

Hedging Climate Change Risk: A Real-time Market Response Approach

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Abstract

We present a novel methodology for constructing portfolios designed to hedge economic and financial risks arising from climate change. We utilize ChatGPT-4 to pinpoint climate-related discussions during earnings conference calls and connect these time-stamped transcripts with high-frequency stock price data at the conversation level. This approach allows us to assess a company's dynamic exposure to climate change risks by analyzing real-time stock price responses to discussions about climate issues. Our proposed portfolio, constructed by taking long (short) positions in stocks with positive (negative) market responses to climate conversations, appreciates in value during periods with negative aggregate climate news shocks. Compared to portfolios constructed using existing alternative methods, our real-time market response-based portfolios demonstrate superior out-of-sample hedge performance. A key advantage of our approach is its ability to capture time-series and cross-sectional variations in stocks' rapidly-evolving exposures to climate risk, relying on the timing of when climate-related issues become salient topics that warrant conference call discussions and real-time market responses to such conversations. Additionally, we showcase the versatility of our approach in hedging other types of dynamic risks: namely political risk and pandemic risk.

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1. Introduction

Climate change stands as one of the paramount challenges of our era. Beyond its wide-ranging social implications, both the physical effects of climate change and the regulatory efforts to slow carbon emissions possess the potential to significantly disrupt economic activities (Litterman et al., 2020). In light of increasing investor awareness about the economic and financial vulnerabilities linked to climate change, there is a rising demand for financial products to hedge these risks. Yet there is a shortage of available instruments tailored to hedge against these risks (see Krueger et al., 2020; Giglio, Kelly & Stroebe, 2021; Stroebe & Wurgler, 2021). A nascent field of research suggests that investors can construct portfolios by purchasing stocks that stand to gain and selling those that stand to lose in the event of a climate risk materialization (Engle et al., 2020). Such a long-short portfolio is poised to appreciate in value when climate risks manifest, thus providing a valuable hedge against climate risk. However, dynamically discerning each stock's exposure to climate risk proves challenging, primarily due to the rapidly changing nature of a firm's vulnerability to climate change. In this paper, we introduce a novel methodology that identifies a company's dynamic exposure to climate change risks based on high-frequency real-time stock price movements during climate-related discussions in conference calls.

The key to constructing the hedging portfolio is successfully identifying assets with positive and negative climate change risk exposures. Existing hedging strategies employ two primary approaches. The first, a "narrative" approach, involves selecting long and short positions based on industry classifications (e.g., clean vs. dirty industries) or ESG scores, as seen in Engle et al. (2020), Pastor et al. (2021), and Hoepner et al. (2018). However, this approach faces two main challenges. Firstly, industry classification and ESG scores are inherently noisy, because many firms operate across multiple industries and exhibit varying climate exposures within the same industry, and there is wide disagreement among ESG rating providers on assigning ESG scores to the same firm (Berg et al., 2022). Secondly, a firm's climate change risk exposure can change rapidly over time. For instance, traditional "brown" firms may transition into

"green" firms within a short timeframe by investing in clean technologies. However, industry classification and ESG scores adjust slowly and cannot capture these swift changes in climate risk exposure.

The second approach involves a "mimicking portfolio" approach, as introduced by Lamont (2001), where climate risk series are projected onto a set of asset returns using time-series data. This method requires investors to estimate each asset's "Beta" to systematic climate risk and sort assets based on these estimated "Betas." Similar to the narrative approach, the mimicking portfolio approach encounters two key challenges. Firstly, Beta estimates inherently contain noise (Campbell et al., 2001; Cosemans et al., 2016).¹ Secondly, the mimicking portfolio approach heavily relies on the availability of a long time-series and learning from past climate risk realizations to determine how assets perform during climate shocks in the future. Consequently, estimated "Betas" based on historical data are ill-positioned to capture future developments in firms' climate risk exposure. In summary, both the "narrative" approach and the "mimicking portfolio" approach grapple with measurement challenges along two intertwined dimensions: noise and slow adjustment to evolving economic realities. In this paper, we introduce a novel methodology designed to address both of these challenges simultaneously.

Our real-time market response approach is based on two fundamental pillars: the identification of climate change discussions during conference call questions-and-answers (Q&As) and the real-time market reactions to such discussions. We retrieve time-stamped conference call transcripts for all US firms from Refinitiv between 2017 and 2021. Next, we divide the Q&A sessions of these conference calls into individual conversations exchanged between corporate managers and one specific analyst, deriving 318,031 conversations from 47,792 conference calls. Following the methodology of Sautner et al. (2023), we initially use Natural Language Processing (NLP) techniques to identify earnings call conversations where climate risk-related bigrams are mentioned. These candidate conversations are then processed through OpenAI's ChatGPT-4 to isolate discussions where climate risk is a primary focus. We subsequently

¹ For example, Campbell, Lettau, Malkiel, and Xu (2001) note that "firm-specific betas ... are difficult to estimate and may well be unstable over time."

manually verify the accuracy of ChatGPT-4's output. Finally, we align these time-stamped climate risk conversations with high-frequency stock price data sourced from the TAQ database, allowing us to observe real-time market reactions to discussions about climate risks. Through this comprehensive process, we have identified 4,105 earnings calls featuring at least one climate-related conversation across 1,150 unique firms.

We operationalize this approach by constructing long-short portfolios that purchase (short) stocks in the top (bottom) deciles of real-time market responses to climate conversations during conference calls, averaged over a rolling past four quarters. To capture the rapidly-evolving nature of firm's exposure to climate risk, we rebalance these portfolios at a quarterly frequency. In other words, a firm can enter, exit, or flip position in our portfolio from one quarter to another. The anticipated outcome is that this portfolio will appreciate when aggregate climate risk materializes. Our methodology harnesses precise real-time market responses to climate-related conversations, reducing susceptibility to measurement noise inherent in industry classifications and ESG scores, or the estimation imprecision associated with "Betas." Moreover, our approach is designed to capture the precise timing during which the stock market recognizes the materiality of a firm's climate exposure, as evidenced by analysts' interests in climate topics during conference call Q&As. The unique advantage is that our portfolio is well aligned with time-series changes in a firm's climate exposure –when a firm's climate exposure becomes material, when a firm transit between negative and positive exposure, or when a firm's climate exposure is no longer salient. Therefore, we are able to make dynamic and adaptive adjustments to evolving economic conditions, as compared to existing measures.

We observe a growing number of stocks with climate risk exposures over time, indicating an increasing awareness of this risk in the financial market. At the start of our sample period, there is an average of 100 firms with climate change risk-related conversations per quarter, which rises to approximately 250 by the end of our sample period. Interestingly, there is a nearly equal distribution of stocks with positive and negative exposures in almost every quarter. There are also several noteworthy patterns that emerge by looking at which stocks are bought or sold. Firstly, our portfolio stocks span a wide

range of industries. Secondly, in our baseline hedging portfolio, which maintains between 50 and 100 stocks throughout our sample period, there is a substantial amount of turnover. More specifically, we replace roughly one third of our hedging portfolio stocks every quarter. These frequent turnovers in the portfolio indicate that firms' exposure to climate risk can change rapidly over time, likely due to technological advancements, shifts in production methods, and evolving regulatory policies. Our methodology effectively captures these swift changes in economic reality.

In line with established practices in the literature (Engle et al., 2020), we evaluate the hedging performance of our portfolios by calculating out-of-sample correlations between monthly portfolio returns and various measures of aggregate climate shocks spanning the period from 2017Q4 to 2022Q1. We consider a range of aggregate climate shock measures as hedge targets, drawing from the expanding body of literature that constructs different time series of news related to physical and regulatory climate risks. Rather than selecting a single preferred climate risk series, we assess the portfolio performance against measures constructed by Engle et al. (2020), Faccini et al. (2021), Ardia et al. (2020), Kelly (2021), Boykoff et al. (2023), and Giglio et al. (2023), as well as attention to climate risk, quantified through Google searches. Our findings indicate that our baseline hedge portfolio consistently achieves an out-of-sample correlation of nearly 20% or more with the majority of the climate shock series, with some reaching maximum correlations well above 30%. This performance substantially surpasses the "narrative" and "mimicking-portfolio" approaches documented in Engle et al. (2020) and Alekseev et al. (2023), and is similar to the quantity-based approach proposed by Alekseev et al. (2023). Our baseline results confirm the notion that real-time market responses to climate risk conversations contain valuable information for identifying firms' time-varying exposure to aggregate climate news shocks and effectively hedging against such shocks.

Our methodology hinges on the capacity and promptness of investors to assimilate and respond to climate risk discussions during earnings calls. If investors display limited attention or delays in processing this information, our method may not accurately capture their responses. Conversely, if investors deem climate-related conversations as inconsequential, any observed stock price fluctuations during these

discussions could be attributed to noise or responses to other unrelated information (e.g., content from earlier conversations). Thus, our approach is likely to be more effective when there is heightened investor attention on climate-related issues. We next enhance our baseline method by incorporating insights from literature on investor attention and information processing.

To implement this insight, we leverage geographically localized extreme heat events and natural disasters, which previous research has demonstrated to impact beliefs and attention regarding aggregate climate risk (see, e.g., Egan & Mullin, 2012; Deryugina, 2013; Joireman et al., 2010; Li et al., 2011; Fownes & Allred, 2019; Sisco et al., 2017). We consider instances of extreme temperatures (relative to historical patterns) and natural disasters, such as hurricanes, floods, and wildfires, within a county. On average, we identify 40 firms headquartered in counties experiencing extreme temperature events and 63 firms experiencing natural disasters in a given quarter. These events are likely to draw investors' attention to climate-related issues for these companies. Consequently, market responses to climate risk topics during conference calls of these affected firms are more likely to capture investors' reactions to climate-related issues. Building on this rationale, we expand our hedging portfolio by incorporating all stocks from companies that have experienced climate risk events in the previous quarter and have climate-related conversations during the current quarter's conference calls. We maintain long (short) positions in stocks that exhibit positive (negative) price movements during climate risk-related conversations. Our expanded hedging portfolio consistently achieves an even higher out-of-sample correlation above our baseline portfolio at a level of nearly 30% or more with the majority of the climate shock series, with some reaching maximum correlations close to 60%.

The central objective of our paper is to employ our real-time market response approach to create portfolios designed to hedge against the occurrence of climate risk events. This application aligns naturally with our methodology because climate risks have only recently come under the spotlight of investor attention. Consequently, there is a scarcity of financial instruments tailored to hedge against such risks and insufficient time-series data to enable investors to accurately estimate the climate risk exposures of various

assets solely based on price data. Nevertheless, our approach can, in principle, be extended to hedge against any emerging macro-level systematic risk series that firms frequently address in their conference calls. To illustrate the versatility of our approach, we apply it to two such systematic risks: political risk and pandemic risk. In line with our findings regarding the hedging of climate risks, we demonstrate that real-time market responses to conference call conversations concerning political and pandemic risks empower us to construct portfolios that effectively hedge the impact of the corresponding macro-level shocks.

