Unlocking ESG Premium from Options

Jie (Jay) Cao
Amit Goyal
Xintong (Eunice) Zhan
Weiming (Elaine) Zhang*

January 2023

Abstract

We find that option expensiveness, as measured by delta-hedged option returns, is higher for low-ESG stocks, indicating that investors pay a premium in the option market to hedge ESG-related uncertainty. We estimate this ESG premium to be about 0.3% per month. All three components of ESG contribute to option pricing. We find that investors pay the ESG premium to hedge jump risks, but not volatility risks. The effect of ESG performance is more prominent during the periods when the attention to ESG is higher and for firms that are more subject to ESG-related risks.

Keywords: ESG, risk premium, delta-hedged option return

JEL Classification : G12, G14, G41, M14

*Jie Cao is at The Hong Kong Polytechnic University, email: jie.cao@polyu.edu.hk. Amit Goyal is at University of Lausanne and Swiss Finance Institute, email: amit.goyal@unil.ch. Xintong Zhan is at Fudan University, email: xintongzhan@fudan.edu.cn. Weiming Zhang is at IE Business School, email: elaine.zhang@ie.edu. We thank Kornelia Fabisik, Stephen Figlewski, Dmitriy Muravyev, Neil Pearson, David Sraer, Grigory Vilkov, Yichao Zhu, and seminar participants at Hong Kong Baptist University, Hong Kong Polytechnic University, Shanghai Jiaotong University, the 2022 American Finance Association Meeting, the Armenian Finance Association Annual Meeting, the 8th Melbourne Asset Pricing Meeting, and the Virtual Derivatives Workshop for helpful comments and suggestions. We acknowledge financial support of the Research Grant Council of the Hong Kong Special Administrative Region, China (Project No. GRF 14500621) and the National Natural Science Foundation of China (Grant No. 72271061). All errors are our own.

1 Introduction

There is a growing interest in whether corporate environmental, social, and governance (ESG) performance matters for financial markets and corporate behavior. Practitioners contend that ESG-related uncertainty is now at the center of focus because investors are concerned that poor ESG performance would cause substantial physical risks, transition risks, supply chain risks, and/or downside risks (Morningstar (2020) and PwC (2020)). There is also academic evidence that ESG performance affects firms' risks including systematic, downside, and crash risks.[1] However, less is understood about the pricing of these risks.

In this paper, we study the pricing of uncertainty associated with ESG, by which we mean operational, reputational, and/or litigation uncertainty due to poor ESG performance. Our interest is not so much in studying the impact of ESG on various risk measures *per se* but rather in analyzing whether investors recognize these risks and pay a premium, that we dub 'ESG premium,' to potentially hedge them. Note that, while risks due to poor ESG performance are normally associated with bad outcomes, the directional impact of ESG uncertainty could be positive. Therefore, we view ESG uncertainty as both on the upside and the downside and conjecture that investors may be willing to pay to hedge against this uncertainty. Option markets are a natural place for us to uncover these insurance premia, if any.[2] The benefit of using options is that option prices reflect the forward-looking market's perception. Ilhan, Sautner, and Vilkov (2021) also use risk-neutral quantities extracted from options to study the pricing of carbon risks. Option returns (suitably delta-hedged) also allow us to isolate the pricing impact of ESG uncertainty due to hedging, from the ESG risk premia on the underlying, if any.

We draw inspiration from Kelly, Pástor, and Veronesi (2016) and Pástor and Veronesi (2013) who show that options whose lives span political events tend to be more expensive, reflecting that political uncertainty is priced. Similar to their arguments about political risks, it is unclear when ESG risks will materialize or how severe they will be. For example, despite the increasing awareness of ESG issues, there remains uncertainty about when and how ESG-related regulatory policies will be implemented, about investors' divestment policies, and about firms' fluctuations in revenues. Options, therefore, are a good vehicle to

[1] See for example, Albuquerque, Koskinen, and Zhang (2019), Hoepner, Oikonomou, Sautner, Starks, and Zhou (2022), and Kim, Li, and Li (2014).

[2] A separate line of inquiry studies whether ESG risks are priced in the market in the sense that investors are compensated with higher expected returns for bearing these risks. Evidence on risk compensation from the stock market is, however, mixed. For example, Hong and Kacperczyk (2009) and Edmans (2011) document opposite effects of corporate social performance (see also Chava (2014) and Chava, Kim, and Lee (2022)). Pástor, Stambaugh, and Taylor (2021) and Pedersen, Fitzgibbons, and Pomorski (2021) show that the effect of ESG performance on stock prices is theoretically ambiguous.

understand how such uncertainties are perceived and ultimately priced. In the context of climate change, Giglio, Maggiori, Rao, Stroebel, and Weber (2021) highlight the importance of alternative asset classes to estimate its impact. For example, these authors use the real estate market to understand the term structure of discount rates for investments in climate change abatement. Somewhat similarly, we study another alternative asset market, viz. the equity options market, to study the risks associated with ESG.

Our conjecture is that investors are willing to pay a premium to hedge against ESG-related uncertainty. We start our empirical investigation by analyzing how firms' ESG scores are related to their option expensiveness, measured using delta-hedged option and straddle returns. These returns insulate the effect of underlying return (for which, the evidence of ESG pricing is ambiguous) and allow us to focus on the object of interest, viz. premium due to ESG uncertainty. Option returns (specifically straddle and strangle returns) are also used by Dew-Becker, Giglio, and Kelly (2021) and Dew-Becker, Giglio, Le, and Rodriguez (2017) to study the pricing of macroeconomic risk and volatility risk, respectively.

To be specific, we pick one call and one put option on each optionable stock that have a time-to-maturity of about one and a half months and are closest to being at-the-money (ATM)—these options are most frequently traded and, hence, most liquid. For each optionable stock and in each month, we evaluate the return over the following month of a portfolio that buys one call (or put), delta-hedged with the underlying stock. To investigate the impact of ESG performance on option returns and gauge the economic magnitude of ESG premium, we sort all options into quintiles based on the ESG scores of the underlying stocks. We calculate three kinds of option returns. First is daily rebalanced delta-hedged returns, following Bakshi and Kapadia (2003) and Cao and Han (2013), so that the portfolio is not sensitive to stock price movements. Second, we calculate buy-and-hold delta-hedged returns to reduce option transaction costs (Bali and Murray (2013) and Goyal and Saretto (2009)). Third, we calculate zero-beta straddle portfolio returns following Coval and Shumway (2001). We calculate the returns and factor model alphas using stock market factors from Fama and French (2018) and the option market factor from Coval and Shumway (2001). We find that both returns and alphas increase monotonically from quintile one (lowest ESG score) to quintile five (highest ESG score), robust across the three different types of option returns. The difference in average delta-hedged option returns on low- and high-ESG stocks can be regarded as the ESG premium that investors are willing to pay in the option market to hedge against their perceived uncertainty for low-ESG stocks. The magnitude of the risk premium using daily-rebalanced delta-hedged returns is around 0.3% per month. Using buy-and-hold delta-hedged returns, the 7-factor monthly alpha for H−L spread portfolio is 0.71% for calls and 0.68% for puts, both statistically significant. Beta-neutral straddle returns yield an estimate of ESG premium of about 3.5%.[3]

Do all the three components of ESG contribute to the relation between ESG scores and option returns? To investigate this question, we separate out the environmental (E), the social (S), and the corporate governance (G) scores and study their individual impact on delta-hedged option returns. Using the portfolio sorts as before, we find that all three aspects of ESG contribute to the positive relationship between delta-hedged option returns and ESG performance, albeit the E-score and the S-score are stronger determinants of option returns than the G-score.

Delta-hedged option returns and straddle returns embed various kinds of risk premia such as volatility risk premium, jump risk premium, and tail risk premium. Many studies document the existence of non-zero volatility premium (Bakshi and Kapadia (2003), Buraschi and Jackwerth (2001), and Coval and Shumway (2001)) and the risk of unforeseen tail events (Bakshi and Kapadia (2003) and Jackwerth and Rubinstein (1996)). It is, therefore, of interest to examine which risk premia contribute to the positive relationship between ESG score and option returns. To directly test whether volatility and tail risk premia are related to ESG scores, we construct straddle returns following Cremers, Halling, and Weinbaum (2015). Via portfolio sorts, we find a positive relationship between ESG and returns to gamma-positive, vega-neutral straddles (portfolios exposed to tail risk), while the relationship between ESG and returns to vega-positive, gamma-neutral straddles (portfolios exposed to volatility risk) is not significant. These results show that jump risks related to ESG performance are strongly priced in the options, while the impact of volatility risks is limited.

If our hypothesis that investors pay a premium to hedge uncertainty is correct, then the effect of ESG on option pricing should increase when public ESG awareness/attention heightens, when the perceived uncertainty for low ESG stocks is expected to be more important. To lend support to our argument, we conduct three tests to examine how the ESG premium changes with the public ESG awareness/attention over time. First, we divide our sample into two sub-periods based on the monthly change in the Google Search Volume of "ESG," and find the alpha for H−L spread portfolio is significantly higher during the period with heightened Google Search Volume. Second, we find that the effect of ESG score on the delta-hedged option return is significantly stronger during the Paris Agreement period (January 2016 to June 2017), when Paris Agreement is effective and likely to impose stringent regulations on firms with poor ESG performances. Third, using aggregated ESG news in the market as a proxy for ESG awareness, we find the ESG premium is much higher when

[3] For the remaining tests, we will mainly focus on the daily-rebalanced delta-hedged option returns.

there is more ESG news.

Next, we use Fama and MacBeth (1973) regressions (FM regressions henceforth) to test the impact of ESG performance on the option level. After controlling for various firm characteristics, option characteristics, and risk measures, we find that lower ESG scores are associated with lower delta-hedged option returns. For example, we find that delta-hedged option returns for calls increase by 0.32% each month if we move from the lowest to the highest quartile of ESG scores (similar to the return spread from portfolio sorts). To disentangle the effect of carbon tail risk (Ilhan, Sautner, and Vilkov (2021)) from broader ESG risks, we run FM regressions of delta-hedged option returns on both ESG score and carbon emission intensity. We find that the ESG score plays an important role even after controlling for the carbon emission intensity, indicating that our results are not merely driven by the carbon emission intensity of the firm, but depend on other aspects of ESG score as well.

Given the complexity of measuring ESG information, ESG ratings from different providers disagree substantially and the validity of these ratings has been debated critically. We perform three different robustness tests to mitigate the concern that our empirical results are only significant to a particular ESG data provider. First, we use ESG score from four alternative data providers, and find three of them are significant while the remaining one is close to significant. Second, we create a combined ESG score using the information from five data providers and show the results are robust. Third, utilizing a noise-correction procedure (Berg, Koelbel, Pavlova, and Rigobon (2022)), we again find consistent patterns.

We next turn to several channels through which the link between ESG score and option market is strengthened or weakened. The first channel is different business models and product market competition. Industries' proximity to the end-consumers has been documented to influence the impact of ESG score on firm fundamentals, because private end-consumers show more social concerns in their consumption (Baron, Harjoto, and Jo (2011) and Curcio and Wolf (1996)). We conjecture that the effect of ESG performance on option prices might be more important in the industries that depend heavily on the trust of end-consumers. Indeed, the options of low-ESG firms are even more expensive if the firms are in industries closer to the end-consumers. In addition, firms offering similar products face stronger market competition, have less "cushion," and are more vulnerable to ESG risk shocks. The marginal value of ESG for firms in competitive industries is also higher (Cao, Liang, and Zhan (2019)). Consistent with these arguments, we find that the results are stronger when the product competition is more intense.

The second channel influencing the ESG premium is through cross-sectional variations in investors' attention on ESG. We use two different methods to capture such heterogeneity.

The first proxy is the political affiliation (Democratic vs. Republican) of the state in which the company is headquartered, because evidence suggests Democratic-leaning voters care more about social performances compared to Republican-leaning voters (Di Giuli and Kostovetsky (2014) and Hong and Kostovetsky (2012)). Our second proxy is the portion of quarterly earnings conference call transcripts that are devoted to environmental-related political topics (Hassan, Hollander, van Lent, and Tahoun (2019)). If there are more environmental-related topics mentioned, the investors' attention to ESG is higher for that firm. We find that the relationship between ESG and delta-hedged option returns is magnified when the firm is headquartered in Democratic states and when there are more environmental-related topics mentioned in the earnings conference calls.

As a third channel, we conjecture that corporate hedging policy would also affect the relationship between ESG performance and option pricing. All else equal, firms with better hedging policy can better handle future (operational) risks. Empirically, we do find that the impact of ESG performance on option pricing is mitigated in the subsample of firms that have hedging activities as indicated in their income statements.

To the best of our knowledge, our paper is the first that formally investigates the effect of ESG performance on risk premia in the options market. Previous literature largely focuses on the stock and corporate bond markets. For example, focusing on the stock market, Hong and Kacperczyk (2009) and Edmans (2011) document opposite effects of corporate social performance (see also Chava (2014)). Flammer (2021) documents the positive effects of corporate social responsibility (CSR) and green bond issuances on the firm value. We complement these studies by exploring the ESG premium in relatively under-studied derivatives markets, and show that option investors pay a premium in the form of more expensive options to hedge against uncertainty associated with poor ESG performance.

