal analysis, I run the following panel regression using an event window of (-5, +5) days and (-10, +10) days around her speeches:

$$CAR_{it} = \beta_1 High\_ESG_{it} + \beta_2 X_{it} + \gamma_t + \theta_i + e_{it}, \tag{IA3}$$

where CAR_{it} is estimated based on FF-3 factor model, $High\_ESG_{it}$ is a dummy variable equal to one for firms with high ESG scores, and zero for other firms. I include industry and event fixed effects.[34]

The results are shown in Panel A, Table IA3. I find that during the event window of (-5, +5) days, cumulative abnormal return for high ESG stocks is 0.57% higher compared to other stocks in the same industry, and it is less significant if I look at the event window of (-10, +10) day, which indicates the effect is short-lived and reverse a little bit afterwards. Using Greta's speech as an exogenous shock on ESG awareness/sentiment of ESG, the results imply that stocks with better social performance do have higher ESG sentiment risks for short sellers. This will make short selling activity rather risky when attention on ESG issues increases rapidly. Next, I investigate the short-term impact of Greta's speech on short sellers activity using the following specification.

$$\begin{aligned} Short\,Selling\,Activities_{it} &= \alpha + \beta_1 High\_ESG_{it} \times Post_t \\ &+ \beta_2 High\_ESG_{it} + \beta_3 Post_t + \beta_4' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{IA4}$$

where $Short\,Selling\,Activities_{it}$ is the daily short selling activities in the event window of (-5, +5) days or (-10, +10) days, including shares on loan, lendable shares, utilization and lending fee. $Post_t$ is a dummy equaling to one after the Greta's speech day. Results are reported in Panel B, Table IA3. For stocks with high ESG scores, there is less short selling demand after Greta's speech, together with a lower utilization ratio and lower lending fee. On the contrary, there is not much difference from supply side, as lendable shares do not change a lot after the

[34] As nine of the ten speeches are in 2019 and I use the ESG scores in December 2018 to classify sample firms, adding firm fixed effects will absorb most variation in ESG performance. In addition, industry fixed effect makes the magnitude of coefficient align with Figure 1. In unreported result, I use firm fixed effect and find consistent results.

speech.

IA4. Short selling activities around European Union (EU) regulation on short selling

The European Union (EU) regulation on short selling (No 236/2012) came into force on November 1, 2012. All investors, except dealers, that trade in EU venues must disclose any short positions above a certain threshold. In particular, a short position must be publicly disclosed when a short position reaches 0.5% of the outstanding amount of share capital, and for each subsequent 0.1% increment. Moreover, notifications have to be updated when values fall below the relevant thresholds.[35] The disclosure rules apply as long as the principal trading venue is located in the EU, irrespective of the investor's domicile, and cover both shares and derivatives positions (on a delta-adjusted basis). This means that each regulated entity must report net short positions calculated by summing up long, short, and delta-adjusted derivatives positions of the reference stock. The disclosure must take place by the next business day (before 3:30 pm local time), and contain the name of the investor, the date when the short position crossed the disclosure threshold, the International Securities Identification Number (ISIN), the name of the shorted stock, and the size of the net short position as a percentage of the issued share capital.

By examining how the short interest on overpriced high ESG stocks changes after the regulation of public disclosure, I could get a better understanding about the role that ESG reputation risk plays during the decision process of short sellers. I focus on stocks in the United Kingdom, because Asset4 has the largest coverage for UK stocks, yet does not cover many stocks in other EU countries.[36] I get short-selling related variables from Markit Europe, and firm fundamentals from Worldscope. Following Stambaugh, Yu, and Yuan (2015), I construct a similar mispricing measure (SYY score) for UK stocks, by combining 11 anomalies to get a composite score. Those with higher SYY scores are relatively overpriced compared to stocks with lower SYY score. I look at a short window of (-12, +12) months around the effective day of EU regulation on short selling disclosure. If short sellers do care about their ESG reputation, they should be less willing to short overpriced stocks with high ESG performance after the regulation comes into force, when all the investors are aware of institutions shorting positions by the next business day. To test this hypothesis, I run the following regression,