Our study contributes to the expanding body of literature that investigates the interplay between climate change and asset markets (see Giglio, Kelly, and Stroebe 2021 for an extensive review). Within the realm of equity markets, Bolton and Kacperczyk (2023) and Hsu et al. (2022) have demonstrated that firms with high carbon emissions and significant pollution are valued at a discount. Barnett (2020) has illustrated that heightened prospects of future climate policy actions result in lower equity prices for firms carrying substantial exposure to climate policy risk. Moreover, Choi et al. (2020) have reported that stocks of carbon-intensive firms exhibit underperformance during periods of unusually warm weather, likely attributed to the increased attention of investors toward climate risks during such periods. Other studies have identified the pricing of climate risk in various other asset classes, including real estate markets (Baldauf et al., 2020; Bakkensen and Barrage, 2022; Bernstein et al., 2019; Giglio, Maggiori, Rao, Stroebe, and Weber 2021; Murfin and Spiegel, 2020), and municipal bond markets (Painter 2020; Goldsmith-Pinkham et al., 2021; Acharya et al., 2022). Of particular relevance to our research focus, Engle et al. (2020) have shown that the stocks of firms with higher (lower) ESG scores tend to experience higher (lower) returns when negative news regarding climate change emerges and thus can be employed to construct long-short portfolios to hedge against adverse climate change news. To the best of our knowledge, ours is the first study to demonstrate that real-time stock price reactions to climate risk discussions during earnings calls can assist investors in constructing portfolios that hedge against climate-related risks.

The most closely related study to ours is the concurrent work by Alekseev et al. (2023). They combine data on the geographic location and trading behaviors of mutual fund managers with data on the

occurrence of localized extreme weather events to investigate which industries mutual fund managers disproportionately buy or sell following such events. Their research demonstrates that portfolios that take long (short) positions in industries that mutual fund managers are more likely to buy (sell) after localized extreme weather events can effectively hedge against the arrival of national climate news. While Alekseev et al. (2023) leverage rich cross-sectional mutual fund trading responses to local climate shocks to predict how investors will reallocate their capital in response to aggregate climate news shocks, we present an alternative and complementary approach. Our method relies on a different source of information to identify firms' time-varying exposure to climate news shocks: when analysts ask climate-related topics during conference calls as well as the direction and magnitude of market reactions to these conversations in real-time. Our approach's distinct advantage lies in its versatility. As demonstrated with political risk and pandemic risk, our approach can be applied to hedge any macro-level risk that is substantial enough to be discussed in a significant number of firms' conference calls. This approach does not require the occurrence of localized "shocks" that alter a subset of investors' beliefs. Furthermore, our approach is well-suited for hedging dynamic risks such that the pricing of such risk can be rapidly evolving. It simply requires investors' reaction to discussions of such risks in conference calls in the recent past year to have a strong correlation with how investors would respond to the same risks in the present.

Our research also contributes to the emerging literature exploring the impact of risk exposure disclosure on asset prices. On the theoretical front, Heinle, Smith, and Verrecchia (2018) delve into the consequences of risk-exposure disclosure on asset prices by reducing investors' perceptions of the uncertainty surrounding a firm's risk. Schmalz and Zhuk (2019) demonstrate that investor learning about firms' risk exposures through earnings results in increased volatility during downturns and skewness in returns. Smith (2022) investigates how risk disclosure influences information acquisition and the feedback loop from prices to investment decisions. More closely related to our work, Smith (2023) illustrates that, in the presence of short-sale constraints, climate risk disclosure can enhance the effectiveness of financial markets in facilitating risk sharing. This is because more precise knowledge about firms' climate exposures

enables investors to construct efficient climate hedging portfolios. On the empirical front, Smith and So (2022) measure the presence and timing of information related to risk, while Lyle et al. (2023) document that risk exposure disclosure reduces the uncertainty surrounding firm risk. To the best of our knowledge, our study provides the first empirical methodology and evidence on how investors can leverage firms' voluntary disclosures in conference calls to construct climate hedging portfolios.

2. Conceptual Underpinning

2.1. Climate Change Risk and Asset Prices

In a broad sense, climate risks can be categorized into physical risks and transition risks (Giglio et al., 2021). Physical risks stem directly from climate change impacts on economic activities and can change firm value. For instance, rising sea levels can potentially harm facilities near coastlines and lead to property value depreciation. Extreme temperatures can hurt the value of companies reliant on energy-intensive processes, such as those in the manufacturing or energy sectors, because these companies face operational challenges and increased costs when extreme temperatures strain energy infrastructure or disrupt supply chains. On the other hand, transition risks affect firms' operations and business models as the economy transitions towards low-carbon. Transition risks encompass regulatory changes, technological advancements, and shifts in consumer and investor preferences away from high-carbon activities. Although physical and transition risks may not materialize simultaneously, they are often correlated and can even move in opposite directions. For instance, the implementation of a carbon tax, representing a negative transition risk, could decrease the likelihood of future negative realizations of physical climate risks.

Different companies may experience divergent impacts from climate risks—transition and physical risks can create winners and losers in asset markets. For instance, in the context of water scarcity, companies heavily reliant on water-intensive operations, such as those in agriculture or certain manufacturing industries, may face increased costs or more frequent operation disruptions due to water scarcity, experiencing value destructions. Conversely, companies specializing in water-efficient technologies or alternative water sources may benefit from increased demand as they offer solutions to mitigate the impact

of water scarcity. Using carbon taxes as an example of climate transition risk, firms heavily dependent on fossil fuels and high carbon emissions, such as traditional coal or oil companies, might see a decline in their value as carbon tax increases costs and erodes profitability. In contrast, companies investing in renewable energy sources or offering energy-efficient technologies may experience an increase in value as their operations align with the goals of the climate-related policy and may even benefit from incentives or subsidies promoting cleaner practices.

Survey evidence supports the diverse risk exposures among investors. Krueger et al. (2020) reveal that among investment professionals, regulatory and technological risks hold somewhat greater significance than physical risks. Notably, a majority of respondents anticipate that regulatory climate risks are presently important, whereas physical risks are generally perceived to gain prominence over longer horizons. Strengthening this viewpoint, Stroebel and Wurgler (2021) report a consensus among finance academics, professionals, regulators, and policymakers that regulatory risks stand out as the primary climate risk for investors and firms over the next five years, with a shift towards physical risks becoming the predominant concern over the next thirty years.

Climate risk exposure manifests in numbers: prior research extensively documents the pervasive impact of exposure to climate-related risks on firm value, implying a tight connection between investor wealth and climate risk exposure. An early study by Matsumura, Prakash, and Vera-Munoz (2014) reveal an association between higher emissions and lower firm values. Similarly, Chava (2014) establish that firms with elevated carbon emissions experience a higher cost of capital. More recently, Ilhan, Sautner, and Vilkov (2021) show that carbon emission risk is reflected in out-of-the-money put option prices. Hsu, Li, and Tsou (2023) develop and test a model indicating that highly polluting firms are more vulnerable to environmental regulation risk, commanding higher average returns. Garvey, Iyer, and Nash (2018) analyze the effect of changes in direct emissions on stock returns, while Bolton and Kacperczyk (2021) find a significantly positive effect of carbon emissions on U.S. firms' stock returns for both direct and indirect carbon emissions.

Given the widespread evidence regarding the relationship between climate change and firm value, a pertinent inquiry arises: how can investors, firms, employees, and other stakeholders hedge against climate-related risks? In the following section, we demonstrate that understanding the empirical relationship between climate change and firm value offers actionable insights on utilizing financial markets to hedge climate risks.

2.2. Hedging Demand and the Choice of Hedging Target

As the awareness of climate change risks increases, stakeholders seek to safeguard their investments and operations against potential losses. For investors, effective climate risk hedging not only shields portfolios from downside impacts but also aligns with evolving environmental, social, and governance (ESG) considerations. Firms, on the other hand, aim to secure their long-term viability by mitigating the financial fallout from climate-related disruptions, ensuring operational resilience, and positioning themselves as sustainable entities in response to evolving market expectations and regulatory environments. In essence, the desire to hedge climate change risk is rooted in the pursuit of financial stability, sustainability, and resilience in the face of an increasingly uncertain climate landscape.

However, due to the long-run and nondiversifiable characteristics of climate risk, traditional futures or insurance contracts, where one party commits to compensating the other in the event of a climate-related disaster, face significant implementation challenges. The inherent difficulty lies in finding a counterparty capable of credibly guaranteeing payouts over the extended time frame and unpredictability associated with climate events that might unfold over decades. Given these constraints, investors are constrained to rely on self-insurance against climate risk. Engle et al. (2020) propose an innovative approach inspired by the logic of Black & Scholes (1973) and Merton (1973), suggesting that a dynamic hedging strategy can approximate the function of an infeasible contract directly paying off in the face of a future climate disaster. Rather than acquiring a security with a direct payoff in such an event, investors can construct portfolios designed to offset short-term return fluctuations influenced by climate change news over the holding period. Using a series of period-by-period hedges against innovations in news about long-run climate change, an investor

can ultimately hedge her long-run exposure to climate risk. Although this portfolio may exhibit a lower Sharpe ratio in the short run compared to the Markowitz mean-variance efficient portfolio, the dynamic hedging approach is positioned to compensate investors for potential losses stemming from the realization of climate risk in the long run.

An emerging stream of literature has used news about long-run climate risk to design an effective hedge target. Engle et al. (2020) construct a climate news index derived from coverage of climate change in The Wall Street Journal (WSJ). This methodology is grounded in the premise that events containing pertinent information on changes in climate risk are likely to be covered by major newspapers, with newspapers serving as a direct information source for investors to update their subjective probabilities of climate risks. The topics covered by newspapers that may carry relevant information span a broad spectrum, including extreme weather events (e.g., floods, hurricanes, droughts, wildfires, extreme temperatures), physical changes to the planet (e.g., sea level changes, glacial melting, ocean temperatures), regulatory discussions, technical progress in alternative fuel delivery, and the price of fossil fuels. The frequency of climate news coverage steadily increases over time and spikes around notable global climate events. Engle et al. (2020) interpret the escalating coverage of climate-related topics as the emergence of adverse news regarding future climate change. They validate this approach by supplementing their WSJ-based analysis with additional sentiment-based examinations of climate coverage in newspapers.

Building upon the groundwork laid by Engle et al. (2020), subsequent research has generated diverse climate news series reflecting various climate risks. In this study, we adopt a neutral stance on the optimal hedge target, recognizing that the most suitable choice depends on individual investors' distinct risk exposures. For instance, institutional investors heavily invested in sectors susceptible to physical climate risks, such as coastal real estate or agriculture, may prioritize safeguarding against value depreciation linked to extreme weather events. Investors concentrating on the energy sector might opt to hedge against transition risks, particularly if their portfolios involve fossil fuel-dependent companies facing potential value declines from regulatory shifts or evolving consumer preferences. Consequently, the motivations for

climate risk hedging can significantly differ among investors, shaped by their portfolio composition, investment goals, and ethical principles. Following the methodology of Alekseev et al. (2023), we evaluate the efficacy of our approach in hedging various types of climate news shocks, considering a comprehensive array of measures that have been developed in recent empirical studies. More details are described in Section 5 and Appendix C.

2.3. Hedge Portfolio

With the climate news shocks at hand as hedge targets, the next step is to systematically identify stocks that exhibit positive or negative responses when (negative) news about climate change emerges. The underlying strategy is to strategically hold or overweight stocks that appreciate in value with the occurrence of (negative) climate change news, while shorting or underweighting stocks that depreciate in such circumstances. By building a portfolio that emphasizes stocks performing well during adverse climate news, investors position themselves to capitalize on future instances of negative climate-related developments. The continual adjustment of this portfolio based on evolving information regarding the association between climate news and stock returns leads to a portfolio that is long on climate change winners and short on losers. To dynamically identify firms experiencing value increases or decreases in response to climate change news, Engle et al. (2020) adopt a “narrative approach” by using the E-component in ESG-Scores, reflective of a firm's environmental friendliness, as proxies for climate risk exposures. The hedge portfolio prioritizes firms with high E-Scores and reduces exposure to those with low E-Scores, with relative weights dynamically updated as more data on the interplay among E-Scores, climate news, and asset prices become available. Engle et al. (2020) demonstrate an out-of-sample correlation of 20% between the hedge portfolio's return and innovations in the WSJ climate change news index.