We also contribute to the growing literature of option pricing. Goyal and Saretto (2009), Bali and Murray (2013), Cao and Han (2013), Zhan, Han, Cao, and Tong (2022), Christoffersen, Goyenko, Jacobs, and Karoui (2018), and Ramachandran and Tayal (2021) explore the impact of various stock and volatility-related characteristics on option returns. Our paper is the first one that examines the effects of underlying firms' ESG performances on option pricing and explores several potential underlying economic channels.

The study most closely related to ours is Ilhan, Sautner, and Vilkov (2021). These authors find that the cost of protection against downside tail risks is larger for firms with more carbon-intensive business models. Our paper is different from theirs in two major aspects. First, we focus on the risks associated with general ESG performance, and not just the carbon policy risks. As discussed above, we show that our results are not due to the impact of carbon risks, or only environmental risks, but rather derive from all components (E, S, and G) of ESG.[4] The evidence from other cross-sectional analyses also shows that the social component is a non-negligible component that amplifies the impact of ESG on option pricing. Second, Ilhan, Sautner, and Vilkov (2021)'s interest is mostly in studying downside risk (hence their focus on deep out-of-the-money options). In contrast, we study the pricing of general uncertainty related to ESG performance (and, therefore, analyze ATM options). Ilhan, Sautner, and Vilkov (2021) do report that carbon risks also have an impact on variance risk premia. We find results consistent with theirs. Importantly, we additionally show that ESG premium embedded in option prices goes beyond that related to volatility risk only and includes premia related to jump risks. Since our interest is in general ESG premium, we quantify it using returns (on delta-hedged options and straddles in our case) rather than prices *per se*. The use of option returns is also advocated by Dew-Becker, Giglio, and Kelly (2021) to study the pricing of macroeconomic risk.

The rest of the paper proceeds as follows. Section 2 describes our data and measures. Section 3 quantifies the ESG premium and investigates the sources of this premium. We present the Fama-Macbeth results using in Section 4. We discuss potential underlying economic channels that affect the cross-section relationship between ESG performance and option pricing in Section 5 and conclude in Section 6.

2 Data and variables

2.1 Data and sample coverage

We collect data on firms' ESG performance from ASSET4.[5] These data provide objective, relevant, and systematic ESG information based on 250+ key performance indicators and 750+ individual data points, from three pillars.[6] ASSET4 provides data on more than 3,000 firms globally, covering major indexes. In the US, ASSET4 covered firms in the S&P 500 index only at the beginning of the sample period and expanded to firms in the Russell 1000 index in the later period.

We obtain the data on US individual stock options from OptionMetrics. The data set includes the daily closing bid and ask quotes, trading volume, and open interest of each option. Options' delta and other Greeks are computed by OptionMetrics based on standard

[4] Our results are robust to controlling for carbon emission measures.

[5] 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, we use the old name for simplicity.

[6] Raw ASSET4 score ranges from 0 to 100. To make the interpretation of regression coefficients easier, we divide the raw ASSET4 score by 100.

market conventions.

Stock returns, prices, and trading volumes are obtained from the Center for Research on Security Prices (CRSP). The accounting data are collected from COMPUSTAT. We obtain institutional holdings (13F) data from Thomson Reuters and analyst coverage data from I/B/E/S. The daily and monthly Fama-French factors and risk-free rates are from Kenneth French's data library. The sample period is from January 2004 to December 2018.

At the end of each month and for each optionable stock, we collect a pair of options (one call and one put) that are closest to ATM and expire on the third Friday/Saturday of the month after the next. For example, on June 30, 2011, we select options expiring on August 20, 2011.[7] For a given month, all options we study have the same expiration day and our cross-sectional analysis is not influenced by the difference in maturities. We focus on these options because short-term ATM options are traded more frequently and with lower effective transaction costs compared to long-term options or expiring options. We apply several filters to the option data. First, our main analyses use options whose stocks do not have ex-dividend dates prior to option expiration (i.e., we exclude an option if the underlying stock paid a dividend during the remaining life of the option). Second, we exclude all option observations that violate obvious no-arbitrage conditions such as $S \geq C \geq \max(0, S - Ke^{-rT})$, where C is the call option price, S is the underlying stock price, K is the strike price, T is the time to maturity, and r is the risk-free rate. Third, to avoid microstructure-related bias, we retain only those options that have positive trading volume and positive bid quotes, with the bid price strictly smaller than the ask price, and the midpoint of bid and ask quotes being at least \$1/8. We keep only options whose last trade dates match the record dates and whose option price dates match the underlying security price dates. Lastly, we only retain stocks with both call and put options available after filtering.

Our final sample contains 51,691 option-month observations for both call and put options on individual stocks. Table 1 shows that the average moneyness of the sample options is one, with a small standard deviation of 0.03. The time to maturity is between 47 and 52 calendar days, with an average of 50 days. These short-term ATM options have relatively smaller bid-ask spreads and provide more reliable pricing information related to investors' perception of risk and uncertainty.

Appendix Table A1 reports the sample coverage details of 893 unique underlying stocks. The average number of stocks in our sample per month is 287. On average, our sample contains only 4.2% of the total number of stocks in the CRSP universe but comprises 25% of the total market capitalization. 73% of our sample stocks are traded at NYSE/AMEX

[7] The growth of weekly options after 2013 generates multiple option expiration dates in each month. However, the third Friday/Saturday is still the most common maturity date for equity options.

and 81% are included in the S&P500 index. Relative to the full CRSP sample, the average size percentile and book-to-market ratio percentile of these stocks in our sample are 91% and 35%, respectively. Moreover, the average institutional ownership is 77% and the average number of analysts following is 16.32. The industry distribution of these stocks does not deviate much from that of the full CSRP sample. Given the characteristics of our sample firm, the results are less likely to be confounded by market frictions, e.g., small, illiquid, less transparent stocks, stocks with low attention, or biased towards a few industries. For example, Table 1 shows that the quoted call option bid-ask spread has a mean (median) of 0.15 (0.11), which is smaller than 0.20 (0.15) in previous related studies such as Cao and Han (2013) and Zhan, Han, Cao, and Tong (2022). A lower bid-ask spread also indicates that option prices adjust faster to investors' flow of information as well as to changes in perceived uncertainty.

2.2 Delta-hedged option return

We calculate delta-hedged call option return following Bakshi and Kapadia (2003) and Cao and Han (2013). We first define the daily rebalanced delta-hedged option gain, which is the change in the value of a self-financing portfolio that consists of a long call position, hedged by a short position in the underlying stock such that the portfolio is not sensitive to stock price movement, with the net investment earning risk-free rate. Specifically, consider a portfolio of a call option that is hedged discretely N times over a period $[t, t+\tau]$. The rebalancing times are t_n (where $t_0 = t$ and $t_N = t + \tau$). The delta-hedged call option gain is:

$$\Pi_{t,t+\tau} = C_{t+\tau} - C_t - \sum_{n=0}^{N-1} \Delta_{c,t_n} \left(S_{t_{n+1}} - S_{t_n} \right) - \sum_{n=0}^{N-1} \frac{a_n r_{t_n}}{365} \left(C_{t_n} - \Delta_{c,t_n} S_{t_n} \right), \tag{1}$$

where Δ_{c,t_n} is the call delta of the call option on date t_n, r_{t_n} is the annualized risk-free rate on date t_n, and a_n is the number of calendar days between t_n and t_{n+1}. The delta-hedged put option gain is defined similarly. With a zero-net investment initial position, the delta-hedged option gain $\Pi_{t,t+\tau}$ is the excess dollar return of the delta-hedged option. Since the option price is homogeneous of degree one in the stock price and the strike price, $\Pi_{t,t+\tau}$ is proportional to the initial stock price. To make it comparable across stocks, we scale the dollar return by $\Delta_{c,t} S_t - C_t$ for call options and $P_t - \Delta_{p,t} S_t$ for puts.[8]

Panels A and B of Table 1 present the summary statistics of delta-hedged option returns for call and put options, respectively. Consistent with the findings of Cao and Han (2013),

[8]We obtain similar results when we scale the delta-hedged option gains by the initial price of the underlying stocks or that of options.

the average delta-hedged returns of individual equity options are negative for both calls and puts. On average, delta-hedged gain for call (put) is −0.57% (−0.49%) over the next month. There is substantial cross-sectional variation in these gains. For example, the lower and the upper quartile of call delta-hedged gains are −1.82% and 0.43%, respectively.

We report stock-related summary statistics in Panel C 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)). RET1 is the stock return in the prior month. RET212 is the cumulative stock return from the prior second through the 12th month. 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. Ln(AMIHUD) is the logarithm of Amihud (2002) stock illiquidity measure, calculated as the average of the daily ratio of the absolute stock return to dollar volume over the previous month. ESG score has a mean of 0.61 and its standard deviation is 0.26. Such a large cross-sectional variation of ESG scores is useful to better estimate the effect of ESG performance on option market. Panel D of Table 1 reports the time-series average of the cross-sectional correlations among these stock variables. ESG score tends to have high correlations with Ln(ME) and Ln(AMIHUD), which we further control in the multivariate regression analyses.

3 ESG premium

3.1 Portfolio sort results

To understand the pricing implications of ESG performance, we start our analysis using portfolio sorts to quantify ESG premium. We use three types of option returns to calculate this premium. First, we rely on daily-rebalanced delta-hedged option returns, as described in Section 2.2. This measure is rebalanced daily so that the portfolio return is not overly sensitive to the stock price movement. We also scale the delta-hedged option dollar gain of the portfolio by the absolute value of securities involved to make it comparable across stocks. Nevertheless, this portfolio is not directly tradable. Therefore, our second measure is a buy-and-hold delta-hedged option portfolio. Specifically, at the end of each month, for delta-hedged call options, we buy one contract of call option hedged by a short position in delta shares of the underlying stock, where delta is the hedge ratio under Black-Scholes model. To reduce option transaction costs, we hold the position for one month without rebalancing the delta-hedge (Bali and Murray (2013) and Goyal and Saretto (2009)). The return of the buy-and-hold delta-hedged option is:

$$HPR_{t+1} = \frac{H_{t+1}}{H_t} - 1 = \frac{(C_{t+1} - \Delta_{c,t}S_{t+1}) \text{ or } (P_{t+1} - \Delta_{p,t}S_{t+1})}{H_t} - 1, \tag{2}$$

where the initial investment cost H_t is $(\Delta_{c,t}S_t - C_t)$ for call options and $(P_t - \Delta_{p,t}S_t)$ for put options, and $\Delta_{c,t}$ and $\Delta_{p,t}$ are the Black-Scholes option call and put deltas, respectively, at time t.

The third option return is a zero-beta straddle portfolio return, which is also not sensitive to stock returns. Dew-Becker, Giglio, and Kelly (2021) also use straddle returns to study whether investors hedge macroeconomic risks. We select a call option and a put option with a maturity of 50 days, and are closest to ATM, as in the main tests. Following Coval and Shumway (2001), we form zero-beta straddles by solving the equations below:

$$\begin{aligned} r_v &= \theta r_c + (1-\theta) r_p \\ \theta\beta_c &+ (1-\theta)\beta_p = 0, \end{aligned} \tag{3}$$

where r_v is the straddle return, θ is the fraction of the straddle's value in call options, and β_c and β_p are the market betas of the call and put, respectively. β_c is calculated using:

$$\beta_c = \frac{S}{C}\Delta_c\beta_s, \tag{4}$$

where β_s is the rolling beta of stock, estimated using weekly returns over the past one year. We hold this portfolio for one month.

To measure the ESG premium, we sort all the stocks into quintiles based on ESG score at the end of each month, then calculate equal-weighted portfolio return for quintiles and the H−L spread portfolio, using the three different option returns. In addition, we report risk-adjusted return based on two different factor models. The first model is a 6-factor model from Fama and French (2018), which includes market factor, size factor, value factor, profitability factor, investment factor, and momentum factor. In the second 7-factor model, besides the six factors, we add a market volatility factor proxied by zero-beta straddle return on S&P 500 index (Carr and Wu (2009) and Coval and Shumway (2001)), to examine whether the portfolio return can be further explained by the systematic volatility risk factor. The portfolio sorting results for daily-rebalanced delta-hedged option returns, buy-and-hold delta-hedged option returns, and straddle returns are reported in Panels A, B, and C of Table 2, respectively. Panels A and B show results separately for delta-hedged calls and delta-hedged puts. Delta-hedged call and put positions are in essence volatility positions, and thus should behave similarly. At the same time, to increase the power of some of our tests, we also pool both calls and puts in results in Panels A and B.

Returns and alphas from factor models exhibit patterns consistent with our conjecture that options on low-ESG stocks are more expensive. Both returns and alphas increase monotonically from quintile one (lowest ESG score) to quintile five (highest ESG score), robust across three different types of option returns. For example, in Panel A of Table 2, where we consider daily-rebalanced delta-hedged option returns, when grouping call and put options together, the 6-factor alpha of quintile one (five) portfolio is −0.66% (−0.37%), leading to a H−L portfolio alpha of 0.29%, statistically significant at the 1% level. The H−L 7-factor alpha is a bit lower at 0.26%, but still significant at the 1% level. Call option returns and put option returns demonstrate similar patterns, though the magnitude of H−L portfolio alphas is slightly larger for put options.

