Unlocking ESG Premium from Options*

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Abstract

We find that option expensiveness, as measured by implied volatility, is higher for low-ESG stocks, showing that investors pay a premium in the option market to hedge ESG-related uncertainty. Using delta-hedged option returns, we estimate this ESG premium to be about 0.3% per month. All three components of ESG contribute to option pricing. The effect of ESG performance heightens after the announcement of Paris Agreement, after speeches of Greta Thunberg, and in the aftermath of Me-Too movement. We find that investors pay ESG premium to hedge volatility, jump, and other higher moment risks. The influence of ESG on option premia is stronger for firms that are closer to end-consumers, facing severer product competition, with higher investors' ESG awareness, and without corporate hedging activity.

Keywords: ESG, implied volatility, delta-hedged option return

JEL Classification: G12, G14, G41, M14

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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 affect firms' risks including systematic, downside, and crash risks.[1] However, less is understood about the pricing of these risk.

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 forward-looking market's perception. Ilhan, Sautner, and Vilkov (2021, henceforth ISV) also use risk-neutral quantities extracted from options to study the pricing of carbon risks. Options (returns, suitably delta-hedged) also allow us to isolate the pricing impact of ESG uncertainty due to hedging and not be confounded by the risk premia, if any, due to ESG on the underlying.

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

[1] See for example, Albuquerque, Koskinen, and Zhang (2019), Hoepner, Oikonomou, Sautner, Starks, and Zhou (2020), 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 social performance (see also Chava (2014) and Chava, Kim, and Lee (2021)). Pástor, Stambaugh, and Taylor (2020) and Pedersen, Fitzgibbons, and Pomorski (2020) show that the effect of ESG performance on stock prices is theoretically ambiguous.

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 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 implied volatility (*ImpVol*). Although derived from Black-Scholes formulas, *ImpVol* is essentially a rescaled version of the option price.[3] As such, all risks that investors deem material for option pricing are embedded in *ImpVol*. Our hypothesis is that low ESG score magnifies the risks that option investors care about and leads options on such stocks to be more expensive compared to those on high-ESG stocks. Our baseline panel results do indicate that low ESG score is associated with higher *ImpVol*. Thus, the first look at the data indeed reveals that investors pay a premium to hedge against uncertainty associated with poor ESG performance.

Towards the goal of establishing causality, we explore whether the impact of ESG score gets amplified in three quasi-natural experiments. First, we look at the impact of Paris Agreement (PA hereafter) on option pricing of low- and high-ESG stocks. 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. We find that the difference in *ImpVol* between low- and high-ESG firms jumps from 10.2% to 16.7% just after the PA is announced. This difference reverts to around 10.0% after Donald Trump's announcement of withdrawal from the PA. Second, we look at ten speeches of Greta Thunberg, a Swedish environmental activist, who is internationally known for challenging world leaders to take immediate actions against climate changes. Greta's speeches provoke the public attention to ESG issues and the spread in *ImpVol* between low- and high-ESG stocks widens

[3] *ImpVol* is often used as market's estimate of future volatility. However, it is only a risk-neutral measure of forward-looking volatility and also reflects various kinds of risks pertinent to option pricing.

in a short window around her speeches. Our third experiment focuses on the impact of social issues, in contrast to environmental and climate issues in the first two experiments. Specifically, we analyze the impact of Me-Too movement, which is a social movement against sexual abuse and sexual harassment. We find that the difference in *ImpVol* between low- and high-ESG firms increases from 11% to 15% in a window of 20 days around October 15th, 2017, when American actress Alyssa Milano posted the term on Twitter, arguably for the first time that the term got an extraordinary amount of attention.

Note that a relation between *ImpVol* and ESG score is only suggestive evidence on the existence of ESG premium in the options market. This is because *ImpVol* comprises not only the various risk premia relevant for option pricing but also market's expectation (albeit risk-neutral) about future volatility. Therefore, our main tool to formally quantify the option pricing effects of ESG score is 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. The delta-hedge is rebalanced daily so that the portfolio is not sensitive to stock price movements. Using Fama and MacBeth (1973) regressions (FM regressions henceforth), we find that lower ESG scores are associated with lower delta-hedged option returns, suggesting relatively more expensive option prices, even after controlling for common determinants of 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.

If our hypothesis is correct, then the effect of ESG on option pricing should increase when there are time-series or cross-sectional shocks to ESG. Therefore, to mitigate endogeneity concerns, we perform two difference-in-differences (DiD) tests. First, we find that the effect of ESG score on the delta-hedged option return is significantly stronger during the PA period (January 2016 to June 2017), when there are more (potential) stringent regulations against poor ESG performance. Second, we investigate multiple shocks to firm-level ESG risk as another quasi-natural experiment to study the robustness of ESG premium in the option market. To identify shocks to firm-level ESG risk, we rely on RepRisk, which is a news-based data provider. RepRisk identifies relatively short-term ESG risk shocks and creates a composite index (RepRisk Index, RRI). We use RRI trend (difference in the RRI between current date and 30 days ago) to identify sudden decreases in firms' ESG performance.[4] We find control firms by matching according to firm fundamentals. We find that options of treated firms that experience sudden increases in ESG risk become more expensive indicated by a drop in delta-hedged option return compared with matched control firms. The results show that when investors trade options, they not only care about the long-term ESG performance (which are relatively stable), but also consider the short-term ESG risk, and price the options accordingly.

Do all the three components of ESG contribute to the relation between ESG scores and option returns? Since some of our experiments (the PA and Greta Thunberg's speeches) are more relevant for environmental issues, one concern might be that our results derive mostly from the 'E' part of ESG. To check whether this is the case, 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. In FM regressions, 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. DiD tests using separate (our own constructed) RRI index for E, S, and G confirm that the effect of environmental risks and social risks are stronger compared to that of governance risks. As a final check, to disentangle the effect of carbon tail risk (ISV (2021)) from broader ESG risks, we run FM regression of delta-hedged option returns on both ESG score and carbon emission score. We find that the ESG score plays an important role even after controlling carbon emission score, indicating that our results are not merely driven by carbon emission intensity of the firm, but depend on other aspects of ESG score as well.

[4] Large jumps in RRI are most likely due to severe ESG-related risk incidents, which are endogenous outcomes of firms' operations and strategies. However, one cannot predict the exact timing of such ESG risk incidents. We make use of such exogenous variation in timing as quasi-natural experiment and rely on multiple firm ESG risk shocks to alleviate concerns of omitted variables.

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. To 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, same as those we use in the FM regressions. 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 three different types of option returns. The magnitude of the risk premium using daily-rebalanced delta-hedged returns is around 0.3% per month (similar to the estimates from FM regressions). 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.

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. We calculate model-free option implied variance, skewness, and kurtosis following Bakshi, Kapadia, and Madan (2003). In FM regressions, we find that low ESG score is significantly related to higher expected volatility and jump risks, indicating that poor ESG performance magnifies both kinds of risks.

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 FM regressions and portfolio sorts, we find a positive relationship between ESG and returns to vega-positive, gamma-neutral straddles (portfolios exposed to volatility risk) and gamma-positive, vega-neutral straddles (portfolios exposed to tail risk). As a final test, we control for the model-free option implied risk measures in our baseline FM regressions to examine whether they can explain the positive relationship between delta-hedged option returns and ESG scores. We find that ESG scores are still significant in explaining option returns even after controlling for proxies of these risks (although delta-hedged put option returns weaken after the addition of these controls). The evidence, therefore, suggests that extra higher moment risks related to ESG performance are priced in the options, in addition to volatility and jump risks.

Does higher perceived uncertainty for low-ESG stocks impact the net demand from option end-users? By utilizing signed option trading volume data from International Securities Exchange (ISE), we find that the net demand from end-users of low-ESG options is higher than that of high-ESG options. This is consistent with our main hypothesis that investors perceive higher uncertainty for low-ESG stocks and accordingly pay a premium via higher option prices to hedge against these uncertainties. Alternatively, it is possible that some investors with lottery preferences might buy call options of low-ESG stocks (Blau, Bowles, and Whitby (2016), and Byun and Kim (2016)) for speculative (meaning non-hedging) purposes such as betting on the upside opportunities of low-ESG stocks. The excess demand for low-ESG (call) options could also partly explain, based on the demand-based option pricing theory (Gârleanu, Pedersen, and Poteshman (2009)), why options on stock with low ESG scores are more expensive than those on stocks with high ESG scores. Our results cannot separate out these two mutually co-existent explanations and are consistent with both. However, results discussed next on economic channels lead us to favor more the explanation based on hedging motives.

We next turn our attention 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 firms' 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, options on 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 ESG premium is through cross-sectional variation in investors' attention on ESG. We use two different methods to capture this attention. The first proxy is the political affiliation (Democratic vs. Republican) of the state where the company is headquartered, because evidence suggests Democratic-leaning voters care more about social performance 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, ours is the first paper that formally investigates the effects of ESG performance on risk premia in 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 social performance (see also Chava (2014)). Flammer (2015, 2021) document positive effects of CSR and green bond issuances on firm value. We complement these studies by exploring ESG premium in relatively under-studied derivatives markets and show that option investors pay a premium in 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), Cao, Han, Zhan, and Tong (2021), 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 performance on option pricing and explores several potential underlying economic channels.

The study most closely related to ours is ISV (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 three 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.[5] The evidence from the Me-Too movement and other cross-sectional analyses also show that the social component is a nonnegligible component that amplifies the impact of ESG on option pricing. Second, ISV'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). ISV 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 and possibly to higher-order moment 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. Third, we provide additional evidence on ESG premium by studying end-user demand and analyzing cross-sectional differences in firms to pin down economic channels.

The rest of the paper proceeds as follows. Section 2 describes our data and measures. We present our baseline results using *ImpVol* and delta-hedged option returns in Section 3. Section 4 formally quantifies the ESG premium and investigates the sources of this premium. 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.[6] These data provide objective, relevant, and systematic ESG information based on 250+ key performance indicators and 750+

[5] Our results are robust to controlling for carbon emission measures.
[6] Asset4 was acquired by Thomson Reuters in 2009 and it now goes by the name Thomson Reuters ESG Scores. However, since the name Asset 4 is widely known, we use the old name for simplicity.

individual data points, from three pillars.[7] Asset4 provides data on more than 3,000 firms globally, covering major indexes. In the U.S., Asset4 covered firms in the S&P 500 index only at the beginning of the sample period and expanded to firms in the Russell 1000 index in the later period.

We obtain the data on U.S. 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 market conventions. We also extract implied volatility information from OptionMetrics Volatility Surface, which contains implied volatilities for options with fixed time to expiration and deltas constructed using interpolation.

Stock returns, price, 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.[8] 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

[7] Raw Asset4 score ranges from 0 to 100. To make the interpretation of regression coefficients easier, we divide the raw Asset4 score by 100.