Recent research by Alekseev et al. (2023) introduces an innovative methodology for constructing hedge portfolios, leveraging insights from mutual fund managers' trading decisions. This approach capitalizes on the correlation between extreme local weather events, such as periods of intense heat or drought, and shifts in individuals' perceptions of climate change severity. Their study focuses on identifying

industries that mutual fund managers disproportionately buy or sell in the aftermath of such extreme local weather events. Although the individual trading responses may not significantly impact equilibrium prices, they offer valuable insights into market-wide trading behavior in anticipation of yet-to-be-observed climate-related news. The authors provide compelling evidence that portfolios adopting long positions in industries preferred by mutual fund managers following extreme weather events, coupled with short positions in industries they are predisposed to sell, significantly outperform alternative strategies like the "narrative approach" in effectively hedging against diverse national climate news series.

2.4. Real-time market reactions to Q&A conversions at conference calls

Early research recognizes earnings conference calls serve as a disclosure mechanism for managers to communicate information to capital markets and have information content (e.g., Frankel et al., 1999; Bowen et al., 2002; Kimbrough, 2005). Matsumoto et al. (2011) show that both the management presentation and Q&A discussion segment of the call are incrementally informative over the accompanying earnings press release. Moreover, over the conference call, the Q&A discussions between managers and analysts are relatively more informative than management presentations, and the additional information content is likely from analysts' involvement. Subsequent research focuses on characteristics of the call that affect its information content and finds that both managers and analysts can influence the amount of information conveyed by, and therefore the market reactions to, conversations in the Q&A discussions. Such characteristics include managers' tone (Price et al., 2012), linguistic complexity (Bushee et al., 2018), knowledge (Li et al., 2014), disclosure horizon (Brochet et al., 2015), spontaneity (Lee, 2016), vocal cues (Mayew and Venkatachalam, 2012; Mayew et al., 2020). Analysts differ in whether they ask probing questions to managers (Frankel et al., 2010) and their ability to elicit information from managers by asking questions (Yezege, 2022).

Recent literature maps intra-day returns to specific analyst-manager dialogs and finds that variations exist in the informativeness of individual question-and-answer conversations between managers and analysts. Mayew et al. (2020) show that manager dialogs with bearish analysts whose forecasts are

missed are more informative, likely because these analysts ask longer and more negative questions and require more back-and-forth iterations with managers. Rennekamp et al. (2022) show that the level of engagement in manager-analyst Q&A exchanges is positively associated with absolute stock returns during the conversation, indicating that more engaged conversations provide greater informative content to capital markets.

Building on prior literature on real-time market returns to conference call conversations, our methodology for constructing a climate risk hedge portfolio is grounded in two key components: an analysis of climate change risk discussions during conference calls and the real-time market reactions to these discussions. The subsequent section outlines the details of our sample construction process.

3. Sample Construction

3.1. Time-stamped Conference Call Transcripts

We obtain earnings call transcripts along with their associated time stamps from Refinitiv Workspace. This platform is recognized for its comprehensive coverage of transcripts related to earnings, guidance, mergers and acquisitions, and other corporate conference calls involving a global cohort of over 7,200 companies. The Refinitiv platform features synchronized textual content with audio components, and the beginning and ending time stamps for each paragraph are embedded in the transcripts. Refinitiv highlights that the time stamps are generated through a collaborative process involving both automated recognition and human oversight. Since it is critical that we accurately identify the timestamp of each conversation, we further validate the reliability of Refinitiv's timestamped transcript by conducting a manual verification on a substantial sample (100 transcripts). We verify that the time disparity is less than one second, providing robust affirmation of the consistency and reliability of the dataset. An example of the transcript data is in Appendix A1.

As discussed by Cao, Flake, and Liu (2023), an inherent challenge in the real-time analysis of granular conference data is the discrepancy between the relative time assigned to each textual component

within a transcript (relative to the start of the audio file) and the absolute real-world time that a conversation takes place. This issue arises since it is a common practice that the transcript audio files start from the second of the first word of the operator instead of the scheduled conference starting time. A slight delay at the start of a conference call can lead to a misalignment between the calculated timestamp of a conversation (based on the scheduled conference starting time) and its actual timestamp. To address this, following the approach recommended by Cao, Flake, and Liu (2023), we adjust (push back) the relative time stamp by 90 seconds. This correction is based on our manual examination of 40 conferences, indicating that audio files typically commence approximately 90 seconds after the scheduled time. Our unit of observation is at the conversation level, delineated by the exchange of dialogues between a specific analyst and managers, each with a defined starting and ending time for alignment with intraday data.

3.2. Identifying Climate Change Risk Conversations using NLP and LLM Tools

We began our study with a dataset of 47,792 earnings call transcripts from the universe of US companies on Refinitiv from January 2017 to December 2021, covering 318,031 conversations. Our initial task was to identify discussions related to climate change risks. To identify discussions related to climate change risks, our initial step is to use NLP techniques to identify conversations with at least one climate change bigrams developed by Sautner (2023), resulting in 16,568 candidate conversations from 2,948 firms.² Given the importance of focusing on conversations where climate risk is the primary subject—to solidly link real-time market responses to the company's climate risk exposure at the time of the earnings call—we processed these candidate conversations through OpenAI's ChatGPT-4. This model helped isolate discussions where climate risk was central.

Due to the complexities of defining "climate change" precisely, we employed a "zero-shot prompting" technique with ChatGPT-4. We presented the text of each candidate conversation as a prompt,

² Sautner (2023) introduced an innovative method for creating four distinct sets of climate change bigrams within earnings calls. The first set encompasses broadly defined aspects of climate change, while the remaining three measures are dedicated to specific climate change "topics." These specific topics include opportunities, physical shocks (such as sea level rise), and regulatory shocks (including carbon taxes and cap and trade markets). In total, there are 9,641 unique bigrams.

asking the model to classify each as either "Related to Climate Change" or "Not Related to Climate Change" and to provide a rationale. The model's responses, which included classification and rationale, allowed us to assess whether GPT-4 accurately understood and responded to the prompts. Out of the initial set of 16,568 candidate conversations, ChatGPT-4 classified 5,910 conversations with primary focus on climate change. We subsequently manually verify the accuracy of ChatGPT-4's output for a random subsample of 100 conversations. For detailed documentation, Online Appendix C1 explains the prompt format used with the ChatGPT model, Online Appendix C2 provides examples of conversations identified as related to climate change along with the GPT's responses, and Online Appendix C3 contrasts two cases where the bag-of-words algorithm and GPT's classifications diverged. The latter two cases showcase the necessity of using GPT to filter candidate conversations identified using the bag-of-words approach: although both conversations mention climate-related bigrams, climate risk is at best a secondary topic in these discussions.

3.3. Real-time Market Reaction to Conference Conversations

Our intraday price and quote data are obtained from the NYSE Trade and Quote (TAQ) database. Earnings calls held during regular trading hours are matching with the trading information available within the TAQ database. However, approximately half of our sample's earnings calls take place after trading hours, making the corresponding trading data inaccessible. For these instances, we match the calls with quote data since the predominant reflection of earnings surprises in price changes occurs through quotes rather than trades, which suggests the feasibility of using quote data to measure market reaction (Grégoire and Martineau, 2021). We clean our intraday trading price data following methodologies established in prior literature (Barndorff-Nielsen et al., 2009; Bollerslev et al., 2016; Bollerslev et al., 2020). Appendix A provides more details.

Following Grégoire and Martineau (2021), we further deal with extreme fluctuations in the quote data. Intra-day bid-ask spreads can exhibit extreme fluctuations, often reflecting noise rather than information. For example, extreme spreads with a bid price of \$ 0.01 and ask prices of \$199,999 can exist in the TAQ database. To address this concern, we retain quote data where the bid-ask difference, relative

to the mid-quote value, is below 20%. This filtering process ensures the reliability of our data by mitigating extreme fluctuations (Grégoire and Martineau, 2021). To further ensure climate change as the primary topic of relevance, we exclude conversations that are either less than one minute or exceed ten minutes in duration. Additionally, we remove conversations that lack trading or quote information or have zero market reactions. In cases where a single conference transcript contains multiple conversations related to climate change, we take the average market reaction across all climate-related conversations. The final sample consists of 4,150 earnings calls with at least one climate-related conversation from 1,150 unique firms.

We provide two examples of climate-related conversations and their associated real-time market reactions in Appendix B. The first example involves AptarGroup, Inc. (Aptar), a manufacturer of consumer dispensing packaging and drug delivery devices. The conversation discusses plastic beverage packaging and Aptar's plan to create more sustainable plastic packaging. It generated a positive market reaction (5.55%). In the second example, analysts are concerned about setbacks in Livent's partnership and investments in Nemaska Lithium, a producer of lithium. In addition, low Lithium prices and Livent's unprofitability generated further negative market reactions (-8.72%).

3.4. Extreme Temperature and Natural Disaster Data

We obtain data on extreme heat events and natural disasters from the Spatial Hazard Events and Losses Database for the United States (SHELDUS) and PRISM Climate Group. Following Alekseev et al. (2023), we identify extreme heat events if either of the three criteria is met. The first criterion captures whether there were any fatalities or injuries attributed to extreme heat within a county using data from SHELDUS. The second criterion for extreme heat events is based on crop indemnity payments and utilizes data collected by the U.S. Department of Agriculture, with a version managed by SHELDUS. The third criterion involves the examination of temperature data obtained from the PRISM Climate Group. More specifically, we identify extreme heat county-months where the maximum temperature exceeds the county's ten-year historical average maximum for the same month by at least 4 degrees Celsius (7.2 degrees Fahrenheit). In addition to extreme heat events, we incorporate 13 other types of natural disasters from the

SHELDUS database, including wind, severe storms/thunderstorms, flooding, winter weather, hail, tornadoes, lightning, drought, hurricanes/tropical storms, wildfires, coastal events, fog, and tsunami/seiche occurrences. The sample consists of 11,657 natural disaster events spanning 3,114 counties over the period from 2017 to 2021.

4. Hedging Portfolio Construction

4.1. Portfolio construction approach

Our approach to constructing climate risk hedge portfolios relies on the idea that real-time market reactions to climate-related conversations at conference calls reflect investors' assessment of a firm's contemporaneous climate risk exposure. We form two portfolios: a baseline portfolio, solely based on conference call conversations, and a refined "complete" portfolio that additionally leverages local climate shocks, which draw market attention to climate-related topics for local firms. In the baseline portfolio, we assess a firm's risk exposure in a given quarter by considering market reactions to climate change-related conversations during the firm's earnings conference calls using a rolling window of the preceding four quarters.³ For example, when determining ConocoPhillips' climate risk exposure at the beginning of 2022Q1, we compute the average market reactions to climate-related conversations in ConocoPhillips' earnings conference calls over the past four available quarters (i.e., 2020 Q4 to 2021Q3), which were -0.03%, missing, -0.11%, and -0.14%, respectively. Since no climate-related conversations occurred in the 2021Q2 earnings call, we utilize the average market reaction of -0.09% (the average of -0.03%, -0.11%, and -0.14%) as a measure of ConocoPhillips' climate risk exposure in 2022Q1.

We operationalize this real-time conversation approach by constructing long-short portfolios that purchase (sell) stocks in the top (bottom) deciles of average market responses to climate conversations during the previous four quarters. We rebalance these portfolios at a quarterly frequency. In robustness analyses, we consider other long-short thresholds, such as top and bottom 20% and 30%.

³ Our first hedging portfolio is formed in 2017Q4 based on earnings calls in the previous three quarters from 2017Q1 to 2017Q3. All subsequent hedging portfolios are formed based on earnings calls in the previous four quarters.