The average buy-and-hold delta-hedged option portfolio return increases monotonically from the lowest ESG options to the highest ESG options, as shown in Panel B of Table 2. The H−L spread is 0.73% for call options and 0.70% for put options. These magnitudes are approximately half of the H−L spread of ten anomalies that can significantly predict option returns (Zhan, Han, Cao, and Tong (2022)).[9] Given the fact that our sample with non-missing ESG scores includes options of relatively large stocks, the economic magnitude of ESG premium is non-trivial.[10]

Panel C of Table 2 shows that beta-neutral straddle returns also increase as ESG scores increase, with a 7-factor alpha of −6.07% for quintile one portfolio and −2.57% for quintile five portfolio, yielding a H−L portfolio alpha of 3.50%. Overall, the portfolio sorting results show that there is an ESG premium in the cross-section of option returns, supporting the hypothesis that investors pay a significant premium to hedge against uncertainties associated with poor ESG performance. The magnitude of ESG premia is around 0.3% for daily-rebalanced delta-hedged returns, around 0.7% for buy-and-hold delta-hedged returns, and around 3.5% for straddle returns.

[9] For example, Zhan, Han, Cao, and Tong (2022) document for call option, EW H−L option return spread of CFV (Cash flow variance) is 1.58%, and is 1.38% for TEF (Total external financing).

[10] Our interest is not in documenting a new trading strategy for option returns. Nevertheless, in unreported tests, we investigate how our results are affected by the option transaction cost. We measure these costs by effective bid-ask spreads. We find that the H−L spread is still statistically significant when the effective option spread is 25% or 50% of the quoted spread. Previous studies such as De Fontnouvelle, Fishe, and Harris (2003) and Mayhew (2002) show that for equity options, the ratio of effective spread to the quoted spread is less than 0.5.

3.2 E, S, or G

In this subsection, we examine the effect of environmental (E-score), social (S-score), and corporate governance (G-score) performance on option pricing, separately. Such investigation allows us to understand whether some components of ESG are relatively more important for option pricing. We repeat portfolio sort analysis similar to those in Table 2, while using E-score, S-score, and G-score as the sorting variables, respectively. Table 3 shows the results for daily rebalanced delta-hedged option returns for call and put options together.[11] When sorting on E-score, Panel A shows that the H−L portfolio alpha is 0.31% (0.28%) based on the 6-factor (7-factor) model, significant at the 1% level. The H−L spread for S-score has a similar magnitude as E-score, while it drops to 0.13% (7-factor alpha) for G-score. Comparisons across three scores show that the E-score and S-score are stronger determinants of option returns than the G-score. Taken together, the results in Table 3 show that option pricing depends on all three kinds of (E, S, and G) risks. Environmental (or climate) risks have been the focus and drawn much attention of the recent academic literature, while the driver of our results is not only environmental performance, but also social performance and governance performance.

3.3 Sources of risk premium

Delta-hedged option returns and straddle returns embed various kinds of risk premia such as volatility risk and tail risk premia. Many studies document a nonzero volatility risk premium (see, for example, Buraschi and Jackwerth (2001) and Coval and Shumway (2001)). In fact, Bakshi and Kapadia (2003) show that priced volatility risk is an important source of the underperformance of delta-hedged portfolios. Similarly, options prices reflect the risk of potential unforeseen tail events (Bakshi and Kapadia (2003) and Jackwerth and Rubinstein (1996)). Accordingly, in this subsection, we investigate whether the positive relationship between ESG and delta-hedged option return is driven by exposures to these kinds of risks.

In order to directly test whether risk premia associated with volatility and jump risks are related to ESG scores, we use tradable portfolios. To do this, we follow Cremers, Halling, and Weinbaum (2015), and use two beta-neutral straddles with different maturities to construct jump risk portfolio and volatility risk portfolio. In particular, the jump risk portfolio is a beta-neutral, vega-neutral, and gamma-positive strategy consisting of (i) a long position in one beta-neutral at-the-money straddle with maturity T_1, and (ii) a short position in y market-neutral at-the-money straddles with maturity T_2, where $T_2 > T_1$ and y is chosen

[11] The results are similar when using buy-and-hold delta-hedged option returns or zero-beta straddle returns.

so as to make the overall portfolio vega-neutral. Similarly, the volatility risk portfolio is a market-neutral, gamma-neutral, and vega-positive strategy consisting of (i) a long position in one market-neutral at-the-money straddle with maturity T_2, and (ii) a short position in y market-neutral at-the-money straddles with maturity T_1, where $T_2 > T_1$ and y is chosen so as to make the gamma of the overall strategy zero. Considering option liquidity, we choose T_2 to be 80 days and T_1 to be 50 days. The rest of the procedure is the same as described in Section 3.1, and we hold these portfolios for a month without additional rebalancing. Higher portfolio returns indicate lower exposures to volatility risk or jump risk.

We use two kinds of straddle returns as dependent variables in portfolio sort analysis similar to those in Table 2. The results are reported in Table 4. Somewhat surprisingly, we find weaker evidence for pricing of volatility risks; the H−L spread returns or alphas are not significantly different from zero for straddle portfolios exposed to only volatility risk (gamma-neutral and vega-positive) in Panel A. In contrast, the H−L spread returns and alphas are large in economic magnitude and strongly statistically significant for straddle portfolios exposed to only jump risks in Panel B (gamma-positive and vega-neutral). The H−L jump straddle portfolio is 5.12% using 7-factor alpha, which is even higher than the corresponding number of 3.50% for beta-neutral straddle spread return in Panel C of Table 2.

3.4 The effect of public awareness: Time-series variation

The perceived uncertainty for low ESG stocks is expected to be more important when the public awareness of ESG issues is high. We corroborate our baseline results by further examining the role of public awareness/attention of ESG, which is proxied by three measures, including Google Search Volume Index (SVI), the announcement of the Paris Agreement, and aggregated ESG news in the market. We first construct H−L portfolio based on ESG score each month, and then investigate how the H−L return spread changes with the time-series variation of the public ESG awareness/attention. Specifically, we run the following regression for different proxies of ESG public awareness/attention.

$$R_t = \alpha_0 + \alpha_1 D_t + \beta' F_t + \varepsilon_t, \tag{5}$$

where D_t is a time dummy indicating the period of high ESG public awareness/attention. Our variable of interest is α_1, which captures the average return/alpha differences between high awareness periods and low awareness periods. For the first proxy, Google Search Volume Index, we divide our sample into two sub-periods based on the logarithm of monthly change in the Google Search Volume Index (DGSVI) of "Environmental, Social and Corporate

Governance." The periods with a higher value are indicated as high awareness periods.[12] For the second proxy, Paris Agreement, we focus on the window around the announcement of the Paris Agreement (July 2014 to December 2018), and assign the period from January 2016 to June 2017 as the high ESG awareness period.[13] We use the number of aggregated ESG news in the market as the last proxy for ESG awareness. Each month, we count the number of ESG news from Reprisk, scaled by the total number of news in the market from Ravenpack, to get the relative amount of ESG news. Then we divide our sample into two sub-periods based on the relative amount of ESG news, and the periods with a higher value are identified as high awareness periods.

We report the results of the Google Search Volume Index, the announcement of the Paris Agreement, and aggregated ESG news in Panels A, B, and C, respectively, of Table 5. The patterns are consistent with our conjecture that the H−L return spread is more prominent when the public ESG awareness/attention is higher. In Panel A, the H−L 7-factor alpha is 0.15% (t-statistic = 1.94) during the low awareness periods, while the H−L 7-factor alpha is 0.35% during the high awareness periods, and the difference between two subperiods is 0.20%, significant at 5% level. Panel B shows during the Paris Agreement, the ESG premium is significantly higher compared to the periods before the announcement of the Paris Agreement and after the withdrawal. Panel C demonstrates similar patterns. When there is more ESG-related news in the market, investors are willing to pay a higher ESG premium.

[12] We find similar results when using other topics such as "Global Warming" and "Socially Responsible Investing."

[13] On December 12, 2015, the PA 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°C" 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)). Another related event is the announcement of the withdrawal of the U.S. from the PA. On June 1, 2017, President Donald Trump announced that the U.S. would cease all participation in the 2015 Paris Agreement on climate change mitigation. Therefore, we assign the period from January 2016 to June 2017 as the high ESG awareness period.

4 ESG performance and delta-hedged option returns: Regression evidence

4.1 Baseline results

To better control for the confounding effect of other firm characteristics and option characteristics, we next study the effect of ESG performance on the cross-section of delta-hedged option returns using monthly FM regressions. The dependent variable (in percent) is the daily rebalanced delta-hedged option gain until month-end scaled by $(\Delta_{c,t}S_t - C_t)$ for calls and $(P_t - \Delta_{p,t}S_t)$ for puts.

We tabulate the results in Table 6, for call options, put options, call and put options together. In columns (1), (3), and (5), control variables include market capitalization, book-to-market ratio, reversal, momentum, idiosyncratic volatility, and stock illiquidity. We also include two option-related variables as controls. Option open interest (OPTION IO) is the total number of option contracts that are open at the end of the previous month and is scaled by the stock trading volume of the last month. Option bid-ask spread (OPTION BA) is the ratio of the difference between the bid and ask quotes of option to the midpoint of the bid and ask quotes at the end of the previous month. For call options, the coefficient on ESG is 0.293 (t-statistic = 2.46). This coefficient shows that delta-hedged call returns increase by 0.135% each month from the lower quartile of ESG score (0.39) to the upper quartile of ESG score (0.85). Given the mean of delta-hedged call return is 0.570%, the economic significance of ESG on option returns is substantial. Columns (3) to (4) report the results for put option, and columns (5) to (6) report the results for call and put option together. These results are largely similar to those for calls.[14] In addition, we control for different types of risk measures, including lagged model-free option implied variance, skewness, and kurtosis in our baseline FM regressions to examine whether these risks could explain the positive relationship between delta-hedged option return and ESG scores. We find that ESG score is still significant in explaining delta-hedged call option returns even after controlling for volatility and jump risks. However, the coefficient estimate declines by about one-third for delta-hedged option returns after the inclusion of lagged risk measures. These results indicate that investors perceive that stocks with lower ESG scores have higher risks beyond those stock characteristics, option characteristics, and risk proxies.

[14] According to Thomson Reuters Refinitiv, the Asset4 ESG scores "are based on the relative performance of ESG factors with the company's sector (for E and S) and country of incorporation (for G)" See https://www.refinitiv.com/en/sustainable-finance/esg-scores#methodology. Our results hold with little change in significance and magnitude, if we control for industry fixed effects in the FM regressions.

Last, to disentangle the effect of climate risks from broader ESG risks, we run FM regressions of delta-hedged option return on both ESG performance and carbon intensity. Carbon intensity is the Scope 1 carbon emission obtained from Trucost scaled by the market value of the firm.[15] We report the results of regressions controlling for carbon emission score in Appendix Table A2. Consistent with higher tail risks documented by Ilhan, Sautner, and Vilkov (2021), we find that firms with the more carbon-intense business model have more negative delta-hedged option returns. However, after controlling for the carbon intensity, the ESG score still plays an important role. This evidence indicates that our results are not purely driven by the carbon emission intensity of the firm but also depend on other aspects of the ESG score.

4.2 Alternative ESG data providers

Given the complexity of measuring ESG information, ESG ratings from different providers can disagree substantially. The validity of these ratings has been debated critically (Eccles and Stroehle (2020), Christensen, Serafeim, and Sikochi (2022), Gibson, Krueger, and Schmidt (2021), Berg, Koelbel, Pavlova, and Rigobon (2022), and Berg, Koelbel, and Rigobon (2022)). For example, Berg, Koelbel, and Rigobon (2022) find the correlation between ESG ratings from six rating providers is pretty low. They decompose the divergence into contributions of scope, measurement, and weights, where measurement contributes most of the divergence. The results indicate that research conclusions are potentially dependent on the choice of rating providers.

We perform three different robustness tests in this subsection to mitigate the concern that our empirical results are only significant based on the ESG data by a particular provider. We use ESG data from four alternative ESG rating providers: KLD, MSCI, Sustainalytics, and RepRisk. (1) KLD scores measure the firm-level social performance, including community relations, product characteristics, environmental impact, employee relations, workforce diversity, and corporate governance, which covers both the social benefits and harms of a firm.[16] (2) MSCI ESG rating identifies both ESG risks and opportunities that are most material to an industry. Within each industry, MSCI identifies industry leaders and laggards according to their exposure to ESG risks and how well they manage those risks relative to peers, and then assigns ratings accordingly. (3) Sustainalytics identifies key ESG issues for

[15]The results are not materially different when scaling the raw carbon emission using revenue, or when including Scope 2 carbon emission.