[8] 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 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 close-to-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 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 cofounded 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 Cao, Han, Zhan, and Tong (2021). 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 measure the 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:

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

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.[9]

Panel 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), 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 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 social performance on option market.[10] Panel D of

[9] We obtain similar results when we scale the delta-hedged option gains by the initial price of the underlying stocks or that of options.
[10] Another popular ESG database used in the literature is MSCI KLD, which has larger sample coverage. However, MSCI KLD ESG score is updated annually, is sticky over time, and has a smaller cross-sectional deviation as the distribution is clustered around zero.

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. Impact of ESG on option implied volatility and delta-hedged returns

3.1. Option implied volatility

Our main goal is to study whether ESG uncertainty is priced in options. As suggestive initial evidence, we start our analysis by examining the relation between corporate ESG performance and option *ImpVol*, which can be considered as a normalized option price. For a given stock at each month end, we define *ImpVol* as the average of ATM call and put implied volatility, by using options with a delta of 0.5 for call and −0.5 for put. We focus on options with 30 days of maturity since short-term options are traded more frequently and with lower effective transaction costs. It is important to note that *ImpVol* reflects not only the market's expectation of future volatility (thus being a proxy for perceived uncertainty) but also embeds different kinds of option risk premia (for example volatility risk premium). Thus, while *ImpVol* does not allow us to gauge the economic magnitude of ESG premium, it is an intuitive way to demonstrate the expensiveness of options related to ESG. We aim to provide some causal evidence on ESG score and perceived uncertainty in this subsection. To do so, we provide visual evidence in this subsection and more rigorous analysis in the Internet Appendix using three quasi-natural experiments.

First, we analyze the impact of the PA (Paris Agreement) on pricing of perceived uncertainty for low-ESG stocks. 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. We divide stocks into five groups based on ESG score and examine the difference in *ImpVol* between low- and high-ESG stocks. Figure 1 plots the difference in *ImpVol* between low- and high-ESG quintile stocks from January 2013 to December 2018. This figure shows that the difference increases suddenly in January 2016, from 10.2% to 16.7%, just after the PA is announced. During this period, when the U.S. is committed to making finance flows consistent with a low greenhouse gases (GHG) emissions and climate-resilient pathway, ESG risks are more likely to be materialized and are indeed reflected in the higher option prices. For example, stocks with poor ESG performance may face a higher uncertainty through carbon tax, or environmentally friendly policies. In contrast, the difference in *ImpVol* between the low- and the high-ESG groups drops to the level around 10.0% after Donald Trump's withdrawal decision from the PA in June 2017, because the future ESG risks are less likely to be materialized.

Second, we analyze the impact of speeches by Greta Thunberg on ESG risk. Greta is a Swedish environmental activist, who is internationally known for challenging world leaders to take immediate actions against climate changes. We select ten well known speeches by Greta. We plot the difference in *ImpVol* between low- and high-ESG firms in a window of 20 days around the speeches in Figure 2. While such difference is positive for the entire window, visual inspection shows that the difference increases in days after Greta's speeches, is the highest on the fourth day after her speeches, and gradually decreases after that. Indeed, Greta's speeches provoke the public attention to ESG issues and the spread in *ImpVol* between low- and high-ESG stocks widens in a short period. Although these speeches may have a limited long-term impact, yet the evidence complements our hypothesis that suddenly increased awareness, or increased attention of ESG issues has a positive impact on the perceived uncertainty and/or its pricing in the option market.

Third, we analyze the impact of Me-Too movement on ESG risk. Me-Too is a social movement against sexual abuse and sexual harassment. The term "Me-Too" was initially used in 2006 on Myspace and began to spread rapidly as a hashtag on October 15th, 2017, when it was quoted by American actress Alyssa Milano on Twitter.[11] On the same day, it had been tweeted more than 200,000 times on Twitter and used by more than 4.7 million people during the first 24 hours on Facebook. We use this Me-Too movement as a shock to the ESG awareness, especially social awareness, and test how perceived ESG uncertainty changes around October 15th.[12] We plot the difference in *ImpVol* between low- and high-ESG firms in a window of 20 days around October 15th in Figure 3. The effect is surprisingly large, that *ImpVol* difference increases from around 11% to around 15% in a very short window. Different from Greta's speech which provokes the public attention on *climate* changes, the Me-Too movement mainly raises the public awareness on *social* issues.

In the Internet Appendix, we formally test the effects of the PA, Greta's speeches, and the Me-Too movement on the difference in *ImpVol* between low and high-ESG firms. We confirm

[11] On October 15, 2017, American actress Alyssa Milano posted on Twitter, "If all the women who have been sexually harassed or assaulted wrote 'Me too' as a status, we might give people a sense of the magnitude of the problem," saying that she got the idea from a friend. A number of high-profile posts and responses from American celebrities soon followed.

[12] There are many follow-up events related to Me-Too movement. We believe that October 15th was the first day with a sudden increase of public's attention. Therefore, we choose this day as the event day.

that 1) sudden increased awareness and attention of environmental and social issues increase investors' perception of uncertainty resulting in more expensive options; and that 2) such increase in attention has no effect on perceived future firm fundamentals.

3.2. Delta-hedged option returns

3.2.1. Baseline results

To better understand the pricing implications of ESG performance, we turn to delta-hedged option returns. Specifically, we 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. The 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 is the total number of option contracts that are open at the end of previous month and is scaled by the stock trading volume of last month. 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 the end of previous month.

We tabulate the results in Panel A of Table 2. Column (1) reports the univariate regression of delta-hedged option returns on the underlying stock's ESG score. The coefficient on ESG is 0.706 (t-statistic = 7.76). This coefficient shows that delta-hedged call returns increase by 0.32% each month from 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 −0.57%, the economic significance of ESG on option returns is substantial. After adding different control variables, the effect of ESG score drops by approximately half, but is still statistically significant, as shown in columns (2) and (3). Columns (4) to (6) report the results for put option. These results are broadly similar to those for calls.

3.2.2. The effect of public awareness

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 of ESG, which is proxied by Google Search Volume Index (SVI). Specifically, we divide our sample into three sub-periods based on the logarithm of monthly Change in the Google Search Volume Index (DGSVI) of "Environmental, social and corporate governance."[13] We run FM regression for high awareness (top tercile DSVI) and low awareness (bottom tercile DSVI) subperiods separately and test the difference in the marginal effects of ESG on delta-hedged option returns.

As reported in Panel B Table 2, the impact of ESG on call option pricing (0.646, *t*-statistic = 2.62) is more pronounced when there is a high DSVI of "ESG" topic, compared with that (−0.107, *t*-statistic = −0.35) when the DSVI of "ESG" topic is low, leading to a difference of 0.752, significant at the 5% level. We document similar results when we replace the dependent variables with delta-hedged put option returns. These results are in line with our hypothesis that the perceived high uncertainty for firms with low ESG performance increases with public awareness of ESG issues.

3.2.3. Difference-in-differences tests

Even though we study option returns (difference in option prices, suitably delta-hedged), there could be concerns of endogeneity. For example, some unobservable variables correlated with ESG performance may also be important for perceived uncertainty and/or option returns. Alternatively, firms may learn from option prices and adjust their ESG performance accordingly. To mitigate these kinds of endogeneity concerns, we perform two DiD tests.

A. Paris Agreement

We again utilize the PA as an event that magnifies the ESG risk and related costs. We investigate how the relationship between ESG performance and option prices changes in three sub-periods: Before-PA (July 2014 to December 2015), In-PA (January 2016 to June 2017), and After-PA (July 2017 to December 2018). We run FM regressions with the same control variables as those in Table 3 for each of the three sub-periods. Our focus is the difference in the coefficients on ESG across the three sub-periods.

Panel C of Table 2 tabulates the results. For expositional purposes, we report only the coefficient on ESG score. We find that the effect of ESG on delta-hedged option return is strongest during the sub-period when PA is effective and becomes statistically insignificant after President Trump's announcement to withdraw from the PA. The ESG coefficient during the In-PA period (0.43, *t*-statistic = 2.22) is statistically different from that during the After-PA period (−0.15, *t*-

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

statistic = −1.18). It is worth noting that sample period in each regression is quite short. Despite this, the differences in ESG coefficients across sub-periods are economically and statistically significant. The last three columns of Table 2 Panel C show similar results for put options. We again find the highest and positive ESG coefficient during the In-PA period. The differences in coefficients across the sub-periods are also large, albeit statistically not different from zero.

B. Firm-level ESG risk shocks

ESG scores are quite stable over time and are likely to be correlated with other characteristics of the firm. Moreover, one major information source for evaluating the ESG performance is voluntary disclosure, which could be endogenous. Therefore, in this subsection we use RepRisk, a news-based data provider to identify sudden increases to ESG risk and investigate how option market reacts to those shocks. RepRisk uses RepRisk Index (RRI) to estimate ESG risk. RepRisk screens daily over 90,000 public sources, 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, RRI increases. We use RRI trend, which is the difference in RRI between the current date and that of 30 days ago, to identify sudden increases in firms' ESG risk.[14]

Identification based on changes in RRI is not perfect because large jumps of RRI are due to severe ESG-related incidents, which are endogenous outcomes of firms' operations and strategies. Nevertheless, one cannot predict the exact timing of such ESG risk incidents. We make use of such exogenous variation in time as quasi-natural experiments and rely on multiple shocks to firm ESG risk to alleviate concerns of omitted variables. In particular, for each treated stock (for which RRI increases), we identify control stocks via propensity score matching according to size, book to market ratio, reversal, momentum, and idiosyncratic volatility. We expect that options of treated firms that experience sudden increase in ESG risk will become more expensive (indicated by a drop in delta-hedged option return) compared with those of matched control firms after the events.

The main specification of the DiD test is:

[14] We use a cutoff of 16 to identify events of large increases in RRI. The results become stronger (weaker) if we use a relatively higher (lower) cutoff. We also use cutoff of 12 and 20 to identify events with sudden increase of ESG risk. These results are qualitatively similar to the ones presented in this sub-section.

$$R_{it+1} = \alpha + \beta_1 Treated_{it} \times Post_{it} + \beta_2 Treated_{it} + \beta_3 Post_{it} + \beta_4 X_{it} + \gamma_t + \theta_i + e_{it+1}, \quad (2)$$

where R_{it+1} is the delta-hedged option return, $Treated_{it}$ is a dummy variable equals one for treated stocks, and zero for control firms. The event window is from three months before the event to three months after the event. $Post_{it}$ is a dummy variable that is equal to one after the events, and zero otherwise. Since we have limited events each month, we rely on panel regressions instead of FM regressions. We add firm and time fixed effects and cluster standard errors by firm.

Panel D of Table 2 shows the results, columns (1) to (3) for call options and columns (4) to (6) show the results for put options, respectively. Column (1) shows that after a sudden increase of ESG risk, monthly call option return of treated firms drops by 0.34% compared with that for the control group. The magnitude of the coefficient barely changes after including control variables. The results are very similar for put options.