$$\begin{aligned} Short\,Selling\,Activities_{it} = \alpha &+ \beta_1 ESG_{it-1} \times Overpriced_{it} \times Post_t \\ &+ \beta_2 Overpriced_{it} \times ESG_{it-1} + \beta_3 Overpriced_{it} \times Post_t \\ &+ \beta_4 ESG_{it-1} \times Post_t + \beta_5 Overpriced_{it} \\ &+ \beta_6 ESG_{it-1} + \beta_7 Post_t + \beta_8' X_{it-1} + \gamma_t + \theta_i + e_{it}, \end{aligned} \tag{IA5}$$

[35] In addition, a short position must be confidentially disclosed only to the regulator when it reaches 0.2% of the outstanding amount of share capital. This requirement is also required for each additional 0.1% above the 0.2% threshold.

[36] With limited stocks in other countries, I could barely identify enough overpriced stocks.

where $Post_t$ is a dummy representing post period after the enforcement of short selling regulation. I include firm and time fixed effects, and the control variables are the same as those in Table 2. Results in Table IA4 shows that there is a sharp decrease of short interest and utilization ratio for overpriced high ESG stocks when investors are required to disclose the short position publicly. I also find a similar but weaker effect for lending fees. These results indicate at least, investors, who trade UK stocks do care about their ESG reputation, and avoid to publicly disclosing their shorting position on high ESG stocks.

IA5. Overpriced stocks, ESG performance and option trading

Investors are more likely to use options to express a bearish view on overpriced stocks than they are to express a bullish view on underpriced stocks. This asymmetry could be attributed to the short-sale constraints, a friction that makes option markets more attractive to traders with bearish views (**?**, and Johnson and So (2012)). If the arbitragers are less willing to short overpriced high ESG stocks because these stocks have other short-sale constraints that I have not considered, then investors may turn to the option market and buy put options, which will influence put option prices (Ramachandran and Tayal (2020)). On the contrary, if arbitragers perceive higher synchronization risks, ESG sentiment risks and ESG reputation risks associated with high ESG stocks, they would not buy put options either, because it is highly uncertain when the mispricing could be corrected and whether the put option price will increase or not. To differentiate these two possibilities and investigate the impact of documented results on option prices, I first examine how the trading behaviors of option end-users differ among options with different ESG scores, for overpriced underlying stocks.

To measure the demand from option end-users, I utilize signed option volume (open/close and buy/sell) data from ISE open/close trade profile, which provides daily buy and sell trading volume for each option series traded at the ISE. The data include the signed volume by two categories of end-users: public customers and firm proprietary traders (including trades by broker/dealer). Public customers include both institutions such as hedge funds and mutual funds, and retail investors. Market maker trades are on the opposite side of end-users, and their trading volume is not directly reported in ISE. Following Chen, Da, and Huang (2019), I focus on end-user demand from public customers, the opposite side of which is the financial intermediaries including both option market makers and firm proprietary traders. For each stock each month, I define signed option trading volume from public customers as:

$$Signed\,Option\,Trading\,Volume_{it} = \frac{Total\,Open\,Buy_{it} - Total\,Open\,Sell_{it}}{Stock\,Trading\,Volume_{it}} \tag{8}$$

where $Total\,Open\,Buy_{it}$ ($Total\,Open\,Sell_{it}$) is the total trading volume of newly initiated long (short) position by public customers in a month, for all the options. To ensure comparability across stocks, I scale the number by stock trading volume over the previous month. I construct

this measure using only call option volumes or only put option volumes, because demand for put option and call option would probably be a different condition on mispricing level. I report the results in Panel A, Table IA5. I find that among overpriced stocks, the net signed option trading volume from public customers is lower for put options of overpriced high ESG stocks. The results are not significant for call options. It shows that short sellers do not turn to option market and buy more put options of overpriced high ESG stocks. Instead, among overpriced stocks, option end-users buys fewer put options of high ESG stocks as well, which is consistent with trading behavior of short sellers.