[16]KLD, formerly known as Kinder, Lydenberg, Domini and Co., was acquired by RiskMetrics in 2009. MSCI bought RiskMetrics in 2010. The data set was subsequently renamed to MSCI KLD Stats as a legacy database. We keep the original name of the data set to distinguish it from the MSCI data set.

different industry peer groups, based on an analysis of the peer group and its broader value chain, a review of companies' business models, and key activities associated with environmental and/or social impacts. It collects data via corporate disclosure, media, and NGO reporting to analyze ESG information according to key ESG issues, and assign scores accordingly. (4) RepRisk is a news-based data provider. It screens over 90,000 public sources each day, including print and online media, government bodies, regulators, and other online sources. When there are material ESG risks such as violations of international standards that can have reputational, compliance, and financial impacts on the company, RepRisk index increases.

All ratings are organized in a way that the higher the scores, the better the ESG performance (we invert the signs of the RepRisk scores, which are designed to measure risks). We include KLD because it is the data set that has been used most frequently in academic studies. We include RepRisk because it relies mainly on the news and media reporting, which has markedly different information compared to other raters that rely on a blend of data sources (Berg, Koelbel, Pavlova, and Rigobon (2022)). ASSET4, MSCI, and Sustainalytics are widely recognized and used by sustainable finance professionals.[17]

We first repeat our baseline FM regression for call and put options together using four alternative ESG data. The results are reported in columns (1) to (4) of Table 7 for call and put options together. To save space, we only report the results with all the controls used in Table 6. We find that the coefficient on ESG score is still significant for three out of four alternative ESG data. Options with higher KLD scores, Sustainalytics scores, or RepRisk scores have higher delta-hedged option returns. The coefficient on ESG score from MSCI is positive but statistically insignificantly different from zero (it is statistically significant in unreported univariate regressions). These results demonstrate that our results are not overly dependent on the choice of ESG rating providers.

ESG score from a single rater has limited information and might be noisy. Therefore, our second robustness test is to construct a combined ESG score using a simple average of available ESG scores for a particular stock. Specifically, for each ESG data provider, we sort all the stocks into deciles according to that ESG score, and assign the rank to each stock. Afterwards, we define the combined ESG score as the average of the rankings, requiring there are at least three ESG ratings available for a particular stock. This approach aggregates ESG information from different data providers, while maintaining a reasonably large sample. Using this combined ESG score, we show the results in column (5) of Table 7.

[17] These ESG data are featured in the 2019 and 2020 investor survey "Rate the Raters" by SustainAbility Institute (see https://www.sustainability.com/globalassets/sustainability.com/thinking/pdfs/sustainability-ratetheraters2020-report.pdf).

Options with higher combined ESG scores have significantly higher delta-hedged option returns.

Following Berg, Koelbel, Pavlova, and Rigobon (2022), we utilize a noise-correction procedure as our third robustness test, in which we instrument ASSET4 ESG scores with ratings of other ESG rating agencies, as in the classical errors-in-variables problem. Specifically, we use two-stage least squares regression to tackle the measurement error problem in ESG scores. The first stage regression uses the ESG scores of four alternative data providers as instruments for ASSET4 ESG score and includes the same controls as in Table 6:

$$ASSET4_{it} = \alpha + \beta_1 KLD_{it} + \beta_2 MSCI_{it} + \beta_3 Sus_{it} + \beta_4 RepRisk_{it} + \beta_4' X_{it} + e_{it}, \quad (6)$$

we run the above regression each month, where $ASSET4_{it}$ is the ASSET4 ESG score for stock i in period t. Denote $\widehat{ASSET}4_{it}$ as the fitted value from estimating equation (6). Then we run the second stage regression using standard FM regression. Column (6) in Table 7 shows the results for call and put combined results. After the correction of the ASSET4 ESG score using other ESG data providers, our results are still significant for both call and put options.

Taken together, our results are not purely driven by a particular ESG data provider, and are robust to alternative ESG data sources, though they may be noisy and contain different ESG information.

4.3 Robustness tests

Our main results are based on ATM options. To explore the effect of ESG performance on options with different moneyness, we define out-of-the-money (OTM) and in-the-money (ITM) options based on the absolute value of delta. Options with the absolute value of delta ranging from 0.2 to 0.4, from 0.4 to 0.6, and from 0.6 to 0.8 are classified into OTM, ATM, and ITM option groups, respectively. We restrict options to have the same maturity as in our main tests, viz. about 50 days. We next calculate the average value of delta-hedged returns for all options in these three categories. FM regressions of delta-hedged returns on ESG performance and other controls are reported in Appendix Table A3.[18] For call options, the effect of ESG on option return is significant across the three moneyness groups (albeit the effect is the strongest for ATM options). For put options, there is no significant effect of ESG

[18]The FM regressions in Table A3 are at the stock level. Option open interest is the average of the total number of option contracts that are divided by the stock trading volume. We calculate option level bid-ask spread as the ratio of the bid-ask spread of option quotes over the midpoint of the bid and ask quotes, and then take the average of option level bid-ask spread into stock level.

on ITM option returns but we observe the largest economic magnitude for the coefficient of ESG performance on OTM option returns. The latter fact is consistent with the argument that ESG is relevant to downside risks because OTM put options are usually used to hedge downside risks.

We also perform a placebo test. ESG investing has become increasingly important for investors only during the last two decades. We posit that prior to 2004, ESG investing influenced only a relatively small part of the investment industry, and thus its impact on option market should be much less significant. We conduct two tests for this conjecture. First, we backfill ASSET4 ESG data from 2004 to the period from 1996 to 2003 as ASSET4 ESG data are not available for the earlier sample period. We find that ESG has no significant impact on delta-hedged option gain in this earlier sample period. Second, we use the KLD data from 1996 to 2003 to repeat the placebo test, and again find insignificant results. These results support our conjecture that the significant impact of ESG on option pricing in the 2004-2018 period is related to the growing (perceived) risks associated with ESG issues.

4.4 ESG performance and different risk measures

In this subsection, we provide further evidence on how ESG performance is related to different option implied risks. Following Ilhan, Sautner, and Vilkov (2021), we use four measures of risks implied by the option prices, including VRP, MFIS, MFIK, and SlopeD.

VRP is computed as the difference between the risk-neutral expected and the realized variance (Carr and Wu (2009) and Bollerslev, Tauchen, and Zhou (2009)). As a proxy for the risk-neutral expected variance, we use the model-free implied variance $MFIV_{t,t+\tau}$ computed on day t for the period τ. The realized variance ($RV_{t,t+\tau}$) is computed from daily log returns over a future window from t to $t+\tau$, that is, with a length corresponding to the period of the options used for the risk-neutral variance. Following Ilhan, Sautner, and Vilkov (2021) and Kelly, Pástor, and Veronesi (2016), the variance risk premium $VRP_{t,t+\tau}$ for period t to $t+\tau$ is computed in the ex-post version on each day t as $(MFIV_{t,t+\tau} - RV_{t,t+\tau})$ and expressed in annual terms. It captures the cost of protection against general uncertainty-related volatility changes in down and up directions. MFIS and MFIK are constructed following Bakshi, Kapadia, and Madan (2003) and quantify the asymmetry of the risk-neutral distribution, and heaviness of the tail in the risk-neutral distribution, respectively. By being normalized, MFIS and MFIK provide information about the expensiveness of protection against left tail events and extreme events. We follow Kelly, Pástor, and Veronesi (2016) and Ilhan, Sautner, and Vilkov (2021) to calculate SlopeD. Specifically, SlopeD is the slope coefficient from regressing implied volatilities of OTM puts (deltas between -0.5 and -0.1) on the corresponding deltas and a constant. A more positive value of SlopeD indicates that deeper OTM puts are relatively more expensive, suggesting a relatively higher cost of protection against downside tail risks.

We then investigate how ESG performance is related to these risks implied from the option market, and report the results in the Appendix Table A4. VRP, MFIK, and SlopeD are negatively related to ESG performance, all significantly at 1% level. The results indicate that options of low ESG firms have higher costs of protection against uncertainty-related volatility changes, jump risks, and downside tail risks. We do not find significant results for MFIS, which captures the information about the expensiveness of protection against left tail events relative to right tail events. One possibility is that options of low ESG firms may also have upside jump opportunities (Cohen, Gurun, and Nguyen (2022)).

5 Additional cross-sectional results

So far, we have documented that ESG scores of the underlying firms affect the cross-section of option returns and there is a significant ESG premium in the options market. In this section, we further explore the heterogeneity across firms, and investigate the impact of ESG conditional on different industries, product competition intensity, investors' awareness, and corporate hedging activity. We focus on the sample that contains both call and put options together.

5.1 Different business models

The proximity to end-consumers potentially influences the impacts of ESG on the firm and further the investors' perception. The intuition is that private end-consumers or individuals show more social concerns in their consumption. End-consumers could, therefore, simply choose not to buy the products if the firm has a poor ESG performance. Such firms therefore face higher uncertainty when the ESG performance is less satisfying. Baron, Harjoto, and Jo (2011) and Curcio and Wolf (1996) find that there is a stronger impact of social performance on firms' financial performance in industries serving end-consumers than firms in other industries. Lev, Petrovits, and Radhakrishnan (2010) also find charitable contributions lead to a significant sales growth only in consumer industries.

Following these studies, we hypothesize that the impact of ESG scores on delta-hedged option returns is stronger for firms that are closer to end-consumers. To test this hypothesis, we follow Lev, Petrovits, and Radhakrishnan (2010), use four-digit SIC industry code, and classify our sample firms into two groups based on their proximity to the end-consumers. We provide details of the classification in the Appendix Variable Definitions. We then test whether the effect of social performance on option return differs between these two groups via FM regressions of delta-hedged option returns.

Panel A of Table 8 reports the regression results. CONSUMER is a dummy that equals one if a firm is in industries classified as closer to end-customers, and zero otherwise. Our focus is on the interaction term, CONSUMER×(ESG Score), which captures the incremental impact of ESG performance on option return for firms that are closer to consumers. We include the same control variables as those in Table 6 (column (6)) but do not report them in Table 8 to avoid clutter. The estimated coefficient on the interaction term is positive and statistically significant at the 5% level. Our results indicate that, among firms that are closer to the end-consumers, the social performance of the firm has a larger impact on the cross-section of option returns, in the sense that options on low-ESG, closer to the end-consumers' firms are relatively more expensive than options on low-ESG, but farther from end-consumers' firms (comparing, of course, still to options on high-ESG firms).

In addition to proximity to end-consumers, product/service differentiation can influence our documented relationship between ESG score and option returns. ESG performance is one strategy for firms to differentiate from their competitors (McWilliams and Siegel (2001), Chih, Chih, and Chen (2010)), and Cao, Liang, and Zhan (2019)). By investing in corporate social goods and differentiating from others, a firm can benefit from higher profit margins and lower risk (Albuquerque, Koskinen, and Zhang (2019)). Such benefits are particularly important for firms operating in competitive industries, as they are more vulnerable to potential risks in the future than firms in concentrated industries. We, therefore, conjecture that when the firms face more severe product competition, social performance will have a larger impact on the perceived uncertainty by a larger amount, and option pricing as well.

We use product market fluidity measure (Hoberg, Phillips, and Prabhala (2014)) as a proxy for product market competition. This measure assesses the degree of competitive threat and product market change surrounding a firm, using computational linguistics and analyzing individual firm business descriptions from 10-Ks. A higher FLUIDITY measure indicates more intense competition from peers offering similar products. Table 8 Panel A, column (2) reports the results of FM regressions for delta-hedged returns. The coefficient of interest to us is on the interaction term FLUIDITY×(ESG Score). We find that this coefficient is positive and statistically significant at the 5% level. Consistent with the product market competition and product differentiation argument, we find the impact of ESG performance on option pricing stronger for firms facing heightened competition. In summary, the results in Panel A of Table 8 indicate that the influence of ESG performance on perceived uncertainty and option pricing depends on the nature of a firm's business and its competitive landscape.

5.2 Cross-sectional variation in ESG attention

Evidence suggests that Democratic-leaning voters care more about CSR. For example, Di Giuli and Kostovetsky (2014) find that firms headquartered in Democratic party-leaning states are more likely to spend resources on CSR. Gromet, Kunreuther, and Larrick (2013) demonstrate that more politically conservative individuals are less in favor of investment in energy-efficient technology than those who are more politically liberal (see also Costa and Kahn (2013)). When the electorate is more Democratic, companies may be more susceptible to pressure from activists to adopt CSR policies (Baron (2001)). We use the political affiliation of the state where the company is headquartered as a proxy for ESG attention.

Specifically, we divide all states into two groups based on whether the Democratic candidates won in the most recent presidential election at the state level. We then construct a dummy BLUE which equals one for the firms headquartered in these states if voters predominantly choose the Democratic Party (referred to as blue states), and zero for firms headquartered in other states. We include BLUE dummy and the interaction term BLUE×(ESG Score) in FM regressions to investigate whether the effect of ESG score on option pricing differs across firms that are subject to different levels of ESG awareness due to political leaning in different states. Panel B of Table 8, column (1) shows the results. As expected, we find that the interaction term is positive and statistically significant at 5% level for calls. The evidence suggests that, when firms are headquartered in Democratic-leaning states, their option pricing is more influenced by ESG performance of the firm than those in Republican-leaning states.