3.3. 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 run FM regressions similar to those in Table 2 Panel A, except that the key independent variable is E-score, S-score, and G-score, respectively. Panel A of Table 3 shows that delta-hedged option returns are higher for firms with higher E-score, S-score, or G-score, indicating that all three aspects of ESG contribute to the positive relationship between delta-hedged option return and ESG performance. Turning to economic significance, one standard deviation increase in E-score, S-score, and G-score is associated with an increase of 0.11%, 0.08%, and 0.04% in delta-hedged call option return after various controls, respectively.[15] Nevertheless, comparisons across three scores show that the E-score and the S-score are stronger determinants of option returns than the G-score.

As an additional check, we again rely on RepRisk to identify sudden increases in firms' E-, S-, and G-related risks to address potential endogeneity concerns. Since RepRisk does not provide separate RRI for environmental risks, social risks, and governance risks, we now utilize the number of news related to different types of risks reported by RepRisk. Taking environmental risk as an

[15] The standard deviation of E-score, S-score, and G-score is 0.31, 0.28 and 0.15, respectively.

example, each month, we count the total number of news related to environmental issues, such as impacts on landscapes, ecosystems, and biodiversity, local pollution, and waste issues. Then we calculate the news changes from month to month, and a firm is identified as a treated firm, if the environmental related news change in a month is larger than 30.[16] We follow the same procedure to identify firms with sudden increase of social risks and governance risks.[17] Then we use propensity score matching based on size, book to market ratio, reversal, momentum, and idiosyncratic volatility, to find the control groups.

The results of DiD tests using panel regressions are reported in Panel B of Table 3. We find that changes in all three types of ESG risks are incorporated in option prices. Options of treated firms that experience sudden increases in environmental, social, or governance risks become more expensive compared to matched control firms after the events. Consistent with FM regression results in Table 3 Panel A, the effects of environmental risks and social risks are stronger compared to that of governance risks.

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 of much of recent attention in academic literature. For example, ISV (2021) find that option-implied tail risks are larger for firms with more carbon-intense business models. The driver of our results is not only environmental performance, which is related to but covers more than carbon emission, but also social performance and governance performance.

Nevertheless, to disentangle the effect of climate risks from broader ESG risks, we run FM regression of delta-hedged option return on both ESG performance and carbon emission score. Carbon emission score is obtained from MSCI ESG rating, and a carbon emission score is given to each firm since 2007, on a scale of zero to ten. Companies with better performances, or lower carbon emissions on this issue have higher scores. The score is adjusted by industry and is thus comparable for two firms from different industries. We report the results of regressions controlling for carbon emission score in Appendix Table A2. Columns (1) and (5) show the univariate

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[16] We choose 30 as the cutoff so that treated firms do experience significant increase in risk and the number of treated firms is not too small. Using this cutoff, in the sample with non-zero change of news, 17%, 21%, and 25% of the firm-month observations are identified to have a sudden increase for environmental risk, social risk, and governance risk. After propensity score matching, 396, 341, and 443 treated events are identified for sudden increase of environmental risks, social risks, and governance risks, respectively.

[17] Examples of social issues are discrimination in employment, social discrimination, impacts on communities, and local participation issues. Examples of governance issues are anti-competitive practices, executive compensation issues, fraud, and tax optimization.

regression results for carbon emission score on call and put option prices. Consistent with higher tail risks documented by ISV (2021), we find that firms with more carbon-intense business model have more negative delta-hedged option returns. However, when we add ESG score in the regression, the effect of carbon emission score is no longer significant. In contrast, ESG score still plays an important role after controlling carbon emission score. This evidence indicates that our results are not purely driven by carbon emission intensity of the firm but also depend on other aspects of ESG score.

3.4. 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 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 on ITM option returns but we observe the largest economic magnitude for 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.

4. ESG premium

4.1. Portfolio sort results

We turn next to quantifying the ESG premium, using portfolio sorts. 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., and used in FM regressions in Section 3.2. This measure is

[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 bid-ask spread of option quotes over the midpoint of bid and ask quotes, and then take the average of option level bid-ask spread into stock level.

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 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 (Goyal and Saretto (2009) and Bali and Murray (2013)). The return of the buy-and-hold delta-hedged option is:

$$HPR_{t+1} = \frac{H_{t+1}}{H_t} - 1 = \frac{\left(C_{t+1} - \Delta_{c,t} S_{t+1}\right) \text{ or } \left(P_{t+1} - \Delta_{p,t} S_{t+1}\right)}{H_t} - 1, \tag{3}$$

where the initial investment cost H_t is $\left(\Delta_{c,t} S_t - C_t\right)$ 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 market 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 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:

$$\begin{gathered} r_v = \theta r_c + (1 - \theta) r_p \\ \theta \beta_c + (1 - \theta) \beta_p = 0, \end{gathered} \tag{4}$$

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:

$$\beta_c = \frac{S}{C} \Delta_c \beta_s, \tag{5}$$

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

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. 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 (Coval and Shumway (2001) and Carr and Wu (2009)), 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 4, respectively.

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, where daily-rebalanced delta-hedged call option returns are of interest, the 6-factor alpha of quintile one (five) portfolio is −0.68% (−0.41%), leading to a H−L portfolio alpha of 0.26%, statistically significant at the 1% level. The H−L 7-factor alpha is a bit lower at 0.23%, still significant at the 1% level. Put option returns demonstrate the same pattern as that in call option returns; the magnitude of H−L portfolio alphas is a bit larger. It is interesting to note that the H−L portfolio return is close to the FM regression coefficient estimates on ESG in Table 3. Since FM coefficients can be interpreted as returns on a portfolio exposed to that characteristic (Fama (1976)), these two complementary results imply that the ESG premium is around 0.3% per month.

Panel C 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 a 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.

4.2. 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 which kinds of risks.

We first use model-free option implied variance, skewness, and kurtosis as dependent variables to see how they are influenced by the ESG score of the underlying firms. The calculation of these measures follows Bakshi, Kapadia, and Madan (2003).[19] Volatility risk is measured using model-free option implied variance. Our two proxies for jump risks are option implied skewness and option implied kurtosis. We report the results of FM regressions with these dependent variables in Panel A of Table 5. We find that higher ESG score is significantly related to lower model-free option implied variance, less negative implied skewness, and lower implied kurtosis, indicating lower expected volatility and jump risks. These results suggest that the impact of ESG uncertainty in option pricing is manifested via its impact on volatility and/or jump risks, consistent with the findings in Hoepner, Oikonomou, Sautner, Starks, and Zhou (2020) and Kim, Li, and Li (2014).

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.[20] 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 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 4.1, and we hold these portfolios for a month without additional

[19] We thank Grigory Vilkov for providing the codes on his website to perform the calculations. Following ISV (2021), we use the interpolated volatility surface data to construct the model-free risk-neutral measures. Because the options studied in our sample have about 50 days to maturity, to match the maturity we employ the implied volatilities of 30 days and 60 days to perform linear interpolation.

[20] Dew-Becker, Giglio, and Kelly (2021) also construct straddle/strangle returns to isolate various kinds of risks.

rebalancing. Higher portfolio returns indicate lower exposures to volatility risk, or jump risks.

We use these straddle returns as dependent variables in FM regressions similar to those in Table 2 Panel A. In addition to the controls in Table 2, we further control for model-free option implied variance, skewness, and kurtosis. The results are reported in Panel B of Table 5. We find that vega-positive, gamma-neutral straddle (portfolios exposed to volatility risk) returns are only marginally significantly related to ESG scores in column (1), while the significance increases when controlling for lagged option implied volatility and jump risk measures in columns (2) to (4). The positive coefficients indicate a higher ESG score is associated with a higher portfolio return, even after controlling for lagged measures of volatility and jump risks. The relationship between gamma-positive, vega-neutral straddle (portfolios exposed to jump risk) returns and ESG scores is positive and significant (at the 10% level) across all regression specifications in columns (5) to (8). Thus, these results show that ESG is important for both volatility risk premia and jump risk premia.

Panel C of Table 5 provides further evidence using portfolio sorts for the same two kinds of straddle returns. 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 in Panel C1. 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 C.2.

As a final test, we control for the lagged model-free option implied variance, skewness, and kurtosis in our baseline FM regressions to examine whether they can explain the positive relationship between delta-hedged option return and ESG scores. These regressions follow the same format as those in Table 2 with the same additional controls. Panel D of Table 5 shows the results. We report the results of baseline regression, after controlling for volatility risk, after controlling for jump risks, and after controlling for both volatility and jump risks in columns (1) to (4) respectively, for call options, and columns (5) to (8) respectively, for put options. 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 half for delta-hedged put option returns after the inclusion of lagged risk measures, mostly due to inclusion of lagged model-free implied variance. These results indicate that investors perceive that stocks with lower ESG scores have higher risks beyond those captured by volatility and jump risks, and that these risks are incorporated in the option prices.

Overall, this subsection shows evidence that options with higher ESG scores have lower volatility and jump risks, and the option premia reflect both kinds of risks. Moreover, there is suggestive evidence that some extra higher moment risks related ESG score are also priced in the options, in addition to volatility risks and jump risks.

4.3. Evidence of perceived ESG uncertainty from end-user net demand

In this subsection, we investigate how option end-users perceive ESG uncertainty by studying the relationship between the net option demand from end-users and the ESG scores of the underlying stocks. Our main hypothesis is that option end-users perceive stocks with lower ESG as riskier and pay significant premia in the options market to hedge against these risks. For example, some risk-averse investors holding the low-ESG stocks may use protective puts to hedge against the downside. At the same time, some speculators with lottery preferences might buy call options of low-ESG stocks (Blau, Bowles, and Whitby (2016), and Byun and Kim (2016)). Based on the demand-based option pricing theory (Gârleanu, Pedersen, and Poteshman (2009)), this excess demand could partly explain why options, particularly call options, on low-ESG stocks are more expensive than options on stocks with high-ESG scores.

To investigate such possibility, we utilize signed option volume (open/close and buy/sell) data from ISE open/close trade profile, which provides daily buy and sell trading volume for each option series traded at the ISE.[21] The data include the signed volume by two categories of end-users: public customers and firm proprietary traders (including trades by broker/dealer). Public customers include both institutions such as hedge funds and mutual funds, and retail investors. Market maker trades are on the opposite side of end-users, and their trading volume is not directly reported in ISE. Following Chen, Joslin, and Ni (2019), we focus on end-user demand from public customers, the opposite side of which is the financial intermediaries including both option market makers and firm proprietary traders.