If the demand for put options of high ESG stocks is relatively lower when the stocks are overpriced, then I would expect the prices of high ESG put options would be cheaper, conditional on mispricing level. I use implied volatility of put options to measure the expensiveness of put options, and put-call implied volatility ratio to proxy for the relative expensiveness of put options. I extract implied volatility information from Option-Metrics Volatility Surface, which contains implied volatilities for options with fixed time to expiration and deltas constructed using interpolation. Specifically, for a given stock at each month end, I obtain the implied volatility of call options with a delta of 0.5 and put options with a delta of -0.5. I focus on options with 30 days of maturity since short-term options are traded more frequently, with lower effective transaction costs and more efficiently priced. Put-call implied volatility ratio is the ratio between implied volatility of put option and implied volatility of call option. I run the Panel regression with time fixed effect and firm fixed effect.

The results in Panel B, Table IA5 show that the coefficient on Overpriced Dummy is significantly positive. Higher put implied volatility and put-call implied volatility ratio shows that the put option is more expensive for overpriced stocks. In the overpriced group, stocks with higher ESG performance have a lower put implied volatility and lower put-call implied volatility ratio. The results demonstrate that among overpriced stocks, the put options of high ESG stocks are cheaper, which is consistent with end-user trading patterns. Investors short less on overpriced high ESG stocks, and also buy less put options, making the put options cheaper compared to low ESG peers. However, one may argue that the lower prices may be due to lower risks associated with high ESG stocks, rather than lower demand from arbitragers. It is possible, while I do not see any reason why this relationship should be stronger among overpriced stocks ex-ante.

Table IA1. Short selling activities around passage of ESG proposal

This table reports panel regression results of different short selling activities around the FTSE4Good US Index inclusion events, including *On loan*, *Lendable shares*, *Utilization ratio*, and *Lending fee*. Event window is (-6, +6) months excluding the event month. The treated group is those firms that have passed a close-call ESG proposal, with supporting rate lower than 55%. The control group is those firms that have rejected a close-call ESG proposal, with supporting rate higher than 45%. At the end of each month, all available stocks are sorted into five quintiles based on the Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals to one for stocks in the fifth quintile, referring to the most "overpriced" stocks. The control group is identified via propensity score matching of the firms based on ESG score, size, book to market ratio, stock return in the prior month, momentum, and idiosyncratic volatility. *Post* equals one after the stocks are included in the Index. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post x Treat x Overprice	-0.852**	-0.783*	0.175	0.136	-3.025***	-2.852**	-0.439	-0.179
	(-2.21)	(-1.80)	(0.83)	(0.58)	(-2.67)	(-2.30)	(-1.60)	(-1.11)
Post x Treat	0.246**	0.196**	0.143	0.177	0.543**	0.399*	0.031	0.030
	(2.46)	(2.38)	(1.34)	(1.53)	(2.04)	(1.91)	(1.28)	(1.10)
Post x Overprice	0.251*	0.271*	-0.142	-0.097	1.102***	1.191***	-0.030	-0.024
	(1.82)	(1.85)	(-1.09)	(-0.69)	(2.80)	(3.10)	(-0.38)	(-0.29)
Treat x Overprice	0.573	0.458	0.235	0.309	2.241	1.848*	0.174	0.057
	(1.08)	(1.42)	(0.88)	(1.19)	(1.33)	(1.80)	(1.23)	(0.50)
Overprice	0.067	0.059	-0.377**	-0.463***	0.085	0.050	0.077	0.100
	(0.38)	(0.32)	(-2.31)	(-2.83)	(0.19)	(0.12)	(0.76)	(0.90)
Post	-0.159***	-0.185***	-0.085	-0.157***	-0.417***	-0.499***	-0.054	-0.028
	(-2.73)	(-3.27)	(-1.52)	(-2.64)	(-2.91)	(-3.57)	(-1.62)	(-1.30)
Treat	-0.011	-0.054	-0.102	-0.236	0.012	-0.106	-0.015	-0.002
	(-0.10)	(-0.51)	(-0.72)	(-1.40)	(0.04)	(-0.33)	(-0.79)	(-0.09)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.798	0.827	0.879	0.878	0.812	0.843	0.554	0.539
Observations	3,289	2,952	3,289	2,952	3,290	2,952	3,290	2,952