Our second proxy for firm-level variation in ESG attention is proposed by Hassan, Hollander, van Lent, and Tahoun (2019).[19] They textually analyze quarterly earnings conference calls and measure the portion of contents that are devoted to environmental-related political topics as CONFENV. It is possible that some firms with poor ESG performance will attract more attention from investors during the conference calls, and one may think of it as an alternative measure of ESG performance. However, firms with good ESG performance may also draw more attention if there are ESG-related news. Empirically, we find that the correlation between CONFENV and ESG score is only −0.02. We run FM regressions of delta-hedged option return on CONFENV and its interaction with ESG score. Panel B of

[19] See also Sautner, van Lent, Vilkov, and Zhang (2022) for an alternative measure using a machine learning keyword discovery algorithm. Our results are robust to using their measure.

Table 8, column (2) shows that the coefficients on the interaction term is positive and statistically significant. These results suggest that when investors and firms discuss more about ESG-related topics during the conference calls, the effect of ESG performance on option pricing becomes stronger as investors pay more attention to these issues and are willing to pay a higher premium to hedge against heightened perceived uncertainties.

5.3 Corporate hedging activities

Next, we examine whether corporate hedging policy reduces the effect of ESG performance on option pricing. Firms can actively manage risks related to various dimensions, such as interest rate, foreign exchange, and operations. Risks because of poor ESG performance may mainly be related to firm operations, such as potential lawsuits and loss of revenue. Specific hedging policies to such risks are not readily available. However, one can infer the ability to manage ESG risk from other hedging policies. For example, if a firm is concerned about financial risk and hedges such risk using derivatives, we conjecture that such a firm is more likely to manage ESG risks as well. We test this hypothesis by dividing firms into two groups based on whether they have non-zero hedge gains/losses according to income statement data from COMPUSTAT. We define a dummy variable, HEDGER, which equals one for firms with non-zero gain/loss from hedging, and zero otherwise.[20] We run FM regressions of delta-hedged option return on HEDGER and its interaction with ESG score. Panel C of Table 8 reports the results for calls and puts, together. We find that the coefficients on HEDGER are positive. This suggests that these firms have relatively lower risk, and their options are relatively cheaper. The coefficient of interest to us is again that on the interaction term. We find it negative and statistically significant. These results indicate that, among firms with hedging activities, the effect of ESG score on option pricing is weaker, consistent with the argument that these firms may actively manage ESG risk.

6 Conclusion

With the increasing awareness of ESG issues in recent years, firms with poor ESG performances face higher uncertainty from different perspectives, such as when and how ESG-related regulatory policies will be implemented, investors' divestment policies, and fluctuations in revenues. Are such uncertainties and risks perceived by investors and priced in the

[20] Firms with hedging policy do not necessarily have gains or losses in their current income statement. Therefore, the information from the income statement is an under-identification of corporate hedging activities.

option market?

Our analysis suggests that ESG uncertainty is priced in the options market and that option prices reflect the market consensus on ESG uncertainty. Via quintile portfolio sorts, we find the magnitude of the ESG premium to be about 0.3% per month. The results are robust to alternative ESG data providers and methods of constructing option returns. All components of ESG contribute to option expensiveness. We find that this premium mainly derives from jump risks. The ESG risk premium in the options market increases when public attention to ESG issues heightens. There is, however, substantial heterogeneity across firms in multiple dimensions, such as the proximity to end-customers, product market competition intensity, investors' awareness, and corporate hedging activities.

Appendix A: Variable Definitions

Option Variables	
Daily-rebalanced Delta-hedged option return	Daily rebalanced delta-hedged option gain is the change (over the next month) in the value of a portfolio consisting of one contract of long option position and delta shares of the underlying stock, re-hedged daily. The call option delta-hedged gain is scaled by $\Delta_c S - C$ to get the delta-hedged option return, where Δ_c is the Black Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged return is defined analogously except we scale by $P - \Delta_p S$.
Monthly buy-and-hold Delta-neutral option buying till month end	For each stock at the end of the previous month, we buy one contract of call/put option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call/put option delta. The position is held for one month to compute the buy-and-hold return.
Beta-neutral straddle return	For each stock at the end of the previous month, following Coval and Shumway (2001), we select θ unit of call option and $1-\theta$ unit of put option that is approximately ATM and has maturity around one month and a half (50 days). θ is determined to make the straddle beta-neutral. The position is held for one month to compute the buy-and-hold return.
Gamma-positive Vega-neutral straddle return	For each stock at the end of the previous month, we take a long position in one beta-neutral ATM straddle with maturity around one month and a half (50 days), and (ii) a short position in y beta-neutral at-the-money straddles with maturity around two months and a half (80 days), and y is chosen so as to make the Vega of the overall strategy is zero.
Vega-positive Gamma-neutral straddle return	For each stock at the end of the previous month, we take a long position in one beta-neutral ATM straddle with maturity around two months and a half (80 days), and (ii) a short position in y beta-neutral at-the-money straddles with maturity around one month and a half (50 days), and y is chosen so as to make the Gamma of the overall strategy is zero.
IMPVAR / IMPSKEW / IMPKURT: Model-free implied risk-neutral variance / skewness / kurtosis	Following Bakshi, Kapadia, and Madan (2003), model-free implied risk-neutral variance /skewness /kurtosis is calculated for options with expiration of 50 days at the end of each month, using implied volatility of 30 days and 60 days from Volatility Surface to perform the linear interpolation.
OPTION OI	The total number of option contracts that are open at the end of the previous month and scaled by the stock trading volume of last month.
OPTION BA	The ratio of the difference between the bid and ask quotes of option to the midpoint of the bid and ask quotes at the end of previous month.

ESG Performance Measure	
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.
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).
RET212	The cumulative stock return from the prior second through the 12th month.
RET1	The stock return in the prior month.
Ln(AMIHUD)	The logarithm of the Amihud (2002) stock illiquidity measure of previous month.
INSTOWN	The percentage of common stocks owned by institutions in the previous quarter.
ANLST	The number of analysts following the firm in the previous month.
IVOL	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, as in Ang, Hodrick, Xing, and Zhang (2006).
BETA	Market beta of rolling 60-month FF-3 monthly return regressions.

CONSUMER	A dummy for stocks in the industry that are close to the end-consumers. Industry classifications are based on Sharpe (1982). The following four-digit SIC codes are assigned to each group. (1) Basic industries: 1000-1299, 1400-1499, 2600-2699, 2800-2829, 2870-2899, 3300-3399; (2) Capital goods: 3400-3419, 3440-3599 excluding 3523, 3670-3699, 3800-3849, 5080-5089, 5100-5129, 7300-7399; (3) Construction: 1500-1599, 2400-2499, 3220-3299, 3430-3439, 5160-5219; (4) Consumer goods: 0000-0999, 2000-2399, 2500-2599, 2700-2799, 2830-2869, 3000-3219, 3420-3429, 3523, 3600-3669, 3700-3719, 3751, 3850-3879, 3880-3999, 4813, 4830-4899, 5000-5079, 5090-5099, 5130-5159, 5220-5999, 7000-7299, 7400-9999; (5) Energy: 1300-1399, 2900-2999; (6) Finance: 6000-6999; (7) Transportation: 3720-3799 excluding 3751, 4000-4799; (8) Utilities: 4800-4829 excluding 4813, 4900-4999; (9) Others: all other SIC codes. Finally, firms in the "consumer goods" and "finance" sectors are classified as closer to the end-consumers.
FLUIDITY	The degree of competitive threat and product market change surrounding a firm, based on Hoberg, Phillips, and Prabhala (2014).
BLUE	Blue (referring to blue states) refers to the states if voters predominantly choose the Democratic Party.
CONFENV	Share of the conversations in the quarterly earnings conference calls that centers on risks associated with environmental-related political topic, proposed by Hassan, Hollander, van Lent, and Tahoun (2019).
HEDGER	Dummy variable equal to one if the firm has nonzero record of cash flow hedge gains/losses in COMPUSTAT.

References

Albuquerque, Rui, Yrjo Koskinen, and Chendi Zhang, 2019, Corporate social responsibility and firm risk: Theory and empirical evidence, *Management Science* 65, 4451–4469.

Amihud, Yakov, 2002, Illiquidity and stock returns: Cross-section and time-series effects, *Journal of Financial Markets* 5, 31–56.

Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, 2006, The cross-section of volatility and expected returns, *Journal of Finance* 61, 259–299.

Bakshi, Gurdip, and Nikunj Kapadia, 2003, Delta-hedged gains and the negative market volatility risk premium, *Review of Financial Studies* 16, 527–566.

Bakshi, Gurdip, Nikunj Kapadia, and Dilip Madan, 2003, Stock return characteristics, skew laws, and differential pricing of individual equity options, *Review of Financial Studies* 16, 101–143.

Bali, Turan G., and Scott Murray, 2013, Does risk-neutral skewness predict the cross-section of equity option portfolio returns?, *Journal of Financial and Quantitative Analysis* 48, 1145–1171.

Baron, David P., 2001, Private politics, corporate social responsibility and integrated strategy, *Journal of Economics and Management Strategy* 10, 7–45.

Baron, David P., Maretno Agus Harjoto, and Hoje Jo, 2011, The economics and politics of corporate social performance, *Business and Politics* 13, 1–46.

Berg, Florian, Julian F. Koelbel, Anna Pavlova, and Roberto Rigobon, 2022, ESG confusion and stock returns: Tackling the problem of noise, Working Paper.

Berg, Florian, Julian F. Koelbel, and Roberto Rigobon, 2022, Aggregate confusion: The divergence of ESG ratings, *Review of Finance* 26, 1315–1344.

Bollerslev, Tim, George Tauchen, and Hao Zhou, 2009, Expected stock returns and variance risk premia, *Review of Financial Studies* 22, 4463–4492.

Buraschi, Andrea, and Jens Jackwerth, 2001, The price of a smile: Hedging and spanning in option markets, *Review of Financial Studies* 14, 495–527.

Cao, Jie, and Bing Han, 2013, Cross section of option returns and idiosyncratic stock volatility, *Journal of Financial Economics* 108, 231–249.

Cao, Jie, Hao Liang, and Xintong Zhan, 2019, Peer effects of corporate social responsibility, *Management Science* 65, 5487–5503.

Carr, Peter, and Liuren Wu, 2009, Variance risk premiums, *Review of Financial Studies* 22, 1311–1341.

Chava, Sudheer, 2014, Environmental externalities and cost of capital, *Management Science* 60, 2223–2247.

Chava, Sudheer, Jeong Ho Kim, and Jaemin Lee, 2022, Risk, return, and environmental and social ratings, Working Paper.

Chih, Hsiang-Lin, Hsiang-Hsuan Chih, and Tzu-Yin Chen, 2010, On the determinants of corporate social responsibility: International evidence on the financial industry, *Journal of Business Ethics* 93, 115–135.

Christensen, Dane M., George Serafeim, and Anywhere (Siko) Sikochi, 2022, Why is corporate virtue in the eye of the beholder? The case of ESG ratings, *Accounting Review* 97, 147-175.

Christoffersen, Peter, Ruslan Goyenko, Kris Jacobs, and Mehdi Karoui, 2018, Illiquidity premia in the equity options market, *Review of Financial Studies* 31, 811–851.

Cohen, Lauren, Umit G. Gurun, and Quoc H. Nguyen, 2022, The ESG-innovation disconnect: Evidence from green patenting, Working Paper.

Costa, Dora L., and Matthew E. Kahn, 2013, Energy conservation "nudges" and environmentalist ideology: Evidence from a randomized residential electricity field experiment, *Journal of the European Economic Association* 11, 680–702.

Coval, Joshua D., and Tyler Shumway, 2001, Expected option returns, *Journal of Finance* 56, 983–1009.

Cremers, Martijn, Michael Halling, and David Weinbaum, 2015, Aggregate jump and volatility risk in the cross-section of stock returns, *Journal of Finance* 70, 577–614.

Curcio, Richard J., and Fran M. Wolf, 1996, Corporate environmental strategy: Impact upon firm value, *Journal of Financial and Strategic Decisions* 9, 21–31.

De Fontnouvelle, Patrick, Raymond P.H. Fishe, and Jeffrey H. Harris, 2003, The behavior of bid-ask spreads and volume in options markets during the competition for listings in 1999, *Journal of Finance* 58, 2437–2463.

Dew-Becker, Ian, Stefano Giglio, Anh Le, and Mariuss Rodriguez, 2017, The price of variance risk, *Journal of Financial Economics* 123, 225–250.

Dew-Becker, Ian, Stefano Giglio, and Bryan Kelly, 2021, Hedging macroeconomic and financial uncertainty and volatility, *Journal of Financial Economics* 142, 23–45.

Di Giuli, Alberta, and Leonard Kostovetsky, 2014, Are red or blue companies more likely to go green? Politics and corporate social responsibility, *Journal of Financial Economics* 111, 158–180.

Eccles, Robert G., and Judith C. Stroehle, 2020, Exploring social origins in the construction of ESG measures, Working Paper.