Exhibit 1: Climate Risk Exposure Measurement

ConocoPhillips (COP) Climate Risk Exposure in The First Quarter of 2022

Baseline Portfolio

2020Q4 Earnings call Feb. 2, 2021 -0.03%	2021Q1 Earnings call May 4, 2021 -0.11%	2021Q2 Earnings call Aug 3, 2021 NA	2021Q3 Earnings call Nov. 2, 2021 -0.14%	Climate Risk exposure in 2022Q1 -0.09%
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Complete Portfolio

<p>In 2021, the winter storm that occurred from February 13 to 17 had a detrimental impact on Harris County, where the headquarters of ConocoPhillips is located.</p>	2021Q1 Earnings call May 4, 2021 -0.11%	Climate Risk exposure in 2022Q1 -0.11%
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Our methodology relies on real-time market responses to climate-related conversations, and its effectiveness is contingent on how swiftly investors process and react during conference calls. If investors exhibit limited attention and experience delays in processing this information, our approach may inadequately capture their responses. Borrowing insights from the investor attention literature, we posit that local climate-related events should direct investors' attention toward climate issues in that locality. Specifically, when a county experiences a significant climate-related event, market reactions in the subsequent earnings calls of firms headquartered in that county should more accurately mirror their risk exposures to climate challenges. For example, during a severe winter storm affecting Harris County, where ConocoPhillips is headquartered, between February 13 and 17, 2021, we anticipate heightened investor attention on climate change-related conversations in the upcoming 2021Q1 earnings call. This renders the market reaction in this call a more precise proxy for the risk exposure in the first quarter of 2022. In cases

where no natural disaster events occurred in the preceding four quarters, we continue to use the average exposure, as in the baseline portfolio.

To construct the complete portfolio, we expand our baseline portfolio by incorporating all stocks from companies that have experienced climate risk events in the previous quarter and have climate-related conversations during the current quarter's conference calls. We maintain long (short) positions in stocks that exhibit positive (negative) price movements during climate risk-related conversations in these companies.

4.2. Case Studies

A key advantage of our portfolio construction approach is its ability to capture time-series and cross-sectional variations in stocks' exposures to climate risk, which can evolve rapidly. This approach hinges on the timing of when climate-related issues become prominent in earnings conference call discussions and the real-time market reactions to such conversations. Consequently, our method effectively tracks companies' changing exposure to climate risk. A company might initially enter our portfolio's long (or short) leg, be removed when its exposure diminishes, and potentially shift to the short (or long) leg if its exposure reverses. In this section, we examine two case studies that demonstrate our approach's capacity to track companies' swiftly changing exposure to climate risk. We provide detailed case studies in Online Appendix D.

The first case is about OGE Energy Corporation, an established player in the Oklahoma energy market, operates through its subsidiary Oklahoma Gas and Electric (OG&E), which services around 887,000 customers in Oklahoma and Western Arkansas. OG&E, with a mix of 66% natural gas, 26% coal, and 8% renewable energy sources, has navigated the evolving regulatory landscape focusing on emissions reductions and climate policies. This adaptation includes pioneering a Smart Grid system in 2018, enhancing responsiveness and efficiency within its network.

OG&E enters our portfolio's long position in early 2019. In the 2019 Q1 earnings call, CEO Robert Sean Trauschke highlighted the successful grid modernization in Arkansas, which likely bolstered investor confidence, with a 3.7% increase in stock price around the climate-related conversation. This modernization, which improves resilience against extreme weather, enhances integration with renewable energy sources, increases energy efficiency, and supports broader electrification, positions OG&E favorably amidst rising climate-related demands. In November 2020, OG&E shifts from a long to a short position in our portfolio. This shift is likely due to the looming regulatory and transition risks related to climate change mentioned by the CEO during the Q4 2020 earnings call, coupled with investors' concerns about the CEO's vague responses to questions about the company's long-term strategy in light of the industry's pivot towards sustainable practices during the COVID-19 pandemic. The stock return reaction to the climate-related conversation in the call was -2.1%.

The second case study features Clean Energy Fuels Corporation, established in 1997 and headquartered in Newport Beach, California, stands out in the sustainable energy sector by focusing on creating natural gas filling stations for vehicle fleets across North America. Under the leadership of co-founder and CEO Andrew J. Littlefair, the company promotes the use of compressed natural gas (CNG) and liquefied natural gas (LNG) but primarily advocates for renewable natural gas (RNG) sourced from organic waste like livestock manure. This sustainable approach aligns with environmental regulations and aims to reduce carbon emissions by 300% compared to traditional diesel, supporting 25,000 vehicles daily through a network of 600 fueling stations. The company's commitment to RNG not only addresses the significant greenhouse gas emissions from the U.S. transportation sector.

In 2017 Q2 and Q3 earnings calls, Clean Energy Fuels experienced fluctuations in investor confidence due to uncertainties related to climate-related regulations and the company's strategic direction. Early in the year, CEO Littlefair's vague remarks regarding upcoming regulations and the company's slow adaptation to market shifts towards electric vehicles contributed to a short position in Clean Energy's stock in our portfolio. Investors were likely concerned about the company's alignment with evolving

environmental standards and the growing preference for electric vehicles over natural gas solutions, resulting a -1.5% stock price drop during climate-related conversations. However, by the end of 2018, the company had successfully shifted its strategy to better leverage regulatory changes and formed significant partnerships, such as with Total Energies Gas and Power and the Harbor Trucking Association. This shift was underscored by the introduction of the "Zero Now Lease Program," which made natural gas vehicles more financially accessible, reflecting positively in stock performance with an average increase of 1.2% during climate-related conversations in 2018 Q1 to Q3 earnings calls, thereby transitioning to a long position in our portfolio.

5. Climate Risk Hedge Targets

Climate change encompasses a spectrum of risks that are imperfectly correlated, including physical threats such as extreme weather and climate transition risks such as the uncertain risk of adjustment toward carbon neutrality (Bolton and Kacperczyk, 2023). To capture these risks, recent literature has adopted a news-based approach to construct a time series that captures news about climate risks. The intuition is that events containing relevant information about shifts in climate change are likely to be covered in news outlets, including newspapers and Television programs. We build on the insights of Engle et al. (2020), which argue that to hedge against a slow-moving long-term risk such as climate change, a hedge can be constructed as a sequence of short-live hedges against *news* about future realizations of these risks. This approach has been adopted in a number of recent studies, for example, Stecula and Merkley (2019), Ardia et al. (2020), Alekseev et al. (2023), and Giglio et al. (2023). Following Alekseev et al. (2023), we remain agnostic of the choice of hedge target by gathering a broad range of measures proposed in the recent literature that overlaps with the time series of our transcript data. For a given climate change news series, we use the AR(1) innovation as the hedge target (Engel et al., 2020; Alekseev et al., 2023). The list of climate change news series is described in Appendix C. Since the first four series (TV, NEWS, GOOGLE, and NYT) span our entire sample period, they constitute the main set of series we use in constructing the hedging targets.

6. Evaluation of Hedge Portfolios

In this section, we evaluate the hedging performance of our portfolios. We start by examining several notable patterns. First, Table 1 reveals a growing number of stocks with climate risk exposures over time, signaling an increasing awareness of this risk in the financial market. In Column 2 (after filtering out extremely lengthy and short conversations), we find that at the onset of our sample period, there is an average of 100 firms engaged in climate change risk-related conversations per quarter, which rises to approximately 250 by the end of our sample period. Notably, Columns 3 and 4 highlight an almost equal distribution of stocks with positive and negative exposures in nearly every quarter. The baseline hedge portfolio initially comprised 50 stocks, increasing to 100 stocks towards the end of our sample period. For the complete hedge portfolio, which includes baseline stocks plus those affected by extreme temperatures or natural disasters, the numbers range from 120 to 240 stocks.

There are also several noteworthy patterns that emerge by looking at which stocks are bought or sold. Tables 2A and 2B show that our portfolio stocks cover a broad spectrum of industries. While they include firms in “polluting” sectors heavily exposed to climate risks, such as energy, utilities, and capital goods, they also encompass stocks in retailing, commercial and professional services, semiconductor equipment, and other sectors. In Tables 3A and 3B, we analyze the decomposition of our baseline and complete portfolios, respectively. The baseline hedging portfolio, maintaining between 50 and 100 stocks throughout our sample period, exhibits significant turnover, with around one-third of stocks being replaced each quarter. This high turnover underscores the dynamic nature of firms' exposure to climate risk, highlighting the ability of our approach to capture dynamic changes in technological advancements, shifts in production methods, evolving regulatory policies, and consumer and investor preferences. Our methodology adeptly captures these rapid changes in economic reality, a pattern also evident in the complete hedging portfolio (Table 3B).

As a criterion for assessing hedging performance, we compare out-of-sample correlations between hedging portfolio returns and AR(1) innovations to various climate news series for each month in our testing period (2017Q4-2022Q1). Table 4 presents these correlations, where each row represents a distinct hedge

portfolio, such as the 10% portfolio that involves sorting stocks based on their exposure to climate change risk and taking long (short) positions in the top (bottom) decile. Each column corresponds to a different climate news series, all coded so that higher values denote negative climate news. As a result, positive correlations indicate successful hedges. The same information is depicted in Figures 1 and 2, where each point in the dot plot represents the out-of-sample correlation coefficient of a hedge portfolio return with a climate news series. The various colors represent different news series, with the first four (TV, NEWS, GOOGLE, and NYT) spanning our entire sample period, while the remaining columns in Table 4 and the second panel in Figures 1 and 2 pertain to hedge targets covering specific periods within our sample.

Our portfolios emerge as robust hedges for the Boykoff et al.(2023)'s TV index and NEWS index, GOOGLE climate-risk search index, and Giglio et al.(2023)'s New York Time index, with the long-short portfolio of the top and bottom deciles (P10%) being the best performer. The results underscore the consistent out-of-sample correlation of nearly 20% or more achieved by our baseline hedge portfolio with the majority of climate shock series, with some correlations approaching maximum values above 30%. This level of performance markedly surpasses the "narrative" and "mimicking-portfolio" approaches documented in Engle et al. (2020) and Alekseev et al. (2023), and aligns closely with the quantity-based approach proposed by Alekseev et al. (2023). These findings suggest that our real-time market response based portfolios effectively hedge a spectrum of climate risks, encompassing both physical and transition risks. As our approach is not tailored to specific climate targets, its robust performance across various measures implies an effective hedge against a shared, common component of climate risks considered in our analysis.

Transitioning to our expanded "complete" hedging portfolio, we first verify whether extreme heat shocks and natural disasters indeed lead to increased investor focus on climate risks of firms headquartered in affected areas. In Online Appendix B, we examine whether climate risk conversations correlate with more extended earnings call discussions and more significant stock price reactions in the quarter following such environmental shocks to a firm's headquarters county. We control for firm and year-quarter fixed

effects. We find that climate risk conversations linked to 0.1% higher absolute stock returns and are 5% longer after a firm's headquarter county experience an environmental shock in the previous quarter, supporting the notion of heightened market attention to these issues.

Panel b of Table 4 and Figure 2 report the hedging performance of the complete portfolio. We observe consistently higher out-of-sample correlations compared to our baseline portfolio, approaching 30% or more, with some reaching maximum correlations exceeding 50%. The long-short portfolio of the top and bottom deciles (P10%) remains the most effective, boasting superior performance and requiring minimal trading costs. Both the baseline and complete portfolios exhibit similar proficiency in hedging various other climate news shocks (as shown in the remaining columns of Table 4 and Panel b of Figures 1 and 2). However, we caution that these results are derived from a specific segment of our overall sample period.