Table IA2. Short selling activities, overpriced dummy and ESG score around Paris Agreement

This table reports panel regression results of different short selling activities as a function of overpriced dummy and ESG performance around Paris Agreement. The event window is six months before December, 2015, and six months after December, 2015 (excluding event month). The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Columns (1) and (2), Column (3) and (4), Columns (5) and (6), and Columns (7) and (8), respectively. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals to one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. *Post* equals one after December, 2015. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG x Post	-3.173***	-2.526**	-0.352	0.674	-9.892***	-6.920*	-0.473*	-0.616**
	(-2.64)	(-2.42)	(-0.37)	(0.74)	(-2.62)	(-1.87)	(-1.70)	(-2.00)
Overprice x ESG	-1.080	-1.120	1.509*	1.180	-2.966	-3.282	-0.137	-0.066
	(-0.98)	(-1.33)	(1.76)	(1.48)	(-1.01)	(-1.24)	(-0.71)	(-0.34)
Overprice x Post	2.982***	2.315***	0.254	-0.556	9.218***	6.570**	0.492**	0.560**
	(3.34)	(2.94)	(0.36)	(-0.80)	(3.30)	(2.35)	(2.15)	(2.16)
ESG x Post	-0.207	-0.813*	0.720	0.442	-0.951	-2.537	-0.196	-0.194
	(-0.36)	(-1.73)	(1.57)	(1.05)	(-0.53)	(-1.52)	(-1.02)	(-0.94)
Overprice	1.106	1.097*	-0.840	-0.711	3.347	3.284*	0.040	0.010
	(1.31)	(1.71)	(-1.32)	(-1.22)	(1.57)	(1.70)	(0.26)	(0.07)
ESG	-1.854	-1.649*	2.323**	1.971*	-5.440*	-5.024**	-0.109	-0.126
	(-1.60)	(-1.86)	(2.26)	(1.90)	(-1.91)	(-2.14)	(-0.53)	(-0.83)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.853	0.891	0.947	0.950	0.876	0.894	0.684	0.612
Observations	8,278	7,488	8,278	7,488	8,278	7,488	8,278	7,488

Table IA3. Impact of Greta's speech

Panel A presents results from panel regression of cumulative abnormal return around Greta Thunberg's speeches, for event window of (-5, +5) days and (-10, +10) days. All the firms are divided into quintiles based on their ESG performance. Cumulative abnormal return is estimated based on FF-3 factor model. *High_ESG* is a dummy for firms with the highest ESG score. Post is a dummy variable equal to one after Greta Thunberg's speeches. Columns (1) and (2), Columns (3) and (4) show the results for event window of (-5, +5) days and (-10, +10) days, respectively. Control variables include the logarithm of market capitalization, the logarithm of book to market value, reversal, momentum and idiosyncratic volatility. All regressions include industry fixed effect & event fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. Panel B presents results from panel regression of short selling activities around Greta Thunberg's speeches. All the firms are divided into quintiles based on their ESG performance. *High_ESG* is a dummy for firms with the highest ESG score. *Post* is a dummy variable equal to one after Greta Thunberg's speeches. Column (1) to (4), Column (5) to (8) show the results of different short selling activities for event window of (−5, +5) days and (−10, +10) days, respectively. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect & day fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test.

Panel A: CAR around Greta's speech				
	Event window: (-5, +5) days		Event window: (-10, +10) days	
	(1)	(2)	(3)	(4)
High_ESG	0.788***	0.566**	0.817***	0.386**
	(3.75)	(2.28)	(4.33)	(2.06)
Ln(ME)		-1.949**		-2.091*
		(-2.43)		(-1.82)
Ln(BM)		-0.461***		-0.807***
		(-4.78)		(-6.35)
Mom1		3.223**		-2.390***
		(2.08)		(-11.40)
Mom12_2		0.550		-8.202***
		(0.88)		(-12.24)
IVOL		-13.584***		-32.538***
		(-2.59)		(-6.40)
Industry fixed effect	Yes	Yes	Yes	Yes
Event fixed effect	Yes	Yes	Yes	Yes
Adjusted R-squared	0.0907	0.119	0.0261	0.00511
Observations	7,308	6,809	7,308	6,809