For each option series and trader type, the option trading volume data are divided into four categories: open buy volume, open sell volume, close buy volume, and close sell volume. We focus on the trading volume from the open position because literature shows that open position contains more information and is less likely to be mechanically influenced by existing positions (Pan and Poteshman (2006)). Specifically, for each month we define signed option trading volume

[21] Trades reported in the ISE data represent about 30% of the total trading volume in equity options.

from public customers as:

$$Signed\ Option\ Trading\ Volume_{it}\ = \frac{Total\ open\ Buy_{it} - Total\ open\ Sell_{it}}{Stock\ Trading\ Volume_{it}}, \qquad (7)$$

where $Total\ open\ Buy_{it}$ ($Total\ open\ Sell_{it}$) is the total trading volume of newly initiated long (short) positon by public customers in a month, for all the ATM options. We exclude options with days to maturity shorter than 15 days or longer than 150 days. To ensure comparability across stocks, we scale the number by stock trading volume over the previous month. For robustness, we also construct this measure using only call option volumes or only put option volumes.

We report the results of net signed option trading volume in Table 6. We find that the net demand from public customers is, for most of the cases, negative. This is consistent with the previous literature that option end-users are, on average, net sellers of equity options (Lakonishok, Lee, Pearson, and Poteshman (2007), Gârleanu, Pedersen, and Poteshman (2009), Muravyev (2016), and Christoffersen, Goyenko, Jacobs, and Karoui (2018)). We find that put options on low-ESG stocks have positive net signed volume from end-users, which suggests a high demand for hedging since these stocks are exposed to highest ESG risk. The net demand is low and negative for options on high-ESG stocks, leading to a statistically significant difference in option demands between low- and high-ESG stock options. We observe a similar pattern for call options. There is more demand for calls with lowest ESG scores, perhaps driven by a higher speculative demand because of higher perceived uncertainty. Our results cannot separate out these two mutually co-existent explanations and are consistent with both leading to more expensive option on low-ESG stocks.

5. Additional cross-sectional results

So far, we have documented that ESG scores of the underlying firm affect the cross-section of option prices and that there is a significant ESG premium in the pricing of options. In this section, we further explore the heterogeneity across stocks, and investigate the impact of social performance conditional on different industries, product competition intensity, investors' awareness, and corporate hedging activity. Our analysis of social issues in the first two subsections further establishes that the effect of ESG on option prices is not driven solely by the environmental aspect of ESG.

5.1. Different business models

The proximity to end-consumers potentially influences the impacts of social performance on firm's uncertainty and further investors' perception of such uncertainty. 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 poor ESG performance. Such firms therefore face higher uncertainty when the ESG performance is less satisfactory. 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 score 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 exact 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 7, columns (1) and (3) report the results for call and put options, respectively. *Consumer* is a dummy that equals one if a firm is in industries classified as closer to end-customers. Our focus is on the interaction term, *Consumer*×(*ESG Score)*, which captures the impact of ESG performance on option return for firms that are closer to consumers. We include the same control variables as those in Table 2 but do not report them in Table 7 to avoid clutter. The estimated coefficient on the interaction term is positive and statistically significant at the 10% (5%) level for call (put) options. Our results indicate that, among firms that are closer to the end-consumers, 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. Social 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 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 (2013)) 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 description from 10-Ks. A higher *Fluidity* measure indicates more intense competition from peers offering similar products. Table 7, Panel A, columns (2) and (4) report the results of FM regressions for call and put option delta-hedged returns, respectively. 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 1% level for both call and put options. Consistent with the product market competition and product differentiation argument, we find the impact of ESG performance on option pricing to be stronger for firms facing heightened competition. In summary, the results in Panel A of Table 7 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 which are subject to different levels of ESG awareness due to political leaning in different states. Panel B of Table 7, columns (1) and (3) show the results for call and put option delta-hedged return, respectively. As expected, we find that the interaction term is positive and statistically significant at 5% (10%) level for calls (puts). The evidence suggests that, when firms are headquartered in more Democratic-leaning states, their option pricing is more influenced by the social 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).[22] They textually analyze quarterly earnings conference calls and measure the portion of contents that are devoted to environmental related political topics as *Conf_Env*. 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 social 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 *Conf_Env* and ESG score is only −0.02. We run FM regressions of delta-hedged option return on *Conf_Env* and its interaction with ESG score. Panel B of Table 7, columns (2) and (4) show that the coefficients on the interaction term for both calls and puts are 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 may 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,

[22] See also Sautner, van Lent, Vilkov, and Zhang (2021) for an alternative measure using machine learning keyword discovery algorithm. Our results are robust to using their measure.

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.[23] We run FM regressions of delta-hedged option return on *Hedger* and its interaction with ESG score. Panel C of Table 7 reports the results for calls and puts, respectively. 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 for both calls and puts. 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 performance 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. How are such uncertainties and risks perceived by investors and then priced in the option market?

Our analysis suggests that ESG uncertainty is priced in the option market and that option prices reflect the market consensus on ESG uncertainty. Specifically, implied volatility is higher and delta-hedged option gain is more negative—both indicating option prices are more expensive—for firms with poor ESG performance. All components of ESG contribute to option expensiveness. We corroborate these results using three quasi-natural experiments, that are the Paris Agreement, Greta Thunberg's speeches, and the Me-Too Movement. Sudden increases in

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

firm-level ESG risks lead to more expensive options as well. Via quintile portfolio sorts, we find the magnitude of the ESG premium to be about 0.3% per month. We find that this premium derives from volatility ad jump risks, and possibly even higher-moment risks. 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	
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 a 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 $P - \Delta_P S$.
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.
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 linear interpolation.
ImpVol: Implied volatility average	The average implied volatility of ATM ($\|\Delta\|$=0.5) call and put options with 30 days of maturity.
ImpVol: Implied volatility difference	The difference between put and call daily implied volatility of ATM ($\|\Delta\|$=0.5) call and put options with 30 days of maturity.
Option open interest	Total number of option contracts that are open at the end of previous month and scaled by the stock trading volume of last month.
Option bid-ask spread	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.
Net signed option volume by public customers	The net signed volume (open buy – open sell) by public customers are sum up across all/call/put option series and dates to compute a monthly net signed option volume, covering all the ATM options with maturities between 15

	days to 150 days. The number is scaled by the stock trading volume of the same month.
Corporate Social Performance (ESG) measures	
ESG score	ESG score is monthly updated from Asset4 database, based on 250+ key performance indicators (KPIs) and 750+ individual data points, from three pillars. The range of ESG score is between 0 and 1 after scaling by 100.
RRI trend	Difference in the RepRisk Index (RRI) between current date and the date 30 days ago. It is recommended by RepRisk data vender to monitor the development of the risk exposure of a company related to ESG issues, or as an indication of when a risk incident has appeared for a company.
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 12^{th} month.
Ret1	The stock return in the prior month.
Ln(Amihud)	The logarithm of the Amihud (2002) stock illiquidity measure of previous month.
Institutional ownership	The percentage of common stocks owned by institutions in the previous quarter.
Analyst coverage	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).
ROE	Net income divided by the shareholder equity last year.
Consumer dummy	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 dummy	Blue (referring to blue states) refers to the states if voters predominantly choose the Democratic Party.
Conf_Env	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	Dummy variable equal to one if the firm has nonzero record of cash flow hedge gains/losses in COMPUSTAT.

References

Albuquerque, Rui, Yrjö 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.

Blau, Benjamin M., T. Boone Bowles, and Ryan J. Whitby, 2016, Gambling preferences, options markets, and volatility, *Journal of Financial and Quantitative Analysis* 51, 515–540.

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

Byun, Sook-Jun, and Da-Hea Kim, 2016, Gambling preference and individual equity option returns, *Journal of Financial Economics* 122, 155–174.

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

Cao, Jie, Bing Han, Xintong Zhan, and Qing Tong, 2021, Option return predictability, *Review of Financial Studies* forthcoming.

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, 2021, Doing well by doing good? Risk, return, and environmental and social ratings, Working Paper.

Chen, Hui, Scott Joslin, and Sophie X. Ni, 2019, Demand for crash insurance, intermediary constraints, and risk premia in financial markets, *Review of Financial Studies* 32, 228–265.

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.

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

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.

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*, forthcoming.

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.

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, 2015, Does corporate social responsibility lead to superior financial performance? A regression discontinuity approach, *Management Science* 61, 2549–2568.

Flammer, Caroline, 2021, Corporate green bonds, *Journal of Financial Economics* forthcoming.

Gârleanu, Nicolae, Lasse Heje Pedersen, and Allen M. Poteshman, 2009, Demand-based option pricing, *Review of Financial Studies* 22, 4259–4299.

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, 2013, 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, 2020, 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.

Lakonishok, Josef, Inmoo Lee, Neil D. Pearson, and Allen M. Poteshman, 2007, Option market activity, *Review of Financial Studies* 20, 813–857.

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.

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.

Muravyev, Dmitriy, 2016, Order flow and expected option returns, *Journal of Finance* 71, 673–708.

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

Pan, Jun, and Allen M. Poteshman, 2006, The information in option volume for future stock prices, *Review of Financial Studies* 19, 871–908.

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, 2020, Sustainable investing in equilibrium, *Journal of Financial Economics* forthcoming.

Pedersen, Lasse Heje, Shaun Fitzgibbons, and Lukasz Pomorski, 2020, Responsible investing: The ESG-efficient frontier, *Journal of Financial Economics* forthcoming.

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, 2021, Firm-level climate change exposure, Working Paper.

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. *Institutional ownership* is the percentage of common stocks owned by institutions in the previous quarter. *Analyst coverage* is the number of analysts following the firm in the previous month. 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 / ($\Delta_c \times S – C$)	−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 / ($P – \Delta_p \times S$)	−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
Institutional ownership	0.77	0.16	0.57	0.68	0.78	0.86	0.93
Analyst coverage	16.32	7.39	7.07	10.89	15.78	21.00	26.33

Panel D: Correlations

Spearman / Pearson	*ESG score*	*Ln (ME)*	*Ln (BM)*	*Ret1*	*Ret212*	*IVOL*	*Ln(Amihud)*	*Institutional ownership*	*Analyst coverage*
ESG score	1.000	0.490	−0.011	0.000	0.011	−0.271	−0.458	−0.271	0.203
Ln (ME)	0.487	1.000	−0.165	−0.029	0.025	−0.336	−0.897	−0.381	0.525
Ln (BM)	0.003	−0.158	1.000	0.004	−0.007	0.022	0.166	−0.012	−0.173
Ret1	−0.009	−0.041	0.004	1.000	0.016	0.013	0.003	0.012	−0.014
Ret212	−0.032	−0.011	−0.021	0.009	1.000	−0.068	−0.100	0.009	−0.035
IVOL	−0.242	−0.312	0.012	0.064	−0.019	1.000	0.280	0.235	−0.034
Ln(Amihud)	−0.448	−0.905	0.173	0.013	−0.090	0.263	1.000	0.263	−0.579
Institutional ownership	−0.203	−0.355	−0.009	0.008	−0.015	0.134	0.202	1.000	−0.070
Analyst coverage	0.187	0.505	−0.162	−0.022	−0.048	−0.038	−0.562	−0.040	1.000

Table 2. 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. *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-West (1987) *t*-statistics are reported in parentheses. The sample period is from January 2004 to December 2018. Panel B reports the average coefficients from monthly FM cross-sectional regressions for subperiods when attention to ESG topics is high or low, as proxied by Google Search Volume index. Panel C reports the average coefficients from monthly FM cross-sectional regressions among three sub-periods: Before-PA period (2014:07 to 2015:12), In-PA period (2016:01 to 2017:06), and After-PA period (2017:07 to 2018:12). We omit the coefficients on control variables (same as those in Panel A). Panel D presents the difference-in-differences estimates of delta-hedged option gains around suddenly heightened ESG risks, using panel regression. The treated group (*Treated*) is identified with RepRisk Index Trend (RepRisk Index this month – RepRisk Index 30 days ago) equal or larger than 16. The control group is identified via propensity score matching of the firms based on size, book to market ratio, stock return in the prior month, momentum, and idiosyncratic volatility. *Post* is a dummy variable equal one after the sudden increase of ESG risks. We define event windows as three months prior to and three months post the event. We run panel regressions controlling for firm fixed effects and time fixed effects. We again omit the coefficients on control variables. The *t*-statistics in parentheses are calculated from robust standard errors clustered by firm.