Our "complete" portfolio includes all stocks that have encountered either a heat shock or a natural disaster shock in their headquarters county in the preceding quarter and engage in climate-related discussions during the current quarter's earnings calls. The inclusiveness of this approach prompts the question: should we consider all these firms, or would it be more beneficial to include solely the top and bottom deciles of firms based on their stock price responses to climate conversations? Table 5 provides an overview of the quarterly count of stocks affected by extreme temperatures and natural disasters, ranging between approximately 100 and 160. To assess hedging performance within this "shocked" stock sample, we formulate hedge portfolios exclusively based on these stocks. Specifically, we progressively broaden the portfolio by incorporating the top and bottom 10%, 20%, and 30% of stocks based on the magnitude of their stock return responses to climate conversations. The outcomes are detailed in Table 6. Across various climate-related news series, the hedge performance of the larger portfolio (P30%) consistently yields superior results. This observation implies that climate shocks significantly amplify investor attention to climate discussions during earnings calls, and even mild stock price reactions to such discussions encompass substantial information regarding the stock's exposure to climate risk.

In our final analysis, we explore the extent to which common factors, specifically the three and five Fama-French factors, contribute to the return correlations of the hedge portfolios. To examine the factor loadings, we run regressions of the hedge portfolio excess returns on the returns of the market and Fama-French factors. The results, presented in Tables 7 and 8, reveal that a few portfolios exhibit a significant loading on the market, but none demonstrate a consistently significant loading on Fama-French factors. In addition, the time-series variation in the Fama-French factors captures, on average, less than 20% of the variation in the hedge portfolios. These results suggest that a common loading on the Fama-French factors is not the primary driver of the high return correlations observed across the different hedge portfolios.

7. Hedging Other Emerging Risks

The primary aim of our paper is to utilize our real-time market response approach for constructing portfolios aimed at hedging against climate risk events. Although our methodology naturally aligns with this application, it holds the potential to be extended to hedge against any emerging macro-level systematic risk series frequently addressed by firms in their conference calls. To showcase the adaptability of our approach, we briefly explore two alternative applications: political risk and pandemic risk. We identify conversations related to political risks and epidemic diseases using the methodology developed by Hassan et al. (2020) and Hassan et al. (2023), respectively. In essence, we identify these conversations by locating words or bigrams found in the dictionaries provided on the authors' website.⁴ Our analysis yields a total of 32,620 earnings call conversations related to political risks from 2017 to 2021 and 8,574 earnings calls with conversations pertinent to epidemic diseases, specifically from 2020 to 2021. The hedge target for political risk comes from the Newspaper-based Economic Policy Uncertainty index (EPU), while the hedge target for pandemic risk comes from the newspaper-based infectious disease equity market volatility tracker developed by Baker, Bloom, David, and Kost (2019). Details of these hedge targets are included in Appendix C.

⁴ <https://github.com/mschwedeler/firmlevelrisk>

As depicted in Figure 3, consistent with our findings regarding the hedging of climate risks, we demonstrate that real-time market responses to conference call conversations concerning political and pandemic risks empower us to construct portfolios that effectively hedge the impact of the corresponding macro-level shocks. Further details on the performance of our portfolios in hedging political and pandemic risk are provided in the Online Appendix A.

8. Conclusion

We present a novel methodology designed to construct portfolios that effectively hedge against economic and financial risks stemming from climate change. Our strategy capitalizes on real-time market responses to climate change-related discussions during conference calls. Through the integration of time-stamped conference call transcripts with high-frequency stock price data at the conversation level, we discern a company's dynamic exposure to climate change risks, relying on real-time stock price movements during climate-related conversations. The proposed portfolio strategy entails taking long positions in stocks with positive market responses to climate conversations and short positions in those with negative market responses. This portfolio exhibits appreciation in value during periods characterized by negative aggregate climate news shocks. Notably, our real-time market response-based portfolios demonstrate superior out-of-sample hedge performance when compared to portfolios constructed using existing alternative methods.

A distinctive advantage of the real-time market response approach lies in its capacity to extract valuable information from the timing when the market deems climate-related issues material enough for discussion in conferences, coupled with the magnitude of market response to such conversations. To illustrate the versatility of this approach, we successfully construct hedge portfolios for political risk and pandemic risk. We acknowledge the potential for future research to delve into a more comprehensive investigation of how our approach can be extended to hedge against other emerging systematic risks.

Our approach and findings bear significant policy and practical implications. Globally, and notably in the United States, there is a growing emphasis on climate-related disclosure by businesses. The U.S. Securities and Exchange Commission has recently proposed a rule mandating public companies to report

their greenhouse gas (GHG) emissions, aligning with similar initiatives in the European Union (EU) and the United Kingdom.⁵ Beyond the rationale of providing investors with information on material risks and exerting pressure on firms to reduce emissions (Greenstone et al., 2023), our research indicates an additional, perhaps less recognized, benefit of climate disclosure—enabling investors to proactively hedge climate change risk by dynamically revealing firms' exposure to such risks.

In practice, there is a prevalent concern among investors regarding insufficient disclosure by portfolio firms, impeding the construction of suitable hedging instruments. For instance, Ilhan, Krueger, Sautner, and Starks (2023) provide survey evidence revealing that a majority of global institutional investors "consider climate risk reporting to be at least as important as financial reporting, with almost one-third considering it more important." Additionally, Krueger, Sautner, and Starks (2020) present survey findings suggesting that "many market participants, including institutional investors, find climate risks difficult to price and hedge, possibly because of their systematic nature, a lack of disclosure by portfolio firms, and challenges in finding suitable hedging instruments." Our approach addresses this concern by providing investors with an effective hedging instrument based on firms' voluntary disclosure in conference calls.

⁵ See <https://www.sec.gov/news/press-release/2022-46>, and <https://www.sec.gov/files/33-11042-fact-sheet.pdf>.

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Appendix A1. Retrieving Time-stamped Conference Call Transcripts

The figure below illustrates the standard format of transcripts in Refinitiv Workspace. Each sentence is timestamped relative to the beginning of the audio file, and clicking on a sentence will play the corresponding segment of the audio.

The screenshot displays the Refinitiv Workspace interface for an audio recording titled "Q4 2020 APPLE INC EARNINGS CALL". The player is paused at 00:28:13/01:00:35. A search bar is present above the transcript. A teal notification box states: "Note: Click on transcript text to play audio." The transcript text is as follows:

...with a very positive response, we expect a more revenue to grow during the December quarter despite shipping a more 12 and 12 Pro 4 weeks into the quarter and a more 12 mini and 12 Pro Max 7 weeks into the quarter. We expect all other products in aggregate to grow double digits, and we also expect Services to continue to grow double digits.

For gross margin, we expect it to be similar to our most recent quarters despite the costs associated with the launch of several new products. For OpEx, we expect to be between \$10.7 billion and \$10.8 billion. We expect OI&E to be around \$50 million and the tax rate to be around 16%.

Finally, today, our Board of Directors has declared a cash dividend of \$0.205 per share of common stock payable on November 12, 2020, to shareholders of record as of November 9, 2020. With that, let's open the call to questions.

Tejas Gala, Apple Inc. - IR Contact 5

Thank you, Luca. (Operator Instructions) Operator, may we have the first question, please?

QUESTIONS AND ANSWERS Return to top

Operator 1

We'll hear first today from Shannon Cross, Cross Research.

Shannon Siemsen Cross, Cross Research LLC - Co-Founder, Principal & Analyst 2

Tim, can you talk a bit more about China? And in terms of linearity, I think, Luca, you'd mentioned that Services in all regions were at an all-time high. I'm not sure exactly what your comment was. But maybe give us a little idea of whether you're seeing any blowback or benefit from the Huawei situation and just dig a bit more into the trends you're seeing in China. And then I have a follow-up.

Timothy D. Cook, Apple Inc. - CEO & Director 3

Thanks, Shannon. If you look at China and look at last quarters – I'll talk about both last quarter and this quarter a bit. Last quarter, what we saw was our non-iPhone business was up strong double digit for the full quarter. And then if you look at iPhone and you look at it in 2 parts: one, pre-mid-September, which is pre the point at which the previous year we would have launched iPhones, that, that period of time, which was the bulk of the quarter, iPhone was growing from a customer demand point of view. And of course, the – not shipping new iPhones for the last 2 weeks of September makes that number in the aggregate a negative.

But the net is the underlying business in China last quarter was very strong and perhaps very different than you might think from just a quick look at the stated number.

In terms of this quarter, given the explanation for last quarter and the momentum that we've got, and as importantly, given the initial data points that we see on iPhone 12 and iPhone 12 Pro, although we don't guide to revenue, as Luca said, I would tell you that we are confident that we will grow this quarter in China. And so we're very bullish on what's going on there.

Appendix A2. Cleaning the TAQ Data

To clean the TAQ data, we begin the removal of entries satisfying at least one of the following criteria: 1) prices that are equal to or less than zero; trade sizes that are equal to or less than zero; 2) corrected trades (i.e., trades flagged with a Correction Indicator, CORR, other than 0, 1, or 2); 3) an abnormal sale condition (i.e., trades for which the Sale Condition, COND, has a letter code other than @, *, E, F, @E, @F, *E, or *F). Following this initial filtration, we assign singular values to each variable for every second. In instances where one or multiple transactions occur within the same second, we derive the sum of volumes, aggregate trade counts, and the volume-weighted average price for that temporal interval. In cases where no transactions transpire within a given second, we assign zero values to both volume and trade counts. Regarding the volume-weighted average price, we employ the most proximate entry from the preceding second.

Appendix B. Examples of Climate Conversations

Example 1: AptarGroup, Inc.

AptarGroup, Inc. (Aptar) is a manufacturer of consumer dispensing packaging and drug delivery devices. This conversation discusses plastic beverage packaging and Aptar's plan to create more sustainable plastic packaging. It generated a positive market reaction (5.55%).

George Leon Staphos, BofA Merrill Lynch, Research Division - MD and Co-Sector Head in Equity Research

I guess, the first question I had was on beverage trends and kind of a two-part. One, the -- in china, you've been managing against this issue now for probably, I don't know, 1.5 years. When should we, if it's possible to discern anniversary that beverage closure issue in china? When will the comps turn flat to positive at least in terms of that issue? And relatedly, what are your customers saying more broadly about their **use of plastic for beverages**, from water to -- in everything else, energy drinks, et cetera?

Stephan B. Tanda, AptarGroup, Inc. - President, CEO & Director

On the first topic or question, you're being very kind with the term managing. That's the reality.

George Leon Staphos, BofA Merrill Lynch, Research Division - MD and Co-Sector Head in Equity Research

That's how we are, stephan.

Stephan B. Tanda, AptarGroup, Inc. - President, CEO & Director

Yes. The china beverage customer is -- constitutes a very good business, but we have very limited visibility both on the end-user demand as well as on the customer orders. So I've called the anniversary before, so I'm not going to do it, again, since I've been wrong. I'll bet that this business, it will continue to surprise both on the upside and on the downside, and it just depends which quarters you compare. And the fourth quarter was kind of a perfect storm, next quarter might be the opposite. And I cannot give you a better answer, unfortunately. Now on your second question, the big debate or the big question with bottled water is really the flat top caps, how can you eliminate the screwing off the caps throwing away, because those single caps are one of the highest volume items that ends up in the sea. So that drives people more to the sports cap closures, that drives more to the solutions where the cap stays with the bottle and, hopefully, also the flip lid product that we are discussing with customers and our technology is already in the market that in some countries with that, again where the **lid stays with the bottle and gets recycled with the bottle**. I mean, the overall theme here is really all about circularity. **Plastic is a very good energy-efficient product, but it needs to come back, it can't be a one-way street.**

George Leon Staphos, BofA Merrill Lynch, Research Division - MD and Co-Sector Head in Equity Research

So that's helpful, Stephan. So from your customer standpoint and from what they're hearing from the consumer, the bigger issue is on the cap on the one hand, which presumably that's **an opportunity and you can solve that, and less on the actual use of plastic as long as it's recyclable and returnable and your customers are comfortable that, that will be resolved.**

Stephan B. Tanda, AptarGroup, Inc. - President, CEO & Director

Yes. And you see initiatives around having them to pay a fee that you get returned when you return the bottle, as has been standard in places like Germany for a long time.