Edmans, Alex, 2011, Does the stock market fully value intangibles? Employee satisfaction and equity prices, *Journal of Financial Economics* 101, 621–640.

Fama, Eugene F., 1976, Foundations of finance, Blackwell.

Fama, Eugene F., and Kenneth R. French, 1992, The cross-section of expected stock returns, *Journal of Finance* 47, 427–465.

Fama, Eugene F., and Kenneth R. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Finance* 33, 3–56.

Fama, Eugene F., and Kenneth R. French, 2018, Choosing factors, *Journal of Finance* 128, 234–252.

Fama, Eugene F., and James D. MacBeth, 1973, Risk, return, and equilibrium: Empirical tests, *Journal of Political Economy* 81, 607–636.

Flammer, Caroline, 2021, Corporate green bonds, *Journal of Financial Economics* 142, 499–516.

Gibson, Rajna, Philipp Krueger, and Peter Steffen Schmidt, 2021, ESG rating disagreement and stock returns, *Financial Analyst Journal* 77, 104–127.

Giglio, Stefano, Matteo Maggiori, Krishna Rao, Johannes Stroebel, and Andreas Weber, 2021, Climate change and long-run discount rates: Evidence from real estate, *Review of Financial Studies* 34, 3527–3571.

Goyal, Amit, and Alessio Saretto, 2009, Cross-section of option returns and volatility, *Journal of Financial Economics* 94, 310–326.

Gromet, Dena M., Howard Kunreuther, and Richard P. Larrick, 2013, Political ideology affects energy-efficiency attitudes and choices, *Proceedings of the National Academy of Sciences* 110, 9314–9319.

Hassan, Tarek A., Stephan Hollander, Laurence van Lent, and Ahmed Tahoun, 2019, Firm-level political risk: Measurement and effects, *Quarterly Journal of Economics* 134, 2135–2202.

Hoberg, Gerard, Gordon Phillips, and Nagpurnanand Prabhala, 2014, Product market threats, payouts, and financial flexibility, *Journal of Finance* 69, 293–324.

Hoepner, Andreas G. F., Ioannis Oikonomou, Zacharias Sautner, Laura T. Starks, and Xiaoyan Zhou, 2022, ESG shareholder engagement and downside risk, Working Paper.

Hong, Harrison, and Leonard Kostovetsky, 2012, Red and blue investing: Values and finance, *Journal of Financial Economics* 103, 1–19.

Hong, Harrison, and Marcin Kacperczyk, 2009, The price of sin: The effects of social norms on markets, *Journal of Financial Economics* 93, 15–36.

Ilhan, Emirhan, Zacharias Sautner, and Grigory Vilkov, 2021, Carbon tail risk, *Review of Financial Studies* 34, 1540–1571.

Jackwerth, Jens Carsten, and Mark Rubinstein, 1996, Recovering probability distributions from option prices, *Journal of Finance* 51, 1611–1631.

Kelly, Bryan, Ľuboš Pástor, and Pietro Veronesi, 2016, The price of political uncertainty: Theory and evidence from the option market, *Journal of Finance* 71, 2417–2480.

Kim, Yongtae, Haidan Li, and Siqi Li, 2014, Corporate social responsibility and stock price crash risk, *Journal of Banking and Finance* 43, 1-13.

Lev, Baruch, Christine Petrovits, and Suresh Radhakrishnan, 2010, Is doing good good for you? How corporate charitable contributions enhance revenue growth, *Strategic Management Journal* 31, 182–200.

Mayhew, Stewart, 2002, Competition, market structure, and bid-ask spreads in stock option markets, *Journal of Finance* 57, 931–958.

McWilliams, Abagail, and Donald Siegel, 2001, Corporate social responsibility: A theory of the firm perspective, *Academy of Management Review* 26, 117–127.

Morningstar, 2020, ESG risk comes into focus. https://www.morningstar.com/features/esg-risk.

Newey, Whitney, and Kenneth D. West, 1987, A simple positive semi-definite, heteroscedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703–708.

Pástor, Ľuboš, and Pietro Veronesi, 2013, Political uncertainty and risk premia, *Journal of Financial Economics* 110, 520–545.

Pástor, Ľuboš, Robert F. Stambaugh, and Lucian A. Taylor, 2021, Sustainable investing in equilibrium, *Journal of Financial Economics* 142, 550–571.

Pedersen, Lasse Heje, Shaun Fitzgibbons, and Lukasz Pomorski, 2021, Responsible investing: The ESG-efficient frontier, *Journal of Financial Economics* 142, 572–597.

PwC, 2020, Six key challenges for financial institutions to deal with ESG risks, PwC Insights-and-Publications. https://www.pwc.nl/en/insights-and-publications/services-and-industries/financial-sector/six-key-challenges-for-financial-institutions-to-deal-with-ESG-risks.html.

Ramachandran, Lakshmi Shankar, and Jitendra Tayal, 2021, Mispricing, short-sale constraints, and the cross-section of option returns, *Journal of Financial Economics* 141, 297–321.

Sautner, Zacharias, Laurence van Lent, Grigory Vilkov, and Ruishen Zhang, 2022, Firm-level climate change exposure, *Journal of Finance*, Forthcoming.

Zhan, Xintong, Bing Han, Jie Cao, and Qing Tong, 2022, Option return predictability, *Review of Financial Studies* 35, 1394–1442.

Table 1: Summary statistics

This table reports the descriptive statistics of delta-hedged option returns and stock characteristics. In Panel A (Panel B), call (put) option delta-hedged gain is the change over the next month in the value of a portfolio consisting of one contract of long call (put) position and a proper amount of the underlying stock, re-hedged daily so that the portfolio is not sensitive to stock price movement. The call option delta-hedged gain is scaled by $(\Delta_C \times S - C)$, where Δ is the Black-Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged gain is scaled by $(P - \Delta_P \times S)$, where P is the price of put option. The resulting ratios are reported in percent per month. Moneyness is the ratio of stock price over option strike price. Days to maturity is the number of calendar days until the option expiration. Option bid-ask spread is the ratio of the difference between the bid and ask quotes of option to the midpoint of the bid and ask quotes at month end. Panel C reports the time-series average of cross-sectional statistics of stock characteristics. ESG score is the monthly updated raw score from Asset4 database and scaled by 100. Ln(ME) is the logarithm of market capitalization. Ln(BM) is the logarithm of book to market ratio. IVOL is the annualized idiosyncratic volatility computed as in Ang, Hodrick, Xing, and Zhang (2006). RET1 is the stock return in the prior month. RET212 is the cumulative stock return from the prior second through the 12th month. Ln(AMIHUD) is the logarithm of Amihud (2002) illiquidity measure of stock over the previous month. INSTOWN 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. Panel D reports the time-series average of cross-sectional correlations. The Pearson correlations are shown below the diagonal together with Spearman correlations above the diagonal. The sample period is from January 2004 to December 2018.

	Mean	Standard Deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
Panel A: Call options (51,691 observations)							
Delta-hedged gain until month end	−0.57	2.65	−3.07	−1.82	−0.72	0.43	1.96
Moneyness	1.00	0.03	0.97	0.99	1.00	1.01	1.03
Days to maturity	50	2	47	49	50	51	52
Option bid-ask spread	0.15	0.14	0.04	0.06	0.11	0.19	0.31
Panel B: Put options (51,691 observations)							
Delta-hedged gain until month end	−0.49	2.38	−2.78	−1.65	−0.64	0.41	1.85
Moneyness	1.00	0.03	0.97	0.99	1.00	1.01	1.03
Days to maturity	50	2	47	49	50	51	52
Option bid-ask spread	0.16	0.14	0.04	0.07	0.12	0.20	0.32

	Mean	Standard Deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
Panel C: Stock characteristics summary							
ESG score	0.61	0.26	0.26	0.39	0.62	0.85	0.94
Ln(ME)	9.04	1.15	7.73	8.21	8.89	9.74	10.59
Ln(BM)	−1.00	0.78	−1.93	−1.45	−0.95	−0.46	−0.08
IVOL	0.24	0.14	0.12	0.15	0.21	0.29	0.40
INSTOWN	0.77	0.16	0.57	0.68	0.78	0.86	0.93
ANLST	16.32	7.39	7.07	10.89	15.78	21.00	26.33

Panel D: Correlations

	ESG score	Ln(ME)	Ln(BM)	RET1	RET212	IVOL	Ln(AMIHUD)	INSTOWN	ANLST
ESG score		0.490	−0.011	0.000	0.011	−0.271	−0.458	−0.271	0.203
Ln(ME)	0.487		−0.165	−0.029	0.025	−0.336	−0.897	−0.381	0.525
Ln(BM)	0.003	−0.158		0.004	−0.007	0.022	0.166	−0.012	−0.173
RET1	−0.009	−0.041	0.004		0.016	0.013	0.003	0.012	−0.014
RET212	−0.032	−0.011	−0.021	0.009		−0.068	−0.100	0.009	−0.035
IVOL	−0.242	−0.312	0.012	0.064	−0.019		0.280	0.235	−0.034
Ln(AMIHUD)	−0.448	−0.905	0.173	0.013	−0.090	0.263		0.263	−0.579
INSTOWN	−0.203	−0.355	−0.009	0.008	−0.015	0.134	0.202		−0.070
ANLST	0.187	0.505	−0.162	−0.022	−0.048	−0.038	−0.562	−0.040	

Table 2: ESG premium

At the end of each month, we rank all stocks in our sample into quintiles by the ESG scores and calculate the equal-weighted average of option return for a portfolio of stocks. ESG score is the monthly updated ESG performance measure from Asset4. In Panel A, option return is daily rebalanced delta-hedged option return. In Panel B, option return is buy and hold monthly delta-hedged option return. For each stock at the end of the previous month, we buy one contract of call/put option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call/put option delta. The position is held for one month to compute the buy-and-hold return. In Panel C, option return is monthly zero-beta straddle return. For each stock at the end of the previous month, following Coval and Shumway (2001), we select θ unit of call option and $1-\theta$ unit of put option that is approximately ATM and has maturity around one month and a half. θ is determined to make the straddle beta-neutral. The position is held for one month to compute the buy-and-hold return. The 6-factor alpha is calculated from the Fama and French (2018) 6-factor model. 7-factor alpha is calculated from Fama and French (2018) 6-factor and market volatility factor, proxied by zero-beta straddle return on S&P 500 index (Coval and Shumway (2001)). All returns are in percent per month and t-statistics are in parenthesis. The sample period is from January 2004 to December 2018.

ESG score rank	Low	2	3	4	High	H−L
			Panel A. Daily rebalanced delta-hedged option returns			
			Call options			
Average return	−0.71	−0.62	−0.54	−0.49	−0.43	0.28
	(−5.67)	(−5.33)	(−4.70)	(−4.39)	(−4.26)	(6.12)
6-factor alpha	−0.68	−0.60	−0.51	−0.46	−0.41	0.26
	(−6.07)	(−5.98)	(−5.49)	(−5.05)	(−5.02)	(5.23)
7-factor alpha	−0.51	−0.43	−0.38	−0.31	−0.28	0.23
	(−3.90)	(−4.06)	(−3.44)	(−2.90)	(−2.98)	(4.09)
			Put options			
Average return	−0.66	−0.53	−0.44	−0.40	−0.34	0.32
	(−5.49)	(−4.42)	(−3.78)	(−3.46)	(−3.34)	(8.05)
6-factor alpha	−0.64	−0.50	−0.42	−0.36	−0.32	0.32
	(−5.99)	(−4.81)	(−4.33)	(−3.87)	(−3.86)	(6.72)
7-factor alpha	−0.47	−0.34	−0.29	−0.22	−0.19	0.29
	(−4.05)	(−3.05)	(−2.62)	(−2.04)	(−2.04)	(5.59)
			Call + Put options			
Average return	−0.68	−0.58	−0.49	−0.45	−0.38	0.30
	(−5.59)	(−4.92)	(−4.24)	(−3.93)	(−3.82)	(7.27)
6-factor alpha	−0.66	−0.55	−0.47	−0.41	−0.37	0.29
	(−6.06)	(−5.45)	(−4.91)	(−4.48)	(−4.48)	(6.11)
7-factor alpha	−0.49	−0.39	−0.33	−0.27	−0.23	0.26
	(−3.99)	(−3.61)	(−3.03)	(−2.49)	(−2.54)	(4.97)