Table IA4. Short selling activities, overpriced dummy and ESG score around the effective day of European Union (EU) regulation on short selling

This table reports panel regression results of different short selling activities as a function of overpriced dummy and ESG performance around effective day (November 1st 2012) of European Union (EU) regulation on short selling (No 236/2012), for stocks traded in the United Kingdom. The event window is twelve months before November 2012, and twelve months after November 2012 (excluding event month). The dependent variable is *On loan*, *Lendable shares*, *Utilization ratio*, *Lending fee* in the next month in Columns (1) and (2), Column (3)s and (4), Columns (5) and (6), and Columns (7) and (8), respectively. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score, constructed accordingly for stocks traded in the United Kingdom. *Overpriced dummy* equals to one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. *Post* equals to one after November 2012. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and price volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test.

	On loan		Lendable shares		Utilization ratio		Lending fee	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG x Post	-1.120**	-1.371**	-0.964	-1.709	-5.068*	-7.913**	-0.334	-0.556**
	(-2.46)	(-2.24)	(-0.47)	(-0.50)	(-1.94)	(-2.45)	(-1.56)	(-2.36)
Overprice x ESG	0.659**	0.906**	-0.556	-0.410	1.600	3.940**	0.053	0.230
	(2.43)	(2.59)	(-0.58)	(-0.25)	(0.99)	(2.25)	(0.33)	(1.53)
Overprice x Post	0.530*	0.774*	2.055	4.915	3.310	6.049**	0.200	0.368*
	(1.75)	(1.91)	(1.11)	(1.04)	(1.55)	(2.39)	(1.00)	(1.69)
ESG x Post	0.266	0.340	1.950	2.932	2.241**	1.664	-0.065	-0.057
	(1.25)	(1.44)	(1.05)	(1.25)	(2.33)	(1.64)	(-0.84)	(-0.71)
Overprice	0.084	-0.097	-0.913	-1.062	0.727	-1.440	0.032	-0.107
	(0.43)	(-0.37)	(-1.49)	(-0.90)	(0.54)	(-1.06)	(0.23)	(-0.86)
ESG	-0.024	-0.039	0.253	0.629	-1.153	-1.539	0.025	-0.004
	(-0.10)	(-0.16)	(0.20)	(0.52)	(-1.23)	(-1.55)	(0.34)	(-0.05)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.747	0.749	0.623	0.619	0.738	0.745	0.665	0.673
Observations	6,274	4,954	6,289	4,969	6,299	4,969	6,284	4,954

Panel B: Short selling activities around Greta's speech								
	Event window: (-5, +5) days				Event window: (-10, +10) days			
	On loan	Lendable shares	Utilization ratio	Lending fee	On loan	Lendable shares	Utilization ratio	Lending fee
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overprice x ESG x Post	-1.539**	-0.261	-2.972**	-0.027	-1.466*	-0.524	-2.681**	0.067
	(-2.09)	(-0.77)	(-2.36)	(-0.51)	(-1.95)	(-1.09)	(-2.22)	(0.85)
Overprice x ESG	1.623	-1.466	3.240	0.133	1.665	-1.210	3.495	0.064
	(0.95)	(-0.88)	(0.78)	(0.97)	(1.02)	(-0.78)	(0.87)	(0.53)
Overprice x Post	0.919**	-0.017	1.986**	0.004	0.805*	0.074	1.714**	-0.062
	(2.12)	(-0.08)	(2.42)	(0.11)	(1.75)	(0.24)	(2.14)	(-0.99)
ESG x Post	0.041	0.106**	0.067	-0.003	0.023	0.134**	-0.046	-0.046
	(1.09)	(2.06)	(0.67)	(-0.10)	(0.46)	(2.05)	(-0.36)	(-1.09)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R-squared	0.908	0.958	0.910	0.467	0.912	0.960	0.914	0.459
Observations	54,075	54,075	54,075	54,075	103,277	103,277	103,277	103,277