Example 2: Livent Corporation

Analysts are concerned about setbacks in Livent's partnership and investments in Nemaska Lithium, a producer of lithium. In addition, low Lithium prices and Livent's unprofitability generated further negative market reactions (-8.72%).

Joel Jackson, BMO Capital Markets Equity Research - Director of Fertilizer Research & Analyst

Paul, you know what I know the Nemaska story quite intimately, unfortunately.

Paul W. Graves, Livent Corporation - President, CEO & Director

You do. You do.

Joel Jackson, BMO Capital Markets Equity Research - Director of Fertilizer Research & Analyst

I do. I've been there. So obviously, you had a claim against them. You got the stake somewhat in lieu of that claim. I understand. Is this basically go back to the drawing board and say, "okay, **the original hydromet plant, we don't think that works.** We're going to go back with at all optionality here. Maybe we'll do just like a chinese conversion plant there, soda ash, sulfuric acid, do new environmental studies, go right back to the beginning, put the plant in whabouchi, not shawinigan. Like I mean, is that the way to think about it? This is a totally, let's go back to scratch, go back to square one, see any good value out of it?

Paul W. Graves, Livent Corporation - President, CEO & Director

Not quite square one. Look, I don't think, for one moment, that what Nemaska did was all entirely useless. I think they actually did a lot of really good work, and they've made some valuable investments in there. **But I think Nemaska had a couple of issues behind it**, frankly, Joel. Well, let's 3, to be blunt. The first issue, I think, that they had was the financing structure, clearly, and that's what drove them into this position. I think the second is that -- and maybe linked to that is they allowed themselves to be overambitious as to what that mine was actually capable of in terms of production. And so they ended with a mine plan that was creating higher capital spend and a whole bunch of issues with regard to its functional capabilities to operate reliably as a mine, particularly in that relatively harsh environment up there. And then the third area was the entire strategy with regard to the chemical conversion plant. I don't, for one minute, think the hydromet capability of technology is not something that could work. It could. We absolutely would love it to work if we can make it work. **But we have to get confident that it is going to operate at an operating cost that makes sense. It's certainly more capital-intensive, but it does have some pretty significant environmental benefits.** I would also say, just to give you an idea as to the challenges, as to that process, **it almost certainly doesn't feel like the location that they've selected for it is actually going to work for it for a whole bunch of geological and engineering reasons.** And so it may be that unless we change the technology, the plant couldn't even shoring even if we wanted it to. And so there's a lot of questions that have to be answered. So while it's not quite a blank sheet of paper, it's certainly not taking the existing plan and tweaking it. It will be a much more fundamental reassessment than that.

Joel Jackson, BMO Capital Markets Equity Research - Director of Fertilizer Research & Analyst

So Paul, obviously, **lithium prices have been really bad this year.** We're seeing on the cost curve, we're seeing a lot of pain. We're seeing all churn, we see the shift. We're seeing oracle with negative margin. We're seeing Livent that basically nears their earnings in the third quarter here. And so when you look at your business model and what you are -- and at this low -- at the low part of the cycle, **Livent is basically near 0 or losing money.** Does that make you think about <https://ir.livent.com/news/news-details/2022/Livent-Announces-Agreement-to-Double-its-Ownership-Stake-in-Nemaska-Lithium-to-50->

Percent/default.aspx, and this next happens, Livent will be better prepared, not better prepared, but better organized, have a better full earnings level at the bottom of the cycle? And what would you do to achieve that? Do you think that's fair?

Paul W. Graves, Livent Corporation - President, CEO & Director

Absolutely. Everything you said, yes. **Now, there's only so much you can do, right? The economics of resource extraction and chemical processing, there's only so much we can do.** We are a low-cost producer, but we do have a cost burden of being a public company, right? If we will report it as a segment of a larger organization, we would look a lot healthier than we do today. And so you kind of got to break through all of this and get your head around what it really means if we had a lot of, for example, mark-to-market investments that we're balancing around in a quarter and you could take some extra earnings. There's lots of noise when you try and compare lithium companies to lithium companies. However, you're absolutely right. **It's hard to grow a business like ours with the profitability where it is.** And so we do have to think differently about it. And frankly, Nemaska is one of those. We have been, I admit, nonconventional and somewhat creative with regard to our partnership with Pallinghurst. But it's a source of capital for us and it's allowing us to operate in a wider plane than we otherwise would have to. We would have had to incur some quite significant cost, maybe one-off, maybe longer, if we weren't partners with Pallinghurst. The expectation, over time, with Nemaska is that we increase our ownership stake, and it becomes a fundamental part of our portfolio, giving us resource diversification and giving us a differentiated story to serve different markets. I think there's no doubt, Europe and North America are looking for supply chains that are shorter that allow them to maybe not touch every part of the world before they get to them. And so I think we're taking steps that, in theory at least, position us well for the future, and we'll keep doing that. We'll absolutely keep doing that. But frankly, everything and anything is on the table to make us more cost-efficient, to give us a more differentiated position with customers, and we'll keep doing everything we can.

Appendix C. Hedge Target

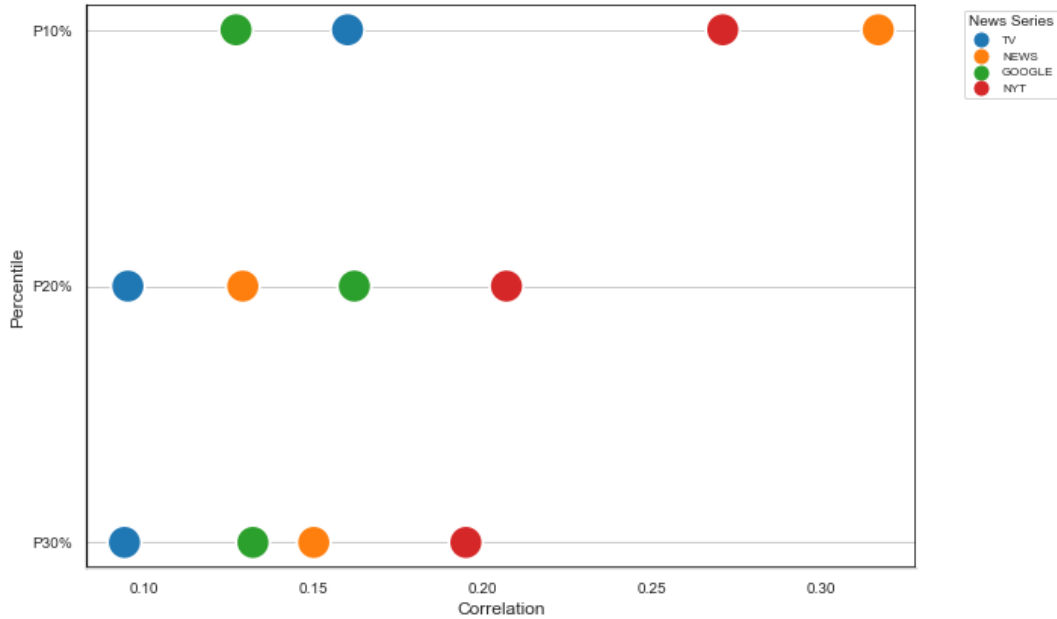
TV	<p>This series reflects US Television coverage of climate change or global warming, constructed by the Media And Climate Change Observatory (MeCCO). MeCCO monitors 130 sources (across newspapers, radio, and TV) in 59 countries in seven different regions around the world. The US Television dataset (Boykoff et al., 2023) specifically monitors seven major television stations (ABC, CBS, CNN, FOX, MSNBC, NBC, PBS) for mentions of climate change at a monthly frequency. It measures the attention given to climate change and its related risks, without distinguishing between positive and negative news. This index is available at a monthly frequency between January 2000 and January 2023 (date of download).</p> <p>Source: https://scholar.colorado.edu/concern/datasets/z890rv64z</p>
NEWS	<p>This series reflects the coverage of climate change news in major US newspapers, including American Public Media, The Associated Press, Los Angeles Times, New York Times, United Press International, USA Today, The Wall Street Journal, and Washington Post. It measures the attention given to climate change and its related risks without distinguishing between positive and negative news. This index is available at a monthly frequency between January 2000 and May 2023 (date of download).</p> <p>Source: https://scholar.colorado.edu/concern/datasets/5x21tg924</p>
GOOGLE	<p>This series of climate news reports reflects the level of interest among the general public in the topic of ‘climate change’ as determined by national Google search trends. It measures the attention given to climate change and its related risks without distinguishing between positive and negative news. The monthly index is constructed between January 2010 to December 2021.</p> <p>Source: <i>Google</i></p>
NYT	<p>The NYT climate news, developed by Giglio et al. (2023), captures news related to climate change in the New York Times. It distinguishes between positive and negative news and is constructed as the number of negative climate articles minus the number of positive climate articles on a given day. The daily series is available between January 2000 to December 18, 2022. To obtain monthly data, they are aggregated by calculating the average of the daily series.</p> <p>Source: https://www.biodiversityrisk.org/download/</p>
CPU	<p>The climate policy uncertainty index (Gavriilidis, K., 2021) searches for articles related to mentions of climate change policy uncertainties in eight major US newspapers, including Boston Globe, Chicago Tribune, Los Angeles Times, Miami Herald, New York Times, Tampa Bay Times, USA Today and the Wall Street Journal. This index is constructed on a monthly basis and is available between January 1987 to August 2022.</p> <p>Source: https://www.policyuncertainty.com/climate_uncertainty.html.</p>
CHNEG	<p>This is the Crimson Hexagon Negative News (CHNEG) climate news indices created by Engle et al. (2020). This index builds on the proprietary news aggregations from Crimson Hexagon, which covers over 1,000 outlets, including the WSJ, The New York Times, The Washington Post, Reuters, BBC, CNN, and Yahoo News. News is separated into good and bad news, and the index is calculated as the shares of negative climate</p>

	<p>change news. The index is available monthly between July 2008 and May 2018.</p> <p>While Engle et al. (2020) also developed the WSJ index, utilizing climate news coverage in <i>The Wall Street Journal</i>, the WSJ index ends in June 2017, before the start of our sample period.</p> <p>Source: Engle et al. (2020), accessed via https://pages.stern.nyu.edu/~jstroebe/</p>
MCCC	<p>ABBL (Ardia et al., 2020) expands upon the WSJ index of Engle et al. (2020) by incorporating new media outlets. It also makes a distinction between positive and negative news. The daily index is available between January 2003 and June 2018. To obtain monthly data, they are aggregated by calculating the average of the daily series.</p> <p>Source: Ardia et al. (2020), accessed via https://sentometrics-research.com/download/mccc/</p>
IntSummit GlobWarm NatDis ClimatePolicy	<p>These four indices are obtained from Faccini et al. (2021) climate new indices: international climate summits (IntSummit), global warming (GlobWarm), natural disasters (NatDis), and narrative indices (ClimatePolicy). The first three indices measure the extent of news coverage related to their respective topics. ClimatePolicy is created through a manual process involving the reading and classification of 3,500 articles. IntSummit and ClimatePolicy focus on news regarding transition risk, while GlobWarm and NatDis are more inclined to capture news concerning physical risk. Data is available daily from January 2000 to November 2019. To obtain monthly data, they are aggregated by calculating the average of the daily series.</p> <p>Source: Faccini et al. (2021), accessed via https://sites.google.com/view/george-skiadopoulos/research/selected-publications?authuser=0</p>