Panel A. Fama-MacBeth regressions of delta-hedged option return on ESG performance

	Call options			Put options		
	(1)	(2)	(3)	(4)	(5)	(6)
ESG score	0.706	0.280	0.293	0.591	0.240	0.207
	(7.76)	(2.36)	(2.46)	(9.38)	(3.11)	(2.69)
Ln(*ME*)		0.095	0.104		0.055	0.126
		(2.56)	(1.23)		(2.30)	(2.23)
Ln(*BM*)		0.043	0.047		0.021	0.020
		(0.83)	(0.91)		(0.61)	(0.61)
Ret1		0.624	0.789		−0.211	−0.313
		(1.09)	(1.37)		(−0.58)	(−0.92)
Ret212		0.482	0.440		0.210	0.185
		(2.30)	(2.31)		(1.89)	(1.75)
IVOL		−2.106	−2.341		−1.852	−1.752
		(−6.04)	(−6.72)		(−8.64)	(−8.61)
Ln(*Amihud*)			0.050			0.039
			(0.65)			(0.72)
Option open interest			−3.644			−5.021
			(−4.63)			(−7.55)
Option bid-ask spread			−1.037			0.469
			(−3.83)			(2.32)
Average adj-R^2	0.005	0.043	0.051	0.007	0.047	0.059
# observations	51,691	48,464	48,464	51,691	48,464	48,464

Panel B. The impact of change in Google Search Volume Index (ΔGSVI) of "ESG" topics				
	Call options		Put options	
	High ΔGSVI	Low ΔGSVI	High ΔGSVI	Low ΔGSVI
ESG score	0.646	−0.107	0.406	0.049
	(2.62)	(−0.35)	(3.41)	(0.41)
High − Low	0.752		0.356	
	(1.98)		(2.01)	
Controls	Yes	Yes	Yes	Yes
Average adj-R^2	0.065	0.080	0.075	0.079
# observations	16,401	15,101	16,401	15,101

Panel C. Paris agreement and the impact of ESG on delta-hedged option return						
	Call options			Put options		
	Before	In	After	Before	In	After
ESG score	0.170	0.429	−0.154	0.122	0.466	−0.009
	(2.32)	(2.22)	(−1.18)	(1.95)	(2.37)	(−0.07)
In − Before	0.259			0.344		
	(1.01)			(1.38)		
In − After		0.583			0.457	
		(2.37)			(1.94)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Average adj-R^2	0.069	0.082	0.041	0.081	0.086	0.061
#observations	5,320	5,469	5,233	5,320	5,469	5,233

Panel D. Delta-hedged option return around heightened ESG risks				
	Call options		Put options	
	(1)	(2)	(3)	(4)
Post×Treated	−0.336	−0.336	−0.240	−0.218
	(−2.74)	(−2.73)	(−2.85)	(−2.56)
Post	0.062	0.055	0.059	0.033
	(0.78)	(0.68)	(0.92)	(0.52)
Treated	0.123	0.133	0.087	0.086
	(1.33)	(1.41)	(1.46)	(1.41)
Controls	No	Yes	No	Yes
Adj-R^2	0.138	0.141	0.251	0.260
# observations	16,169	16,131	16,169	16,131

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

In Panel A, we run FM regressions similar to those in Table 2 Panel A except that we use separate *E-score, S-score, and G-score* as ESG performance. We report only the coefficients of interest. Panel B presents the difference-in-differences panel regression results of how delta-hedged option returns react to sudden heightened environmental risks, social risks, and governance risks, separately.

Panel A: Delta-hedged option return and E-score, S-score, G-score

	Call options			Put options		
	(1)	(2)	(3)	(4)	(5)	(6)
E-score	0.340			0.242		
	(3.01)			(2.72)		
S-score		0.281			0.214	
		(2.00)			(3.05)	
G-score			0.282			0.202
			(1.51)			(1.68)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Average adj-R^2	0.051	0.051	0.051	0.059	0.059	0.059
# observations	48,464	48,464	48,464	48,464	48,464	48,464

Panel B: Delta-hedged option gains around sudden heightened E, S, and G risks

	Call options			Put options		
	E	*S*	*G*	*E*	*S*	*G*
Post×Treated	−0.471	−0.503	−0.321	−0.309	−0.590	−0.149
	(−2.27)	(−2.80)	(−1.70)	(−2.37)	(−1.97)	(−1.68)
Post	−0.044	0.103	0.141	−0.207	0.118	−0.026
	(−0.27)	(0.80)	(0.96)	(−1.94)	(0.82)	(−0.41)
Treated	0.149	0.108	0.048	0.154	0.178	−0.000
	(0.98)	(0.74)	(0.32)	(1.45)	(0.86)	(−0.00)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R^2	0.125	0.133	0.164	0.218	0.201	0.290
# observations	6,549	7,620	7,392	6,549	7,620	7,392

Table 4. 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)).

ESG score rank	P1	P2	P3	P4	P5	P5−P1
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)
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)

ESG score rank	P1	P2	P3	P4	P5	P5−P1
			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 5. Model-free implied risk-neutral variance, skewness, kurtosis, and ESG performance

This table reports the average coefficients from monthly FM cross-sectional regressions. In Panel A, the dependent variable is model-free implied risk-neutral variance, skewness, and kurtosis form options data, as in Bakshi, Kapadia, and Madan (2003). *ESG score* is the monthly updated ESG performance measure from Asset4. The definitions of other control variables are reported in the supplementary appendix. Panel B reports the average coefficients from monthly FM cross-sectional regressions, using vega-positive, gamma-neutral straddle returns and gamma-positive, vega-neutral straddle returns as dependent variables. In addition to the same set of independent variables in Table 2, we also include lagged model-free implied risk-neutral variance, skewness, and kurtosis as control variables. Panel C1 and C2 report the portfolio sorting results of vega-positive, gamma-neutral straddle returns, and gamma-positive, vega-neutral straddle returns, respectively. We report raw returns and alphas from 6-factor, and 7- factor models. Panel D reports the average coefficients from monthly FM cross-sectional regressions as in Table 2, using 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 as dependent variable (in percentage), after controlling for lagged model-free implied risk-neutral variance, skewness and kurtosis. All independent variables are winsorized each month at the 0.5% level. We report Newey-West (1987) *t*-statistics in parentheses below the coefficients. The sample period is from January 2004 to December 2018.

Panel A: Model-free implied risk-neutral variance, skewness and kurtosis as dependent variables

	Implied variance		*Implied skewness*		*Implied kurtosis*	
	(1)	(2)	(3)	(4)	(5)	(6)
ESG score	−0.128	−0.040	0.021	0.102	−0.050	−0.030
	(−20.08)	(−11.35)	(2.01)	(10.40)	(−2.11)	(−2.45)
Controls	No	Yes	No	Yes	No	Yes
Average adj-R^2	0.104	0.497	0.008	0.088	0.004	0.132
# observations	51,687	48,460	51,687	48,460	51,687	48,460

Panel B: Straddle returns exposed to specific risks as dependent variable

	Vega-positive, gamma-neutral (volatility risk sensitive)				Gamma-positive, vega-neutral (jump risk sensitive)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESG score	1.754	2.001	2.182	2.129	2.328	2.080	1.863	1.878
	(1.68)	(1.98)	(1.98)	(2.01)	(2.37)	(2.13)	(1.85)	(1.89)
Implied variance		−8.903		−7.062		3.584		2.859
		(−1.50)		(−1.57)		(1.30)		(1.18)
Implied skewness			−1.973	−1.922			1.890	1.814
			(−1.83)	(−1.78)			(2.46)	(2.23)
Implied kurtosis			1.428	1.260			−1.082	−1.111
			(1.93)	(1.96)			(−2.04)	(−1.94)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Average adj-R^2	0.056	0.057	0.056	0.058	0.045	0.046	0.044	0.046
# observations	44,100	43,655	43,655	43,655	44,100	43,655	43,655	43,655

ESG score rank	P1	P2	P3	P4	P5	P5−P1
Panel C1: Portfolios of 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 C2: Portfolios of 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)

Panel D: Delta-hedged option return as dependent variable								
	Call options				Put options			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESG score	0.293	0.236	0.424	0.284	0.207	0.129	0.249	0.123
	(2.46)	(3.27)	(5.71)	(2.57)	(2.69)	(2.03)	(3.87)	(1.77)
Implied variance		−2.368		−3.030		−2.359		−2.447
		(−7.29)		(−6.14)		(−9.12)		(−9.02)
Implied skewness			−0.859	−0.935			0.008	0.053
			(−6.60)	(−4.84)			(0.10)	(0.61)
Implied kurtosis			0.110	0.022			0.118	0.068
			(1.81)	(0.21)			(2.43)	(1.31)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Average adj-R^2	0.051	0.073	0.067	0.073	0.059	0.082	0.063	0.085
# observations	48,464	48,460	48,460	48,460	48,464	48,460	48,460	48,460

Table 6. ESG performance and end-user option demand

This table reports net signed option trading volume for all the options, call options, and put options sorted on the ESG scores of the underlying stocks. Using signed option trading volume by public customers from International Securities Exchange (ISE), *net signed option volume by public customers* is the difference between the total buying volume from initiating long positions (open buy), and the total selling volume from initiating short positions (open sell), within a month for all the ATM options with maturities between 15 days to 150 days, scaled by the stock trading volume of the same month. At the end of each month, we rank all stocks in our sample into quintiles by the ESG scores and calculate equal-weighted signed option trading volume for each the portfolio. We report Newey-West (1987) *t*-statistics in parentheses. The sample period is from May 2005 to December 2018.