Table IA5. End-user option demand and option prices

Panel A displays the panel regression of net signed option trading volume of call options and put options as a function of ESG performance, overpriced dummy and other control variables. Panel B reports the panel regression of put implied volatility, put-call implied volatility ratio as a function of ESG performance, overpriced dummy and other control variables. Using signed option trading volume by public customers from International Securities Exchange (ISE), net signed option volume by public customers is the difference between the total buying volume from initiating long positions (open buy), and the total selling volume from initiating short positions (open sell), within a month for all options, scaled by the stock trading volume of the same month. Put implied volatility is implied volatility of ATM put options. Put-call implied volatility is implied volatility of ATM put options divided by implied volatility of call options. At the end of each month, all available stocks are sorted into five mispricing quintiles based on Stambaugh, Yu, and Yuan (2015) mispricing score. *Overpriced dummy* equals to one for stocks in the fifth quintile, referring to the most "overpriced" stocks. *ESG score* is the monthly updated raw score from Asset4 database and scaled by 100 at the end of last month. Control variables include the logarithm of market capitalization, the logarithm of book to market value, institutional ownership, analyst coverage, firm leverage, loss dummy indicating negative earnings, and idiosyncratic volatility. All regressions include firm fixed effect and time fixed effect. The t-statistics in the brackets are calculated from robust clustered standard errors by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, based on a two-sided test. The sample period is from January 2006 to December 2019.

Panel A. End-user option demand				
	Net singed call option		Net singed put option	
	(1)	(2)	(3)	(4)
Overprice x ESG	-3.127	-1.369	-3.503*	-4.195**
	(-1.35)	(-0.56)	(-1.74)	(-2.06)
Overpriced dummy	2.653	2.005	1.258	1.792
	(1.49)	(1.05)	(0.91)	(1.23)
ESG	4.393	3.132	-0.452	1.698
	(1.53)	(1.10)	(-0.20)	(0.75)
Ln(ME)		-1.462		-2.905***
		(-1.02)		(-2.83)
Ln(BM)		-3.343***		-1.377
		(-2.61)		(-1.48)
Institutional ownership		-3.039		15.198***
		(-0.53)		(3.74)
Analyst		0.182*		-0.023
		(1.72)		(-0.23)
Leverage		-6.642		-2.214
		(-1.54)		(-0.57)
Loss dummy		0.654		0.544
		(1.05)		(0.85)
IVOL		-11.542**		-15.577*
		(-2.07)		(-1.80)
Firm fixed Effect	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes
Adj R-squared	0.0843	0.0871	0.0705	0.0838
Observations	87,103	78,434	85,921	77,367

Panel B. Implied volatility of put options and put-call implied volatility ratio				
	Put implied volatility		Put-call implied volatility ratio	
	(1)	(2)	(3)	(4)
Overprice x ESG	-1.965*	-1.767**	-1.297**	-0.864*
	(-1.73)	(-2.11)	(-2.49)	(-1.75)
Overpriced dummy	3.847***	2.319***	0.913**	0.592*
	(4.68)	(3.87)	(2.38)	(1.65)
ESG	-5.370***	-2.137***	-0.467	-0.145
	(-5.51)	(-2.90)	(-1.21)	(-0.38)
Ln(ME)		-3.039***		-0.775***
		(-10.01)		(-4.11)
Ln(BM)		-0.117		0.098
		(-0.51)		(0.79)
Institutional ownership		1.229		1.338
		(0.89)		(1.30)
Analyst		-0.046**		-0.038**
		(-2.15)		(-2.53)
Leverage		5.944***		0.377
		(4.66)		(0.43)
Loss dummy		3.402***		0.047
		(13.84)		(0.37)
IVOL		96.344***		-3.553*
		(22.82)		(-1.78)
Firm fixed Effect	Yes	Yes	Yes	Yes
Time fixed Effect	Yes	Yes	Yes	Yes
Adj R-squared	0.731	0.797	0.114	0.114
Observations	98,222	88,437	98,222	88,437