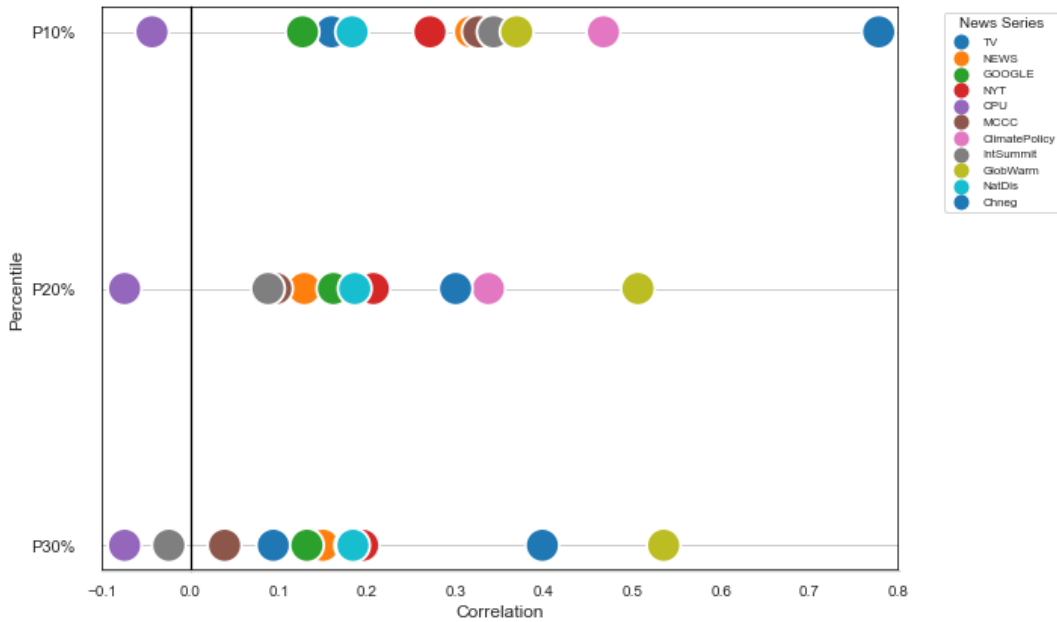
In addition, we use similar methods to hedge against risks related to economic uncertainty and infectious disease.

EPU	<p>Newspaper-based economic policy uncertainty developed by developed by Scott R. Baker, Steven J. Davis, and Jeffrey Levy. Data is available monthly from January 1985 to April 2023 (date of download).</p> <p>Source: https://www.policyuncertainty.com/state_epu.html</p>
Infection	<p>Newspaper-based infectious disease equity market volatility tracker developed in Baker, Bloom, David, and Kost (2019). Data is available daily from January 1985 to Mary 2023 (date of download). To obtain monthly data, they are aggregated by calculating the average of the daily series.</p> <p>Source: https://www.policyuncertainty.com/infectious_EMV.html</p>

Figure 1: Climate Change Hedge Performance of Baseline Portfolios



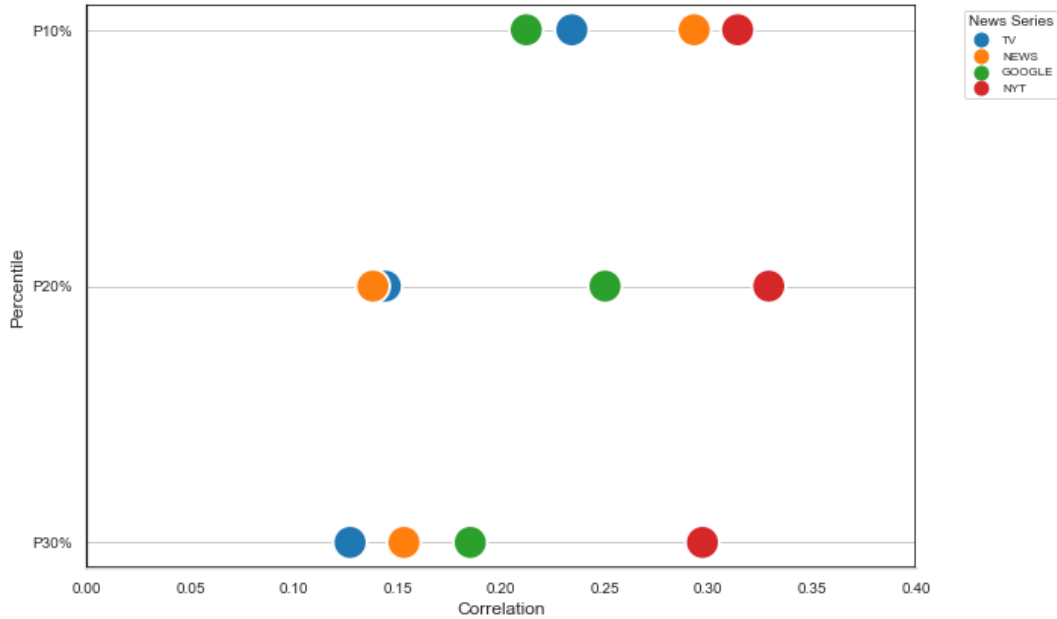
(a) Four main climate news series



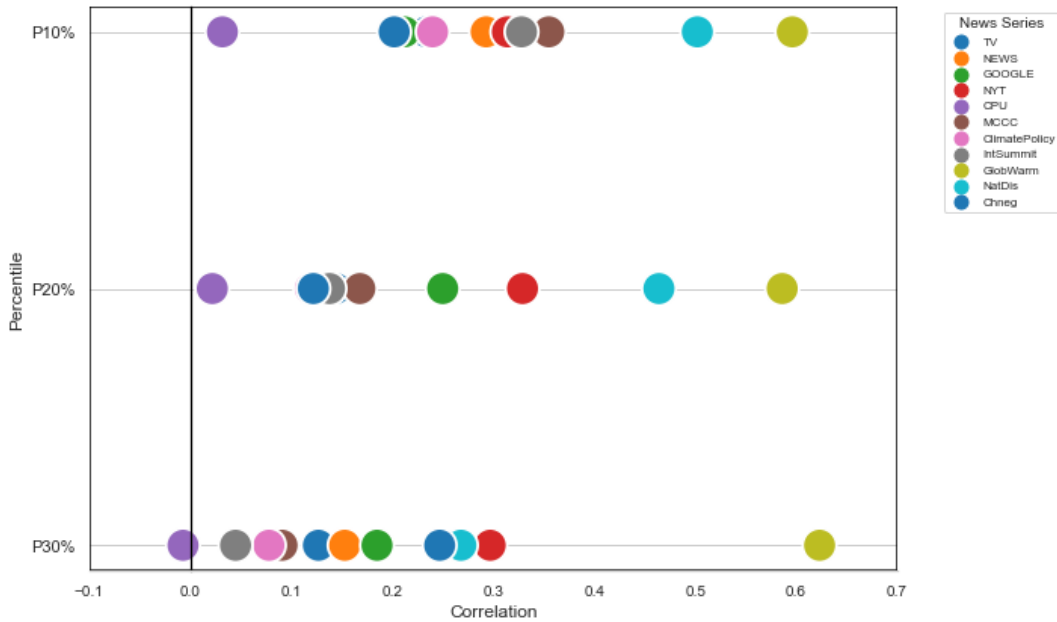
(b) All climate news series

Note: This figure shows the monthly return correlations for climate change baseline hedge portfolios and various news-based hedge targets. The hedge portfolios are formed based on purchasing and shorting stocks in climate exposure percentiles 10%, 20%, and 30%, respectively. For climate news series, such as TV, NEWS, GOOGLE, NYT, CPU, and MCCC, the sample period of hedge portfolio is from 2017Q4 to 2022Q1. For climate news series, such as ClimatePolicy, IntSummit, GlobWarm, NatDis, the sample period of hedge portfolio is from 2017Q4 to 2018Q4. For climate news series, such as Chneg, the sample period of hedge portfolio is from 2017Q4 to 2018Q2. Different colors represent different groups of climate news series. Panel A presents the hedge performance based on the four primary climate news series. Panel B presents the hedge performance based on all eleven climate news series.

Figure 2: Climate Change Hedge Performance of Complete Portfolios



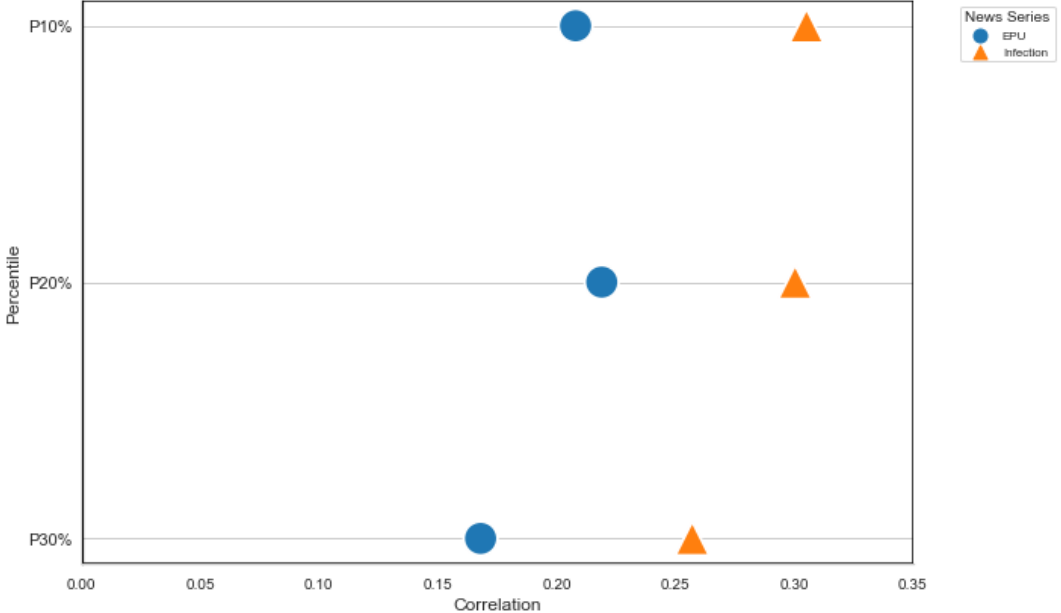
(a) Four main climate news series



(b) All climate news series

Note: This figure shows the monthly return correlations for climate change complete hedge portfolios and various news-based hedge targets. The hedge portfolios are formed based on purchasing and shorting stocks in climate exposure percentiles 10%, 20%, and 30%, respectively. For climate news series, such as TV, NEWS, GOOGLE, NYT, CPU, and MCCC, the sample period of hedge portfolio is from 2017Q4 to 2022Q1. For climate news series, such as ClimatePolicy, IntSummit, GlobWarm, NatDis, the sample period of hedge portfolio is from 2017Q4 to 2018Q4. For climate news series, such as Chneg, the sample period of hedge portfolio is from 2017Q4 to 2018Q2. Different colors represent different groups of climate news series. Panel A presents the hedge performance based on the four primary climate news series. Panel B presents the hedge performance based on all eleven climate news series.