ESG score rank	Low	2	3	4	High	H−L
Panel B. Buy-and-hold delta-hedged option returns						
	Call options					
Average return	−2.59	−2.45	−2.27	−2.18	−1.85	0.73
	(−17.88)	(−17.50)	(−17.14)	(−17.09)	(−15.95)	(10.70)
6-factor alpha	−2.41	−2.30	−2.10	−2.01	−1.70	0.71
	(−17.06)	(−17.34)	(−16.71)	(−17.35)	(−15.53)	(9.70)
7-factor alpha	−2.19	−2.10	−1.89	−1.76	−1.48	0.71
	(−17.91)	(−18.27)	(−18.41)	(−17.72)	(−16.32)	(9.59)
	Put options					
Average return	−2.17	−1.97	−1.83	−1.76	−1.47	0.70
	(−16.75)	(−16.41)	(−15.77)	(−15.22)	(−15.06)	(11.66)
6-factor alpha	−2.19	−2.02	−1.86	−1.78	−1.51	0.68
	(−18.60)	(−17.97)	(−17.60)	(−17.30)	(−16.04)	(10.73)
7-factor alpha	−1.98	−1.81	−1.66	−1.55	−1.30	0.68
	(−19.83)	(−19.47)	(−19.52)	(−18.54)	(−17.45)	(10.05)
	Call + Put options					
Average return	−2.38	−2.21	−2.05	−1.97	−1.66	0.72
	(−17.58)	(−17.33)	(−16.71)	(−16.46)	(−15.83)	(11.41)
6-factor alpha	−2.40	−2.26	−2.08	−2.00	−1.71	0.70
	(−19.01)	(−18.93)	(−18.22)	(−18.24)	(−16.42)	(10.31)
7-factor alpha	−2.18	−2.05	−1.88	−1.76	−1.49	0.69
	(−20.25)	(−20.52)	(−20.39)	(−19.05)	(−17.54)	(9.93)
Panel C: Zero-beta straddle returns						
Average return	−9.93	−9.55	−8.17	−7.80	−7.59	2.34
	(−9.28)	(−8.50)	(−7.26)	(−5.98)	(−6.33)	(2.89)
6-factor alpha	−9.12	−8.75	−7.65	−6.68	−6.94	2.18
	(−8.23)	(−7.65)	(−6.53)	(−4.91)	(−5.26)	(2.44)
7-factor alpha	−6.07	−5.55	−3.77	−2.25	−2.57	3.50
	(−6.42)	(−5.57)	(−3.81)	(−2.04)	(−2.99)	(4.10)

Table 3: Separate effect of E-score, S-score, and G-score

At the end of each month, we rank all stocks in our sample into quintiles by the E-score, S-score, and G-score and calculate the equal-weighted average of daily rebalanced delta-hedged option return (calls and puts together) for a portfolio of stocks in Panel A, Panel B, and Panel C, respectively. E-score, S-score, and G-score is the monthly updated ESG performance measure from Asset4. The 6-factor alpha is calculated from the Fama and French (2018) 6-factor model. 7-factor alpha is calculated from Fama and French (2018) 6-factor and market volatility factor, proxied by zero-beta straddle return on S&P 500 index (Coval and Shumway (2001)). The sample period is from January 2004 to December 2018.

ESG score rank	Low	2	3	4	High	H−L
			Panel A. E-score			
Average return	−0.70	−0.57	−0.47	−0.47	−0.38	0.32
	(−5.55)	(−5.24)	(−3.92)	(−4.20)	(−3.62)	(7.97)
6-factor alpha	−0.66	−0.56	−0.44	−0.44	−0.35	0.31
	(−5.80)	(−6.24)	(−4.51)	(−4.86)	(−4.09)	(6.51)
7-factor alpha	−0.49	−0.42	−0.30	−0.29	−0.21	0.28
	(−3.72)	(−4.63)	(−2.65)	(−2.81)	(−2.16)	(5.06)
			Panel B. S-score			
Average return	−0.68	−0.57	−0.51	−0.44	−0.38	0.30
	(−5.70)	(−4.85)	(−4.41)	(−3.87)	(−3.76)	(8.18)
6-factor alpha	−0.66	−0.55	−0.48	−0.41	−0.36	0.30
	(−6.52)	(−5.32)	(−4.99)	(−4.37)	(−4.40)	(7.32)
7-factor alpha	−0.49	−0.39	−0.33	−0.27	−0.23	0.26
	(−4.45)	(−3.35)	(−3.13)	(−2.52)	(−2.42)	(6.02)
			Panel C. G-score			
Average return	−0.61	−0.58	−0.53	−0.45	−0.42	0.19
	(−4.60)	(−4.96)	(−4.60)	(−4.17)	(−4.20)	(3.64)
6-factor alpha	−0.57	−0.55	−0.49	−0.44	−0.40	0.17
	(−4.80)	(−5.61)	(−5.42)	(−4.84)	(−4.96)	(2.79)
7-factor alpha	−0.40	−0.40	−0.34	−0.30	−0.27	0.13
	(−2.93)	(−3.83)	(−3.17)	(−2.90)	(−3.12)	(1.82)

Table 4: Volatility risk premium, jump risk premium, and ESG performance

This table reports the portfolio sorting results of volatility risk premium, jump risk premium based on ESG performance. Panels A and B report the portfolio sorting results of vega-positive, gamma-neutral straddle returns (volatility risk sensitive), and gamma-positive, vega-neutral straddle returns (jump risk sensitive), respectively. ESG score is the monthly updated ESG performance measure from Asset4. We report raw returns and alphas from 6-factor and 7-factor models. The sample period is from January 2004 to December 2018.

ESG score rank	Low	2	3	4	High	H−L
Panel A: Vega-positive, gamma-neutral (volatility risk sensitive) straddle returns						
Average return	2.12	1.55	1.31	1.25	1.93	−0.19
	(4.51)	(3.70)	(2.53)	(1.72)	(3.03)	(−0.37)
6-factor alpha	1.88	1.49	1.39	1.06	2.00	0.12
	(3.28)	(3.34)	(2.83)	(1.34)	(2.66)	(0.22)
7-factor alpha	1.26	0.92	0.37	0.02	0.53	−0.73
	(2.01)	(1.92)	(0.67)	(0.02)	(0.60)	(−1.03)
Panel B: Gamma-positive, vega-neutral (jump risk sensitive) straddle returns						
Average return	−6.54	−6.24	−4.84	−3.69	−2.30	4.24
	(−11.16)	(−10.66)	(−7.96)	(−5.24)	(−2.89)	(7.93)
6-factor alpha	−6.36	−6.04	−4.84	−3.41	−2.26	4.10
	(−9.76)	(−10.12)	(−7.32)	(−4.64)	(−2.42)	(7.49)
7-factor alpha	−4.80	−4.64	−2.78	−1.17	0.32	5.12
	(−8.64)	(−8.17)	(−4.92)	(−1.82)	(0.43)	(8.80)

Table 5: Impact of Google search index, Paris Agreement, and aggregate ESG news

This table reports the time-series regression estimates of H−L spread of daily rebalanced delta-hedged option return in the following regression.

$$R_t = \alpha_0 + \alpha_1 D_t + \beta' F_t + \varepsilon_t.$$

At the end of each month, all available options (calls and puts together) are sorted into five quintiles based on the ESG performance. H−L portfolio is constructed by buying options with the highest ESG scores and shorting options with the lowest ESG scores. In Panel A, the whole period is divided into two subperiods based on the innovation of Google search volume index of topic "ESG" D_t equals one when the innovation of Google search volume index of topic "ESG" is higher. In Panel B, D_t equals one during the Paris Agreement period (January 2016 to June 2017), and zero during 18 months before the Paris Agreement period and 18 months after the Paris Agreement period (July 2014 to December 2015, July 2017 to December 2018). In Panel C, the whole period is divided into two subperiods based on the total number of ESG news obtained from RepRisk scaled by the number of all the news from Ravenpack. D_t equals one when there are more aggregated ESG news, zero otherwise. F_t is a vector including Fama and French (2018) 6 factors in 6-factor model, and includes an extra market volatility factor in 7-factor model. To adjust for serial correlation, robust Newey and West (1987) t-statistics are reported in parentheses.

	α_0	α_1
Panel A. Impact of Google search index		
Average return	0.18	0.23
	(2.26)	(2.19)
6-factor model	0.19	0.20
	(2.59)	(2.23)
7-factor model	0.15	0.20
	(1.94)	(2.22)
Panel B. Impact of Paris Agreement		
Average return	0.14	0.37
	(1.88)	(2.57)
6-factor model	0.12	0.40
	(1.48)	(2.52)
7-factor model	0.12	0.39
	(1.46)	(2.52)
Panel C. Impact of aggregated ESG news		
Average return	0.18	0.25
	(1.99)	(2.08)
6-factor model	0.17	0.25
	(1.78)	(2.25)
7-factor model	0.16	0.23
	(1.70)	(2.10)

Table 6: Delta-hedged option return and ESG performance

Panel A reports the average coefficients from monthly FM cross-sectional regressions. The dependent variable (in percentage) is the daily rebalanced delta-hedged option gain until month end scaled by $(\Delta_C \times S - C)$ for calls and $(P - \Delta_P \times S)$ for puts. Columns (1)-(2), columns (3)-(4), and columns (5)-(6) report the results for call options, put options, call and put options together, respectively. ESG score is the monthly updated ESG performance measure from Asset4. The definitions of other control variables are reported in the supplementary appendix. All independent variables are winsorized each month at the 0.5% level. To adjust for serial correlation, robust Newey and West (1987) t-statistics are reported in parentheses. The sample period is from January 2004 to December 2018.

	Call options		Put options		Call + Put options	
	(1)	(2)	(3)	(4)	(5)	(6)
ESG score	0.293	0.198	0.207	0.143	0.260	0.178
	(2.46)	(1.82)	(2.69)	(2.04)	(2.93)	(2.23)
Ln(ME)	0.104	−0.036	0.126	0.013	0.112	−0.018
	(1.23)	(−0.48)	(2.23	(0.25)	(1.73)	(−0.32)
Ln(BM)	0.047	0.017	0.020	0.009	0.034	0.013
	(0.91)	(0.36)	(0.61)	(0.29)	(0.85)	(0.36)
RET1	0.789	0.229	−0.313	−0.500	0.29	−0.092
	(1.37)	(0.40)	(−0.92)	(−1.52)	(0.67)	(−0.22)
RET212	0.440	0.411	0.185	0.174	0.317	0.298
	(2.31)	(1.99)	(1.75)	(1.50)	(2.22)	(1.90)
IVOL	−2.341	−1.093	−1.752	−0.791	−2.059	−0.946
	(−6.72)	(−3.91)	(−8.61)	(−5.21)	(−8.29)	(−5.19)
Ln(AMIHUD)	0.050	−0.013	0.039	−0.036	0.045	−0.029
	(0.65)	(−0.19)	(0.72)	(−0.79)	(0.73)	(−0.55)
OPTION OI	−3.644	−3.209	−5.021	−4.216	−3.539	−3.036
	(−4.63)	(−4.21)	(−7.55)	(−6.39)	(−6.29)	(−5.31)
OPTION BA	−1.037	−1.233	0.469	0.403	−0.244	−0.345
	(−3.83)	(−4.25)	(2.32)	(1.77)	(−1.43)	(−2.07)
BETA		0.089		0.131		0.111
		(1.13)		(2.28)		(1.69)
IMPVAR		−2.016		−1.788		−1.928
		(−6.00)		(−8.71)		(−7.71)
IMPSKEW		−0.966		0.070		−0.445
		(−4.82)		(0.81)		(−3.73)
IMPKURT		0.101		0.132		0.113
		(1.44)		(2.59)		(2.45)
Avg adj-R^2	0.051	0.073	0.072	0.086	0.053	0.075
# obs	48,464	48,460	48,464	48,460	96,928	96,920

Table 7: Delta-hedged option return and alternative ESG scores

This table reports the average coefficients from monthly FM cross-sectional regressions for call and put options together. The dependent variable (in percentage) is the daily rebalanced delta-hedged option return until month end. ESG score in columns (1) to (4) is KLD, MSCI, Sustainalytics and Reprisk, respectively. ESG score in column (5) is a combined ESG score from Asset4, KLD, MSCI, Sustainalytics, and Reprisk. For each ESG data provider, we sort stocks into quintiles and assign the rank to the stocks. The combined ESG score is the ranking average of available ESG scores, requiring at least three measures available. ESG score in column (6) is the fitted value from the regression, which regressing Asset ESG score on KLD, MSCI, Sustainalytics, and Reprisk. The definitions of other control variables are presented in the supplementary appendix. All independent variables are winsorized each month at the 0.5% level. To adjust for serial correlation, robust Newey and West (1987) t-statistics are reported in parentheses.