ESG score rank	P1	P2	P3	P4	P5	P5−P1
Calls and Puts	0.81	0.16	−0.12	−0.74	−1.02	−1.84
	(0.59)	(0.68)	(−0.68)	(−4.94)	(−6.77)	(−4.82)
Calls	1.05	0.16	−0.18	−1.26	−1.42	−2.47
	(0.15)	(0.64)	(−0.93)	(−7.02)	(−8.15)	(−3.92)
Puts	0.59	0.16	−0.08	−0.21	−0.61	−1.20
	(1.83)	(0.71)	(−0.26)	(−0.31)	(−2.35)	(−3.70)

Table 7. 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. 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. Panel A analyzes the impact of product market. *Consumer* is a dummy variable equals 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 (2013)) is calculated based on 10-K and proxy for product market threats. Panel B analyzes the impact of ESG attention. *Blue (Red)* is a dummy referring to the states of firms' headquarter whose voters predominantly choose either the Democratic Party (blue) or Republican Party (red) presidential candidates. *Conf_Env* is the share of the transcript of the conference call that focuses on political risk related to environment (Hassan et al. (2019)). Panel C analyzes the impact of firm's hedging activity. *Hedger* is a dummy variable equals to one if the firm has nonzero record of cash flow hedge gains/losses in COMPUSTAT. All regressions include control variables in Table 2 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-West (1987) *t*-statistics in parentheses below the coefficients. The sample period is from January 2004 to December 2018.

Panel A. Product market				
	Call options		Put options	
	(1)	(2)	(3)	(4)
Consumer×(*ESG score*)	0.195		0.137	
	(1.76)		(2.27)	
Consumer	−0.175		−0.180	
	(−2.07)		(−3.29)	
Fluidity×(*ESG score*)		0.042		0.034
		(3.09)		(3.05)
Fluidity		−0.046		−0.031
		(−4.69)		(−4.32)
ESG score	0.031	−0.143	0.057	−0.130
	(0.52)	(−1.42)	(1.16)	(−1.84)
Controls	Yes	Yes	Yes	Yes
Average adj-R^2	0.053	0.058	0.068	0.077
# observations	48,464	48,464	48,464	48,464

Panel B. Attention to ESG				
	Call options		Put options	
	(1)	(2)	(3)	(4)
Blue×(*ESG score*)	0.231		0.093	
	(2.03)		(1.68)	
Blue	−0.287		−0.168	
	(−3.26)		(−2.46)	
Conf_Env×(*ESG score*)		0.021		0.034
		(1.81)		(2.30)
Conf_Env		−0.010		−0.022
		(−0.37)		(−1.71)
ESG score	−0.075	0.036	0.049	−0.034
	(−0.59)	(0.14)	(0.49)	(−0.17)
Controls	Yes	Yes	Yes	Yes
Average adj-R^2	0.080	0.077	0.083	0.081
# observations	37,907	40,935	37,907	40,935

Panel C. Firms' hedging activity		
	Call options	Put options
	(1)	(2)
Hedger×(*ESG score*)	−0.168	−0.134
	(−2.11)	(−2.12)
Hedger	0.120	0.059
	(2.06)	(1.03)
ESG score	0.171	0.211
	(2.07)	(3.09)
Controls	Yes	Yes
Average adj-R^2	0.079	0.082
# observations	48,464	48,464

Figure 1. Implied volatility difference between low ESG and high ESG stocks around PA

This figure plots the difference in implied volatility between Low ESG and high ESG stocks from January 2013 to December 2018. Low (High) ESG stocks are lowest (highest) quintile sorted based on ESG scores. Implied volatility (in percentage) is the average implied volatility of ATM call and put options with 30 days of maturity, at the end of each month. We select ATM options from the volatility surface provided by Option-Metrics with delta equal to 0.5 for call options and −0.5 for put options. The sample period is divided into three based on dates of Paris Agreement (PA). Before-PA corresponds to sample period from 2013:01 to 2015:12; In-PA corresponds to the sample period from 2016:01 to 2017:06; and After-PA corresponds to the sample period from 2017:07 to 2018:12.

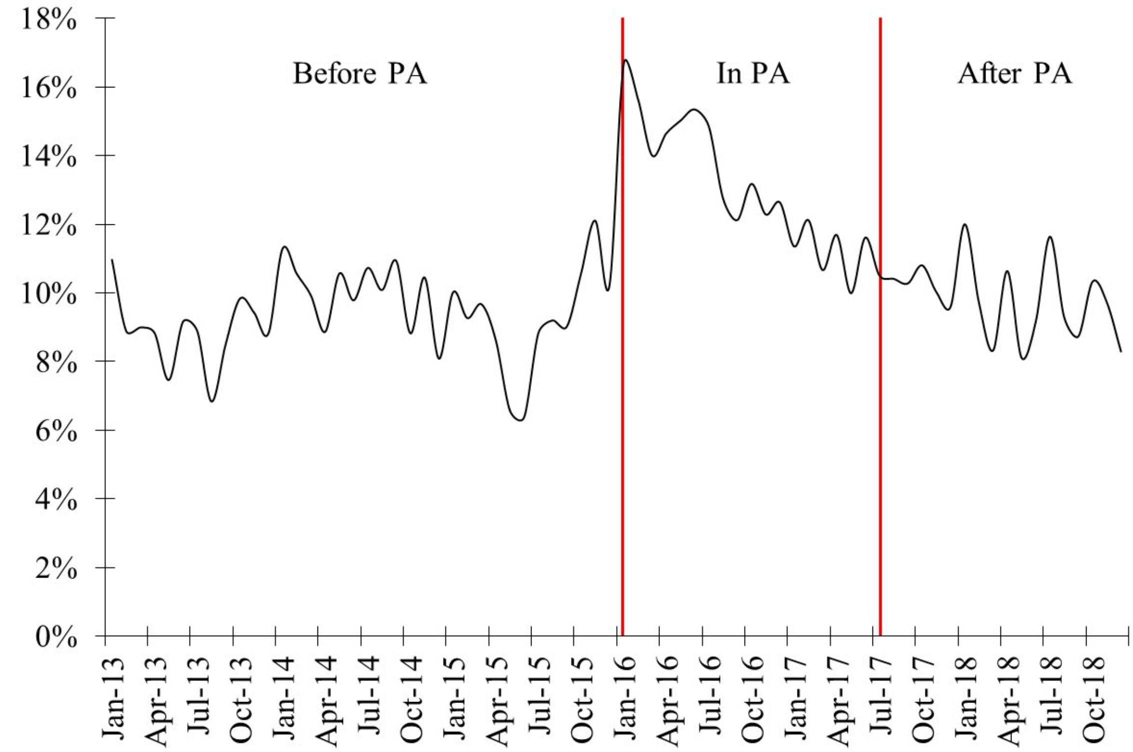


Figure 2. Implied volatility difference between low ESG and high ESG stocks around Greta Thunberg's speeches

This figure plots the difference in implied volatility between Low ESG and high ESG stocks around Greta Thunberg's speeches in a window of (−10, +10) days. Implied volatility (in percentage) is the daily average implied volatility of ATM call and put options with 30 days of maturity. We select ATM options from the volatility surface provided by Option-Metrics with delta equal to 0.5 for call options and −0.5 for put options. Low (High) ESG stocks are lowest (highest) quintile sorted based on ESG scores.

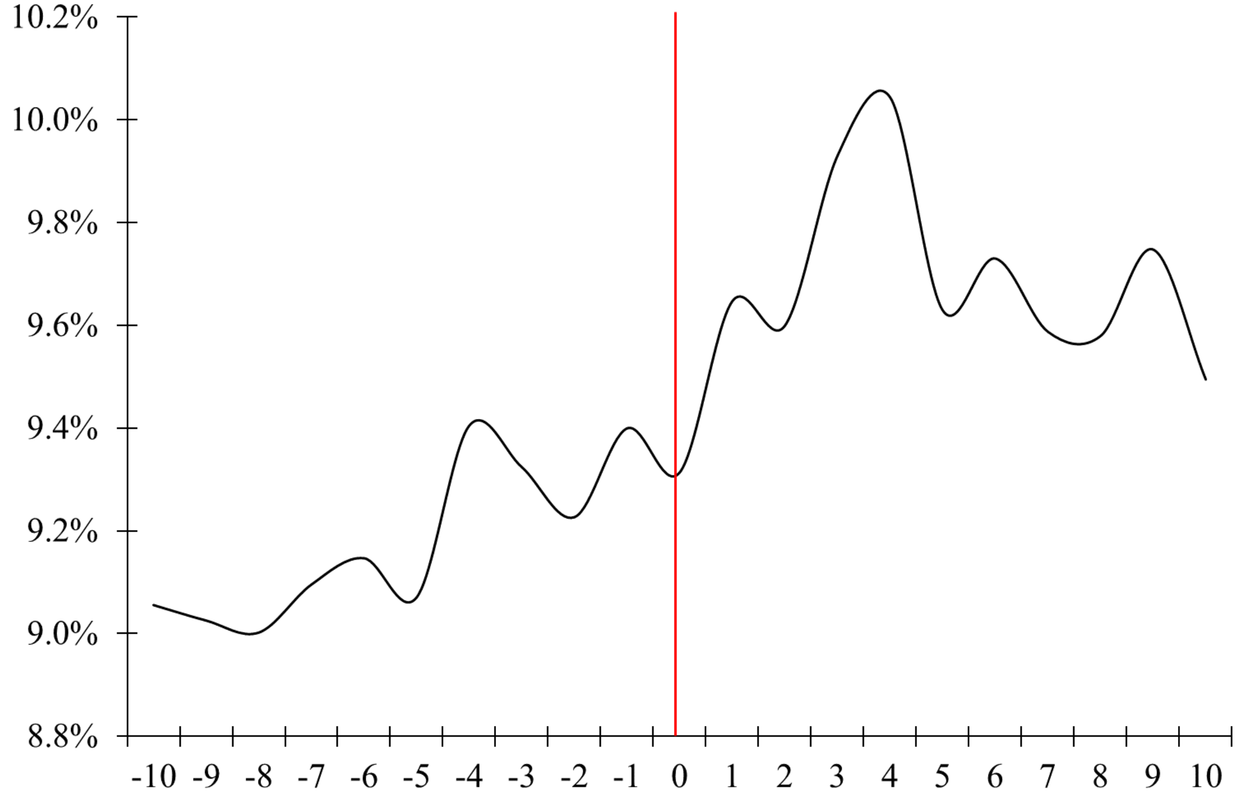
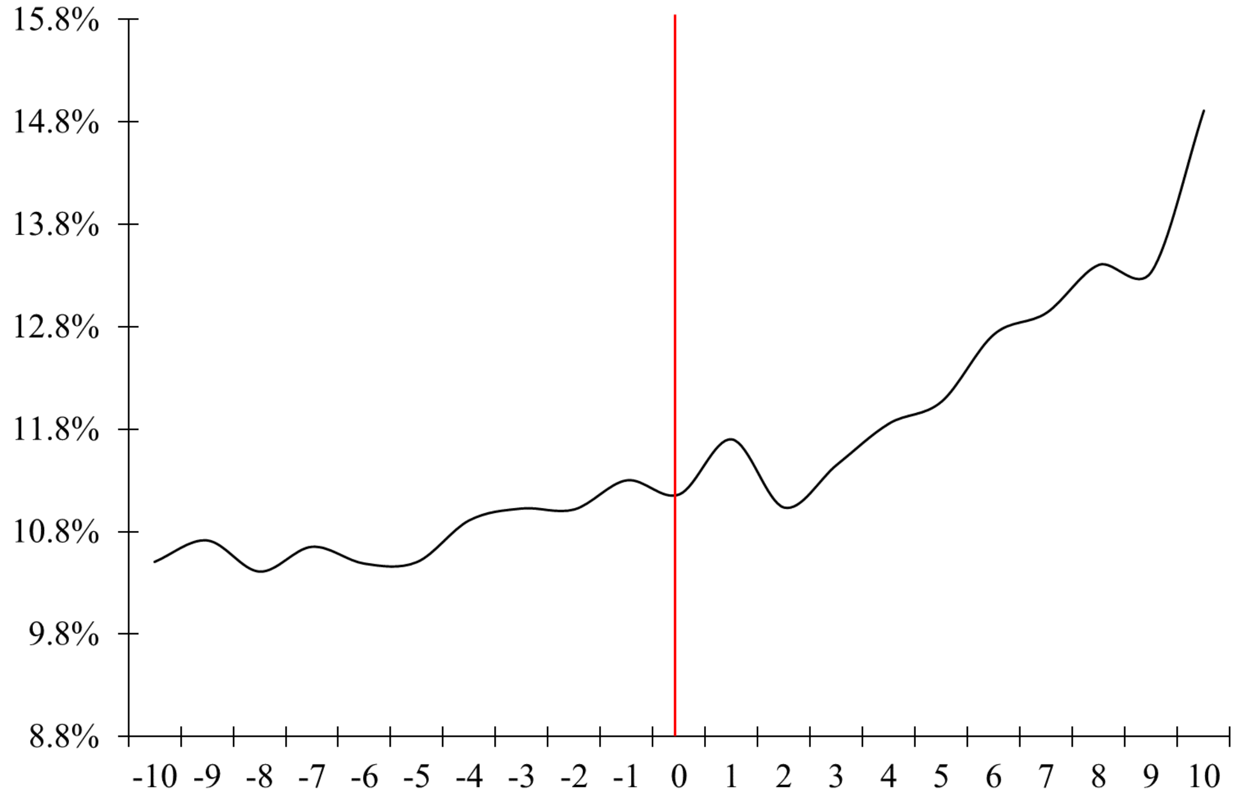