	KLD (1)	MSCI (2)	Sustainalytics (3)	Reprisk (4)	Combined (5)	IV (6)
ESG score	0.031	0.021	0.511	0.007	0.070	0.147
	(4.04)	(1.64)	(2.38)	(3.71)	(2.25)	(2.07)
Ln(ME)	−0.174	−0.038	−0.034	−0.001	0.005	−0.071
	(−3.39)	(−0.48)	(−0.63)	(−0.02)	(0.09)	(−1.13)
Ln(BM)	0.065	0.061	−0.040	0.087	0.045	−0.002
	(1.86)	(1.61)	(−1.32)	(2.41)	(1.14)	(−0.06)
RET1	0.297	−0.419	−0.736	0.279	−0.227	−0.672
	(0.92)	(−1.30)	(−1.65)	(0.73)	(−0.62)	(−1.48)
RET212	0.274	−0.151	−0.051	0.025	0.035	−0.102
	(2.22)	(−0.90)	(−0.36)	(0.19)	(0.22)	(−0.69)
IVOL	−0.341	−1.181	−1.228	−0.647	−1.231	−1.228
	(−2.23)	(−4.87)	(−5.37)	(−3.81)	(−6.13)	(−4.71)
Ln(AMIHUD)	−0.155	−0.047	−0.105	−0.058	0.000	−0.121
	(−3.35)	(−0.63)	(−1.90)	(−0.91)	(0.08)	(−2.12)
OPTION OI	−3.629	−3.391	−2.498	−3.941	−3.251	−1.934
	(−7.89)	(−4.83)	(−4.05)	(−6.99)	(−6.58)	(−2.44)
OPTION BA	−0.446	−0.355	0.108	−0.339	−0.273	−0.178
	(−3.57)	(−2.14)	(0.61)	(−2.10)	(−1.97)	(−0.78)
BETA	0.263	0.211	0.060	0.218	0.189	0.072
	(4.27)	(2.58)	(1.50)	(2.92)	(1.97)	(1.74)
IMPVAR	−3.562	−1.924	−1.296	−2.558	−1.636	−1.500
	(−14.94)	(−7.64)	(−8.62)	(−14.10)	(−7.60)	(−10.30)
IMPSKEW	−0.570	−0.569	−0.428	−0.574	−0.606	−0.306
	(−4.94)	(−4.08)	(−4.78)	(−4.77)	(−4.18)	(−2.98)
IMPKURT	0.445	0.194	0.094	0.361	0.125	0.106
	(11.83)	(2.61)	(1.73)	(6.39)	(1.73)	(1.97)
Avg adj-R^2	0.088	0.092	0.073	0.086	0.083	0.084
# obs	230,538	118,664	73,998	139,792	114,092	54,420

Table 8: Product market, ESG attention, firm's hedging activity, and the impact of ESG performance on delta-hedged option returns

The table reports the average coefficients from monthly FM cross-sectional regressions for call and put options together. The dependent variable (in percentage) is the daily rebalanced delta-hedged option gain until month end. Panel A analyzes the impact of product market. CONSUMER is a dummy variable equal to one if the firm's SIC codes are from 0000-0999, 2000-2399, 2500-2599, 2700-2799, 2830-2869, 3000-3219, 3420-3429, 3523, 3600-3669, 3700-3719, 3751, 3850-3879, 3880-3999, 4813, 4830-4899, 5000-5079, 5090-5099, 5130-5159, 5220-5999, 7000-7299, 7400-9999. Fluidity data (Hoberg, Phillips, and Prabhala (2014)) is calculated based on 10-K and proxy for product market threats. Panel B analyzes the impact of ESG attention. BLUE is a dummy referring to the states of firms' headquarters whose voters predominantly choose the Democratic Party presidential candidates. CONFENV is the share of the transcript of the conference call that focuses on political risk related to environment (Hassan, Hollander, van Lent, and Tahoun (2019)). Panel C analyzes the impact of firm's hedging activity. HEDGER is a dummy variable equal to one if the firm has nonzero record of cash flow hedge gains/losses in COMPUSTAT. All regressions include control variables in Table 6 but their coefficients are not reported. ESG score is the monthly updated ESG performance measure from ASSET4. The definitions of other control variables are reported in the supplementary appendix. All independent variables are winsorized each month at the 0.5% level. We report Newey and West (1987) t-statistics in parentheses below the coefficients. The sample period is from 2004 to 2018.

Panel A. Product market

	(1)	(2)
CONSUMER×ESG score	0.168	
	(2.02)	
CONSUMER	−0.180	
	(−2.60)	
FLUIDITY×ESG score		0.033
		(2.13)
FLUIDITY		−0.031
		(−2.88)
ESG score	0.066	−0.153
	(1.20)	(−1.44)
Controls	Yes	Yes
Avg adj-R^2	0.081	0.092
# obs	96,920	94,938

Panel B. Attention to ESG		
	(1)	(2)
BLUE×ESG score	0.181	
	(2.10)	
BLUE	−0.174	
	(−2.63)	
CONFENV×ESG score		0.029
		(1.99)
CONFENV		−0.019
		(−2.14)
ESG score	−0.084	0.109
	(−0.91)	(1.54)
Controls	Yes	Yes
Avg adj-R^2	0.092	0.082
# obs	75,806	91,248

Panel C. Firms' hedging activity	
	(1)
HEDGER×ESG score	−0.145
	(−2.48)
HEDGER	0.096
	(2.37)
ESG score	0.109
	(2.33)
Controls	Yes
Avg adj-R^2	0.09
# obs	96,920

Table A1: Sample coverage

This table provides details about the stock-month sample for the underlying stocks with qualified option observations of both call and put. At the end of each month, we extract from the Ivy DB database of Option-Metrics one call and one put on each optionable stock. The selected options are approximately ATM with a common maturity of about one-and-a-half month. We exclude the following option observations: moneyness is lower than 0.8 or higher than 1.2; the option price violates obvious no-arbitrage option bounds; the reported option trading volume is zero; the option bid quote is zero or the midpoint of the bid and ask quotes is less than $1/8; and the underlying stock paid a dividend during the remaining life of the option. We exclude stocks with missing ESG scores from ASSET4 data and only retain stocks with both call and put options available after filtering. Panel A reports the time-series summary statistics and Panel B reports the time-series average of cross-sectional distributions. Panel C reports the time-series average of Fama-French twelve industry distribution for the stocks in our sample. Percent coverage of stock universe (EW) is the number of sample stocks, divided by the total number of CRSP stocks. Percent coverage of the stock universe (VW) is the total market capitalization of sample stocks divided by the total market value of all CRSP stocks. Percent in S&P500 index is the number of stocks in the S&P500 index divided by the number of stocks in the sample. The size and book-to-market percentiles are defined using the full CRSP sample. INSTOWN is the percentage of common stocks owned by institutions in the previous quarter. ANLST is the number of analysts following the firm in the previous month. The sample period is from 2004 to 2018.

	Mean	Std Dev	10th prctl	Lower qrtl	Median	Upper qrtl	90th prctl
Panel A: Time-series distribution (180 monthly observations)							
Number of stocks in the sample	287	75	200	228	297	347	383
Stock % coverage of stock universe (EW)	4.17	1.11	2.65	3.28	4.25	5.01	5.47
Stock % coverage of stock universe (VW)	25.18	5.66	17.40	21.19	25.11	29.71	32.60
Stock % traded at NYSE/AMEX	73.20	4.02	68.26	70.43	72.54	76.06	78.53
Stock % in S&P500 index	80.78	8.80	71.61	74.26	77.84	90.74	100
Panel B: time-series average of cross-sectional distributions (51,691 stock-month observations)							
Size CRSP percentile	0.91	0.07	0.81	0.87	0.92	0.96	0.98
Book-to-market CRSP percentile	0.35	0.24	0.08	0.15	0.30	0.53	0.73
INSTOWN	0.77	0.16	0.57	0.68	0.78	0.86	0.93
ANLST	16.32	7.39	7.07	10.89	15.78	21.00	26.33

Panel C: Time-series average of industry distribution

FF-12 Industry	This sample	CRSP sample	FF-12 Industry	This sample	CRSP sample
Consumer nondurables	4.90%	4.64%	Telecom	2.64%	2.87%
Consumer durables	2.27%	2.17%	Utilities	4.34%	2.49%
Manufacturing	11.52%	8.27%	Wholesale	12.26%	9.09%
Energy	6.33%	3.91%	Healthcare	8.79%	10.47%
Chemicals	4.03%	2.06%	Finance	12.55%	18.78%
Business Equipment	16.93%	15.52%	Others	13.50%	19.73%

Table A2: Fama-MacBeth regressions of delta-hedged option return on ESG performance and carbon intensity

This table reports the average coefficients from monthly FM cross-sectional regressions. The dependent variable (in percentage) is the daily rebalanced delta-hedged option (calls and puts together) gain until month end. Carbon intensity is the Scope 1 carbon emission obtained from Trucost scaled by the market value of the firm. ESG score is the monthly updated ESG performance measure from ASSET4. The definitions of other control variables are reported in the supplementary appendix. All independent variables are winsorized each month at the 0.5% level. To adjust for serial correlation, robust Newey and West (1987) t-statistics are reported in parentheses. The sample period is from January 2004 to December 2018.

	(1)	(2)
Carbon intensity	−0.034	−0.029
	(−3.01)	(−2.12)
ESG score	0.597	0.219
	(8.35)	(2.58)
Ln(ME)		−0.044
		(−0.86)
Ln(BM)		0.039
		(0.94)
RET1		0.093
		(0.21)
RET212		0.312
		(1.94)
IVOL		−1.023
		(−5.48)
Ln(AMIHUD)		−0.050
		(−0.95)
OPTION OI		−2.967
		(−5.26)
OPTION BA		−0.479
		(−2.62)
BETA		0.128
		(1.81)
IMPVAR		−1.852
		(−7.46)
IMPSKEW		−0.395
		(−3.49)
IMPKURT		0.142
		(2.92)
Avg adj-R^2	0.011	0.084
# obs	92,386	89,484

Table A3: Fama-MacBeth regressions of delta-hedged option return on ESG performance: Different moneyness

This table reports the average coefficients from monthly FM cross-sectional regressions for options with different maturities. We define OTM, ATM, and ITM option groups based on the absolute value of delta: OTM ($0.2 < |\Delta| \leq 0.4$) ATM ($0.4 < |\Delta| \leq 0.6$), ITM ($0.6 < |\Delta| \leq 0.8$) The selected options have a common maturity of about one and a half month. Delta-hedged option return (in percentage) is defined as the daily rebalanced delta-hedged option gain until month end. The dependent variable is the average value of delta-hedged option returns for all options in these three categories. ESG score is the monthly updated ESG performance measure from ASSET4. The definitions of other control variables are reported in the supplementary appendix. All independent variables are winsorized each month at the 0.5% level. We report Newey and West (1987) t-statistics in parentheses below the coefficients. The sample period is from 2004 to 2018.

	OTM	ATM	ITM
ESG score	0.141	0.160	0.124
	(1.94)	(2.67)	(1.99)
Ln(ME)	−0.068	−0.079	−0.088
	(−1.02)	(−1.60)	(−2.23)
Ln(BM)	0.008	0.013	0.012
	(0.23)	(0.44)	(0.51)
RET1	−0.131	0.149	0.348
	(−0.39)	(0.49)	(1.30)
RET212	0.160	0.184	0.240
	(0.99)	(1.29)	(2.16)
IVOL	3.622	1.548	0.916
	(4.90)	(2.47)	(1.74)
Ln(AMIHUD)	−0.038	−0.043	−0.050
	(−0.70)	(−1.08)	(−1.51)
OPTION OI	−2.026	−1.346	−0.595
	(−3.55)	(−3.92)	(−1.49)
OPTION BA	−0.311	−0.627	−1.993
	(−1.84)	(−2.55)	(−4.62)
BETA	0.051	0.071	−0.024
	(1.00)	(1.86)	(−0.69)
IMPVAR	−6.862	−4.266	−2.629
	(−9.33)	(−8.39)	(−6.79)
IMPSKEW	−0.580	−0.271	−0.048
	(−4.08)	(−2.38)	(−0.63)
IMPKURT	−0.021	0.068	0.006
	(−0.21)	(1.43)	(0.13)
Avg adj-R^2	0.081	0.081	0.067
# obs	99,371	89,367	68,509

Table A4: Fama-MacBeth regressions of different risks on ESG performance
This table reports the average coefficients from monthly FM cross-sectional regressions for VRP, MFIS, MFIK, and SlopeD. VRP is a measure of the variance risk premium. MFIS is a measure of the model-free implied skewness. MFIK is a measure of the model-free implied kurtosis. SlopeD measures the steepness of the function that relates implied volatility to moneyness (measured by an option's Black-Scholes delta) for OTM put options with 30 days maturity. ESG score is the monthly updated ESG performance measure from Asset4. The definitions of other control variables are reported in the supplementary appendix. All independent variables are winsorized each month at the 0.5% level. We report Newey and West (1987) t-statistics in parentheses below the coefficients. The sample period is from 2004 to 2018.

	VRP (1)	MFIS (2)	MFIK (3)	SlopeD (4)
ESG score	−1.409	−0.959	−11.482	−4.796
	(−4.08)	(−0.81)	(−6.00)	(−10.28)
Ln(ME)	−0.338	−4.053	−1.678	−0.019
	(−1.41)	(−7.78)	(−1.20)	(−0.05)
Ln(BM)	0.343	0.171	7.908	1.182
	(2.81)	(0.74)	(11.79)	(7.93)
RET1	4.379	−17.985	13.791	6.113
	(3.29)	(−8.02)	(2.10)	(3.87)
RET212	−0.320	−3.731	−2.518	2.208
	(−0.97)	(−5.24)	(−1.07)	(3.59)
IVOL	0.649	68.907	−531.44	−88.451
	(0.19)	(10.13)	(−14.27)	(−7.81)
Ln(AMIHUD)	0.901	−0.127	15.424	5.247
	(3.42)	(−0.30)	(10.00)	(7.43)
BETA	−0.639	0.761	−19.618	−2.197
	(−2.92)	(1.82)	(−12.91)	(−6.45)
Avg adj-R^2	0.097	0.047	0.132	0.161
# obs	114,852	114,852	114,852	114,852