Figure 3. Implied volatility difference between low ESG and high ESG stocks around Me-Too movement

This figure plots the difference in implied volatility between Low ESG and high ESG stocks around Me-Too movement in a window of (−10, +10) days. Implied volatility (in percentage) is the daily average implied volatility of ATM call and put options with 30 days of maturity. We select ATM options from the volatility surface provided by Option-Metrics with delta equal to 0.5 for call options and −0.5 for put options. Low (High) ESG stocks are lowest (highest) quintile sorted based on ESG scores.



Appendix Tables

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. Institutional ownership is the percentage of common stocks owned by institutions in the previous quarter. Analyst coverage is the number of analysts following the firm in the previous month. The sample period is from January 2004 to December 2018.

	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
Panel A: Time-series distribution (180 monthly observations)							
Number of stocks in the sample each month	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
Institutional ownership	0.77	0.16	0.57	0.68	0.78	0.86	0.93
Analyst coverage	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 emission scores

This table 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. *Carbon emission score* is the monthly updated proxy for carbon performance of the firm from MSCI. *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-West (1987) *t*-statistics are reported in parentheses. The sample period is from January 2004 to December 2018.

	Call options				Put options			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Carbon emission score	0.044	0.023	0.009	0.004	0.028	0.004	−0.003	−0.010
	(2.99)	(1.37)	(0.57)	(0.21)	(2.45)	(0.36)	(−0.33)	(−0.94)
ESG		0.622		0.242		0.645		0.282
		(4.08)		(2.08)		(5.72)		(2.97)
Ln(ME)			−0.093	−0.106			−0.205	−0.210
			(−1.19)	(−1.37)			(−3.04)	(−3.11)
Ln(BM)			0.049	0.046			0.014	0.017
			(0.76)	(0.72)			(0.34)	(0.39)
Ret1			−0.500	−0.458			−1.029	−1.023
			(−1.13)	(−1.04)			(−2.94)	(−2.90)
Ret212			−0.377	−0.386			−0.198	−0.218
			(−1.99)	(−2.01)			(−1.17)	(−1.28)
IVOL			−2.046	−1.965			−1.96	−1.822
			(−5.55)	(−5.33)			(−8.24)	(−7.72)
Ln(Amihud)			−0.110	−0.106			−0.155	−0.141
			(−2.30)	(−2.19)			(−4.87)	(−4.20)
Option open interest			−3.434	−3.508			−4.689	−4.481
			(−3.91)	(−3.96)			(−4.51)	(−4.28)
Option bid-ask spread			−0.898	−0.865			0.506	0.491
			(−2.54)	(−2.43)			(1.64)	(1.66)
Average adj-R^2	0.001	0.007	0.056	0.060	0.001	0.010	0.065	0.069
# observations	33,618	32,874	31,877	31,193	33,618	32,874	31,877	31,193

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 ($0.2 < |\Delta| \le 0.4$) ATM ($0.4 < |\Delta| \le 0.6$), ITM ($0.6 < |\Delta| \le 0.8$) 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 scaled by ($\Delta_c \times S-C$) for calls and ($P-\Delta_p \times S$) for puts. 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-West (1987) *t*-statistics in parentheses below the coefficients. The sample period is from January 2004 to December 2018.

	Call options			Put options		
	OTM	ATM	ITM	OTM	ATM	ITM
ESGscore	0.241	0.343	0.277	0.171	0.053	−0.048
	(1.84)	(3.90)	(2.45)	(2.34)	(2.64)	(−1.25)
Ln(ME)	0.132	0.065	−0.004	0.093	0.024	−0.021
	(1.61)	(1.07)	(−0.08)	(1.69)	(0.79)	(−0.85)
Ln(BM)	0.023	0.021	−0.004	−0.007	−0.004	−0.001
	(0.46)	(0.61)	(−0.11)	(−0.19)	(−0.15)	(−0.03)
Ret1	0.703	0.917	0.801	0.038	−0.124	−0.101
	(1.43)	(2.09)	(1.83)	(0.13)	(−0.65)	(−0.71)
Ret212	0.122	0.354	0.362	0.117	−0.045	−0.017
	(0.62)	(1.91)	(2.50)	(0.99)	(−0.62)	(−0.38)
IVOL	−5.748	−4.629	−3.748	−4.127	−2.075	−0.072
	(−4.62)	(−4.81)	(−4.39)	(−5.42)	(−3.98)	(−0.19)
Ln(Amihud)	0.056	0.013	−0.008	0.042	0.008	−0.040
	(0.73)	(0.20)	(−0.15)	(0.86)	(0.29)	(−1.73)
Option open interest	−3.940	−3.088	−1.294	−3.560	−1.970	−1.199
	(−6.14)	(−6.26)	(−2.51)	(−5.21)	(−4.85)	(−2.86)
Option bid-ask spread	−0.703	−0.560	−2.286	0.037	−0.595	−0.587
	(−2.73)	(−1.57)	(−3.44)	(0.19)	(−2.58)	(−2.80)
Average adj-R^2	0.045	0.045	0.053	0.060	0.052	0.062
# observations	50,726	47,646	38,877	49,557	42,514	30,279

Internet Appendix for "Unlocking ESG Premium from Options"

IA1. Implied volatility around PA

We first check whether the Paris Agreement (PA hereafter) had any effect on investors' perception of risk and uncertainty related to ESG. 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)).[24] For stocks with low ESG performance, regulatory risks and litigation risks would increase, through the adoption of a carbon tax for instance. As a result, after the PA was announced and ESG risk have higher probability to be materialized, we expect the effect of ESG performance on perceived uncertainty and its effect on option prices, if any, to be magnified.

Another related event is the announcement of 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. Firms with poor ESG performance could benefit from the decrease in short-term regulatory risks after the withdrawal announcement by President Trump. Therefore, we conjecture that perceived uncertainty of firms with weak ESG performance would be lower after the announcement of the withdrawal.

Figure 1 shows suggestive evidence that the difference in *ImpVol* between the low- and the high-ESG stocks increases after the PA is announced but drops after Donald Trump's withdrawal. For a more rigorous analysis, we use panel regressions. Our regression specification for testing these effects is:

$$ImpVol_{it} = \alpha + \beta_1 ESG_{it-1} \times In + \beta_2 ESG_{it-1} \times After + \beta_3 ESG_{it-1} + \beta_4' X_{it-1} + \gamma_t + \theta_i + e_{it}, \quad \text{(IA1)}$$

where $ImpVol_{it}$ is the average of *ImpVol* of call and put on stock i at the end of month t; In is a time indicator variable that equals to one during the PA effective period (December 2015 to May 2017); $After$ is another time indicator variable that equals to one after Donald Trump's announcement to exit the PA (June 2017 to December 2018); X_{it-1} are the control variables including market capitalization, book-to-market ratio, reversal, momentum, idiosyncratic volatility, return on equity, institutional ownership, and lagged dependent variable; γ_t is the time fixed effect; and θ_i is the stock fixed effects. Coefficient on the interaction term β_1 (β_2) shows the incremental effect of ESG performance on *ImpVol* after entering (exiting) the PA. Specification without the interaction effects is the baseline regression.

Table IA1 shows the estimation results of equation (A1). The baseline specification (1) shows a negative relation between *ImpVol* and ESG, suggesting that low-ESG firms are perceived to be riskier. Controlling for firm characteristics in specification (2) shows that the effect of ESG is still statistically significant (coefficient = −4.37, *t*-statistic = −5.08). In addition, columns (3)

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

and (4) show how the effect of ESG score changes conditional on the efficacy of the PA. After the announcement of PA, the effect of ESG on $ImpVol$ become stronger. The coefficient β_1 on the interaction term of ESG with In dummy is −4.34 (t-statistic = −2.97). The coefficient β_2 on the interaction term of ESG with $After$ dummy is not statistically different from zero, while the difference between two interaction terms (reported as $After - In$) is significant. These effects are consistent with our hypotheses—when President Trump officially announced that the U.S. would withdraw from the PA, option investors anticipated that the regulatory risks associated with bad social performance would decrease, or in other words, ESG risk are less likely to materialize. Therefore, the difference in *ImpVol* (difference in option expensiveness) between low- and high-ESG groups reverted to levels as those before the PA.

IA2. Implied volatility around Greta Thunberg's speeches

Greta Thunberg is a Swedish environmental activist, who is internationally known for challenging world leaders to take immediate actions against climate changes. We conjecture that her speeches provoke public attention to ESG issues. To test this hypothesis, we select ten of her well known speeches. Figure 2 shows that the spread in *ImpVol* between low- and high-ESG stocks widens in a short period after her speeches. For a more formal analysis, we run the following panel regression for low- and high-ESG firms only:

$$ImpVol_{it} = \beta_1 Treated_{it} \times Post_t + \beta_2 Treated_{it} + \beta_3 Post_t + \beta_4 X_{it} + \gamma_t + \theta_i + e_{it}, \quad \text{(IA2)}$$

where $ImpVol_{it}$ is the $ImpVol$, and $Treated_{it}$ is a dummy variable equal to one for firms with low-ESG scores, and zero for firms with high-ESG scores. $Post_t$ is a dummy variable equal to one for days after Greta's speeches, and zero otherwise. The event window is (−10, +10) or (−5, +5) days around the speeches. We add industry and time fixed effects in the regressions.[25]

The results are shown in Table IA2. We find that the *ImpVol Average* of call and put increases by around 0.3% for low-ESG stocks after Greta' speeches. In contrast, there is no effect on the *ImpVol Difference* between put option and call option. These results imply that sudden increased awareness of ESG risk has an impact on investors' perception of risks but not future firm fundamentals.

IA3. Implied volatility around Me-Too movement

The third event we utilize to investigate the change of ESG risks is Me-Too movement. Me-Too is a social movement against sexual abuse and sexual harassment. The term "Me-Too" was initially used in 2006 on Myspace, and began to spread rapidly as a hashtag on October 15th, 2017. On that day, American actress Alyssa Milano posted on Twitter, "If all the women who have been sexually harassed or assaulted wrote 'Me too' as a status, we might give people a sense of the magnitude of the problem," saying that she got the idea from a friend. A number of high-profile posts and responses from American celebrities soon followed. On the same day, it had been tweeted more than 200,000 times on Twitter and used by more than 4.7 million people during the first 24 hour on Facebook. We use this Me-Too movement as a shock to the ESG awareness, and test how ESG risks changes around October 15th, 2017. Figure 3 in the paper shows that difference in *ImpVol* between low- and high-ESG firms increases from around 11% to around 15% in a very

[25] As nine of the ten speeches are in 2019 and we use the ESG scores in December 2018 to classify sample firms, we cannot add firm fixed effects which absorb most of the cross-sectional variation in ESG performance.

short window. For a more formal analysis, we run the following panel regression for low- and high-ESG firms only:

$$ImpVol_{it} = \beta_1 Treated_{it} \times Post_t + \beta_2 Treated_{it} + \beta_3 Post_t + \beta_4 X_{it} + \gamma_t + \theta_i + e_{it}, \quad \text{(IA3)}$$

where $ImpVol_{it}$ is the *ImpVol*, and $Treated_{it}$ is a dummy variable equal to one for firms with low-ESG scores, and zero for firms with high-ESG scores. $Post_t$ is a dummy variable equal to one for days after October 15th, and zero otherwise. The event window is (−20, +20) or (−10, +10) days around the speeches. We add industry and time fixed effects in the regressions.

The results are shown in Table IA3. We find that the *ImpVol Average* of call and put increases by around 1.58% for low-ESG stocks within 10 days after October 15th. In contrast, there is no effect on the *ImpVol Difference* between put option and call option. These results imply that sudden increased awareness of social risk has an impact on investors' perception of risks but not future firm fundamentals.

Table IA1. Effect of ESG performance on implied volatility around Paris Agreement

This table reports panel regression coefficients of implied volatility on ESG score and other controls. The dependent variable is the average implied volatility of ATM call and put options with 30 days of maturity, at the end of each month. We select ATM options from the volatility surface provided by Option-Metrics with delta equal to 0.5 for call options and −0.5 for put options. *ESG score* is the monthly updated ESG performance measure from Asset4. Control variables include market capitalization, book-to-market ratio, reversal, momentum, institutional ownership and return on equity. The definitions of these variables are reported in the supplementary appendix. Columns (1) and (2) show the baseline results. Columns (3) and (4) show the effect of Paris Agreement. *In* is a dummy variable for In Paris Agreement period (2016:01 to 2017:06), and *After* is a dummy variable for after the Paris Agreement period (2017:07 to 2018:12). We control for firm fixed effects and time fixed effects. All independent variables are winsorized each month at the 0.5% level. The *t*-statistics in parentheses are calculated from robust standard errors clustered by firm.

	(1)	(2)	(3)	(4)
ESG score	−6.695	−4.370	−6.732	−4.504
	(−7.16)	(−5.08)	(−7.22)	(−5.23)
In×(*ESG score*)			−4.341	−2.418
			(−2.97)	(−2.25)
After×(*ESG score*)			−1.649	0.705
			(−1.14)	(0.52)
Ln(ME)		−0.058		−0.058
		(−13.01)		(−13.05)
Ln(BM)		0.005		0.004
		(1.59)		(1.41)
Ret1		−0.110		−0.096
		(−16.72)		(−15.56)
Ret212		−0.038		−0.033
		(−10.79)		(−9.73)
Institutional ownership		−0.021		−0.022
		(−1.45)		(−1.48)
Return on equity		−0.001		−0.001
		(−1.51)		(−1.53)
After − In			2.692	3.123
Prob > F			0.039	0.021
Firm Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Adj-R^2	0.650	0.679	0.650	0.678
# observations	124,904	109,676	124,904	109,676

Table IA2. Implied volatility around Greta Thunberg's speeches

Panel A presents results from panel regressions of implied volatility around Greta Thunberg's speeches. *ImpVol Average* (in percentage) is the daily average implied volatility of ATM call and put options with 30 days of maturity. *ImpVol Difference* (in percentage) is the daily difference between put and call daily implied volatility of ATM call and put options with 30 days of maturity. We select ATM options from the volatility surface provided by Option-Metrics with delta equal to 0.5 for call options and −0.5 for put options. All the firms are divided into quintiles based on their ESG performance. *Treated* is a dummy for firms with lowest ESG score. Control group refers to firms with highest ESG score. *Post* is a dummy variable equal to one after Greta Thunberg's speeches. Columns (1) and (2) show the results for *ImpVol Average* of event window of (−10, +10) days and (−5, +5) days, respectively. Columns (3) and (4) show the results for *ImpVol Difference* between put and call options. Control variables include market capitalization, book-to-market ratio, reversal, momentum, institutional ownership and return on equity. The definitions of these variables are reported in the supplementary appendix. We include industry fixed effects and time fixed effects. All independent variables are winsorized each month at the 0.5% level. The *t*-statistics in parentheses are calculated from robust standard errors clustered by firm.

Panel A. Implied volatility around Greta Thunberg's speeches

	ImpVol Average (Call + Put) / 2		*ImpVol Difference (Put – Call)*	
	(−10, +10)	(−5, +5)	(−10, +10)	(−5, +5)
	(1)	(2)	(3)	(4)
Post×Treated	0.336	0.308	−0.189	0.144
	(1.94)	(2.01)	(−1.00)	(0.79)
Post	1.510	1.907	0.042	0.038
	(3.13)	(2.90)	(0.37)	(0.34)
Treated	1.015	0.935	−0.204	−0.327
	(0.75)	(0.69)	(−0.73)	(−1.01)
Ln(*ME*)	−3.608	−3.723	0.265	0.312
	(−6.93)	(−7.20)	(1.86)	(1.95)
Ln(*BM*)	0.062	−0.100	0.236	0.205
	(0.07)	(−0.11)	(1.21)	(1.03)
Ret1	−26.099	−26.229	0.045	−1.153
	(−3.41)	(−3.14)	(0.04)	(−0.95)
Ret212	−6.007	−5.967	−0.681	−1.108
	(−1.56)	(−1.58)	(−1.95)	(−2.80)
Institutional ownership	−0.149	−0.311	0.486	0.951
	(−0.05)	(−0.11)	(0.30)	(0.54)
Return on equity	−8.900	−9.780	2.720	2.533
	(−1.92)	(−1.93)	(1.84)	(1.97)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Adj-R^2	0.349	0.344	0.018	0.019
# Observations	50,037	26,272	50,037	26,272

Table IA3. Implied volatility around Me-Too movement

This table presents results from panel regressions of implied volatility around Me-Too movement. The event day is October 15th, 2017. *ImpVol Average* (in percentage) is the daily average implied volatility of ATM call and put options with 30 days of maturity. *ImpVol Difference* (in percentage) is the daily difference between put and call daily implied volatility of ATM call and put options with 30 days of maturity. We select ATM options from the volatility surface provided by Option-Metrics with delta equal to 0.5 for call options and −0.5 for put options. All the firms are divided into quintiles based on their ESG performance. *Treated* is a dummy for firms with lowest ESG score. Control group refers to firms with highest ESG score. *Post* is a dummy variable equal to one after Greta Thunberg's speeches. Columns (1) and (2) show the results for *ImpVol Average* of event window of (−20, +20) days and (−10, +10) days, respectively. Columns (3) and (4) show the results for *ImpVol Difference* between put and call options. Control variables include market capitalization, book-to-market ratio, reversal, momentum, institutional ownership and return on equity. The definitions of these variables are reported in the supplementary appendix. We include industry fixed effects and time fixed effects. All independent variables are winsorized each month at the 0.5% level. The *t*-statistics in parentheses are calculated from robust standard errors clustered by firm.

	ImpVol Average (Call + Put) / 2		*ImpVol Difference (Put – Call)*	
	(−20, +20)	(−10, +10)	(−20, +20)	(−10, +10)
	(1)	(2)	(3)	(4)
Post×Treated	2.242	1.578	0.203	0.438
	(3.09)	(3.29)	(0.51)	(1.51)
Treated	0.735	0.663	−0.138	−0.332
	(0.54)	(0.46)	(−0.31)	(−0.73)
Ln(*ME*)	−4.126	−4.182	−0.224	−0.182
	(−7.71)	(−7.55)	(−0.89)	(−1.03)
Ln(*BM*)	−0.912	−0.906	−0.284	−0.096
	(−1.11)	(−1.07)	(−0.88)	(−0.36)
Ret1	−18.862	−16.854	−1.599	−2.670
	(−2.05)	(−1.72)	(−0.97)	(−1.29)
Ret212	5.667	6.522	−0.236	−0.111
	(1.97)	(2.30)	(−0.58)	(−0.25)
Institutional ownership	3.372	5.623	1.011	0.898
	(0.83)	(1.31)	(0.97)	(0.78)
Return on equity	−40.622	−40.322	2.153	2.155
	(−2.47)	(−2.59)	(1.16)	(1.34)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Adj-R^2	0.435	0.481	0.018	0.013
# Observations	10,598	5,419	10,598	5,419