Figure 3: Political Risk and Pandemic Risk Hedge Performance



Note: This figure shows the monthly return correlations for political risk and pandemic risk hedge portfolios based on percentiles 10%, 20%, and 30%, respectively. The sample period of political risk (pandemic risk) hedge portfolio is from 2017Q4 (2020Q3) to 2022Q1. Dots in squares present the hedge performance based on the political risk news series. Dots in triangles present the hedge performance based on pandemic risk news series.

Table 1: Summary Statistics of Climate Change Hedge Portfolios

Quarter	Climate exposure	Refined climate exposure	Positive climate exposure	Negative climate exposure	Baseline hedging portfolios	Complete hedging portfolios
2017Q1	63	44	23	21	-	-
2017Q2	192	137	71	66	-	-
2017Q3	145	102	52	50	-	-
2017Q4	144	73	41	32	43	123
2018Q1	135	97	46	51	51	141
2018Q2	140	84	47	37	58	156
2018Q3	150	99	47	52	49	108
2018Q4	201	123	60	63	48	121
2019Q1	192	136	75	61	54	135
2019Q2	229	143	79	64	58	139
2019Q3	218	143	73	70	65	139
2019Q4	223	140	82	58	70	144
2020Q1	197	137	71	66	72	154
2020Q2	73	49	30	19	70	150
2020Q3	212	158	78	80	62	132
2020Q4	261	205	97	108	63	123
2021Q1	332	264	137	127	70	136
2021Q2	329	181	90	91	86	174
2021Q3	339	245	116	129	95	223
2021Q4	330	249	129	120	100	233
2022Q1	-	-	-	-	104	241

Note: This table presents summary statistics of climate hedge portfolios by quarter. The sample period of conferences with climate exposure is from 2017Q1 to 2021Q4. The sample period of hedge portfolios is from 2017Q4 to 2022Q1. Climate exposure represents the number of conferences with at least one conversation related to climate change. Refined climate exposure shows the number of conferences after filtering out extreme and no-response conversations. Extreme conversations are identified as those with a duration of less than/equal to one minute or greater than/equal to ten minutes. No-response conversations are identified as those with zero or missing market response. Positive (Negative) climate exposure indicates the number of conferences with a positive (negative) average market reaction to the climate change conversations. Baseline (Complete) hedge portfolios indicates the number of stocks in the hedge portfolios without (with) consideration of climate shocks.

Table 2A: Industrial Distribution of Baseline Portfolios.

GICS	Industry	Number of firms			
		Avg.	Min	Median	Max
1010	Energy	9.4	4	9.5	18
1510	Materials	8.6	4	8.5	13
2010	Capital Goods	16.3	8	15.5	25
2020	Commercial & Professional Services	4.4	1	4.5	7
2030	Transportation	2.0	1	2	4
2510	Automobiles & Components	3.2	1	3	8
2520	Consumer Durables & Apparel	1.2	1	1	2
2530	Consumer Services	1.6	1	1.5	3
2550	Retailing	2.5	1	2	6
3010	Food & Staples Retailing	1.3	1	1	2
3020	Food, Beverage & Tobacco	1.5	1	1.5	2
3030	Household & Personal Products	1.2	1	1	2
3510	Health Care Equipment & Services	1.0	1	1	1
3520	Pharmaceuticals, Biotechnology & Life Sciences	1.0	1	1	1
4010	Banks	1.2	1	1	2
4020	Diversified Financials	1.9	1	2	4
4030	Insurance	1.9	1	2	3
4510	Software & Services	2.1	1	1	6
4520	Technology Hardware & Equipment	2.6	1	2	5
4530	Semiconductors & Semiconductor Equipment	3.1	1	3	6
5010	Telecommunication Services	1.0	1	1	1
5020	Media & Entertainment	1.0	1	1	1
5510	Utilities	6.3	3	6.5	9
6010	Real Estate	2.2	1	2.5	3

Note: This table shows the industrial distribution of baseline climate hedge portfolios. The average, minimum, median, and maximum value of stocks for each industry are at quarterly level. The sample period is between 2017Q4 to 2022Q1.

Table 2B: Industrial Distribution of Complete Portfolios.

GICS	Industry	Number of firms			
		Avg.	Min	Median	Max
1010	Energy	25.6	10	22.5	52
1510	Materials	20.3	14	19.5	32
2010	Capital Goods	29.4	18	26.5	49
2020	Commercial & Professional Services	7.2	3	7	10
2030	Transportation	4.3	3	4	6
2510	Automobiles & Components	6.8	1	7.5	11
2520	Consumer Durables & Apparel	2.2	1	2	3
2530	Consumer Services	2.4	1	2.5	4
2550	Retailing	3.6	1	2.5	10
3010	Food & Staples Retailing	1.8	1	2	3
3020	Food, Beverage & Tobacco	2.5	1	2	4
3030	Household & Personal Products	1.2	1	1	2
3510	Health Care Equipment & Services	1.0	1	1	1
3520	Pharmaceuticals, Biotechnology & Life Sciences	1.2	1	1	2
4010	Banks	3.2	1	3	8
4020	Diversified Financials	2.6	1	3	5
4030	Insurance	2.3	1	3	4
4510	Software & Services	3.0	1	2.5	8
4520	Technology Hardware & Equipment	4.8	2	4.5	8
4530	Semiconductors & Semiconductor Equipment	5.8	4	6	9
5010	Telecommunication Services	1.0	1	1	1
5020	Media & Entertainment	1.0	1	1	1
5510	Utilities	23.4	16	23	33
6010	Real Estate	3.2	1	3	6

Note: This table shows the industrial distribution of complete climate hedge portfolios. The average, minimum, median, and maximum value of stocks for each industry are at quarterly level. The sample period is between 2017Q4 to 2022Q1.

Table 3A: Decomposition of Baseline Hedge Portfolios

Quarter	Incumbent	New entrant	Exit	Positive	Negative	Position change
2017Q4	0	43	0	22	21	0
2018Q1	42	9	1	26	25	0
2018Q2	43	15	8	29	29	1
2018Q3	34	15	24	24	25	2
2018Q4	33	15	16	23	25	7
2019Q1	35	19	13	26	28	7
2019Q2	37	21	17	29	29	7
2019Q3	44	21	14	33	32	8
2019Q4	53	17	12	35	35	8
2020Q1	45	27	25	36	36	9
2020Q2	49	21	23	35	35	11
2020Q3	52	10	18	31	31	11
2020Q4	39	24	23	32	31	15
2021Q1	45	25	18	36	34	20
2021Q2	43	43	27	43	43	24
2021Q3	71	24	15	47	48	25
2021Q4	68	32	27	49	51	23
2022Q1	74	30	26	52	52	27

Note: This table displays a decomposition of baseline hedging portfolios by quarter. Incumbent (New entrant) represents the number of stocks that were (were not) held in the last quarter. Exit represents number of stocks were held in the last quarter but are absent in this quarter. Positive (Negative) shows the number of stocks in portfolios with a positive (negative) average market reaction to climate change. Position change indicates the number of stocks in given quarter changed their position in the portfolios. Past four quarters are used to construct quarterly portfolios except for 2017Q4. Three historical quarters are used to construct the portfolios in 2017Q4.

Table 3B: Decomposition of Complete Hedge Portfolios

Quarter	Incumbent	New entrant	Exit	Positive	Negative	Position change
2017Q4	0	123	0	71	52	0
2018Q1	122	19	1	80	61	2
2018Q2	126	30	15	86	70	6
2018Q3	87	21	69	53	55	15
2018Q4	88	33	20	56	65	24
2019Q1	108	27	13	56	79	33
2019Q2	108	31	27	66	73	37
2019Q3	114	25	25	69	70	34
2019Q4	103	41	36	70	74	32
2020Q1	114	40	30	84	70	41
2020Q2	123	27	31	81	69	47
2020Q3	120	12	30	72	60	43
2020Q4	89	34	43	70	53	51
2021Q1	88	48	35	72	64	57
2021Q2	106	68	30	93	81	69
2021Q3	159	64	15	119	104	89
2021Q4	188	45	35	124	109	91
2022Q1	196	45	37	132	109	93

Note: This table displays a decomposition of complete hedging portfolios by quarter. Incumbent (New entrant) represents the number of stocks that were (were not) held in the last quarter. Exit represents number of stocks were held in the last quarter but are absent in this quarter. Positive (Negative) shows the number of stocks in portfolios with a positive (negative) average market reaction to climate change. Position change indicates the number of stocks in given quarter changed their position in the portfolios. Past four quarters are used to construct quarterly portfolios except for 2017Q4. Three historical quarters are used to construct the portfolios in 2017Q4.

Table 4: Climate Hedge Performance

Panel A: Climate Hedge Performance of Baseline Portfolios

Percentile	Correlation	TV	NEWS	GOOGLE	NYT	CPU	MCCC	ClimatePolicy	IntSummit	GlobWarm	NatDis	Chneg
10%	Pearson	0.160	0.317	0.127	0.271	-0.043	0.326	0.467	0.343	0.369	0.183	0.778
10%	Spearman	0.117	0.407	0.133	0.384	-0.037	0.337	0.582	0.375	0.425	0.139	0.857
20%	Pearson	0.095	0.129	0.162	0.207	-0.074	0.097	0.337	0.088	0.506	0.186	0.300
20%	Spearman	0.025	0.155	0.123	0.317	-0.154	0.050	0.625	0.193	0.475	0.264	0.667
30%	Pearson	0.094	0.150	0.132	0.195	-0.074	0.039	0.182	-0.024	0.535	0.184	0.398
30%	Spearman	0.075	0.185	0.091	0.244	-0.157	0.043	0.436	0.054	0.214	0.125	0.690

Panel B: Climate Hedge Performance of Complete Portfolios

Percentile	Correlation	TV	NEWS	GOOGLE	NYT	CPU	MCCC	ClimatePolicy	IntSummit	GlobWarm	NatDis	Chneg
10%	Pearson	0.234	0.293	0.212	0.314	0.032	0.355	0.240	0.328	0.596	0.502	0.202
10%	Spearman	0.197	0.323	0.108	0.367	0.022	0.320	0.325	0.414	0.504	0.418	0.190
20%	Pearson	0.144	0.138	0.250	0.329	0.022	0.168	0.119	0.138	0.586	0.464	0.122
20%	Spearman	0.043	0.150	0.169	0.375	-0.051	0.095	0.336	0.200	0.454	0.457	0.071
30%	Pearson	0.127	0.153	0.185	0.297	-0.007	0.091	0.078	0.045	0.623	0.268	0.247
30%	Spearman	0.062	0.147	0.096	0.341	-0.095	0.072	0.186	0.121	0.389	0.082	0.262

Note: This table displays the monthly correlations between the returns of climate hedge portfolios and AR(1) innovations of various climate index series. The portfolios are constructed with sorting thresholds set at 10%, 20%, and 30% respectively. All climate index series are coded so that higher numbers indicate negative climate news. Consequently, positive correlation coefficients indicate successful hedges. Panel A (B) shows the climate hedge performance of baseline (complete) portfolios. For climate news series, such as TV, NEWS, GOOGLE, NYT, CPU, and MCCC, the sample period of hedge portfolio is from 2017Q4 to 2022Q1. For climate news series, such as ClimatePolicy, IntSummit, GlobWarm, NatDis, the sample period of hedge portfolio is from 2017Q4 to 2018Q4. For climate news series, such as Chneg, the sample period of hedge portfolio is from 2017Q4 to 2018Q2.

Table 5: Summary Statistics of Climate Shocks

Quarter	Heat Shock		Natural Disaster	
	# County	# Firm	# County	# Firm
2017Q4	52	78	13	19
2018Q1	57	86	15	24
2018Q2	60	93	22	32
2018Q3	18	26	26	45
2018Q4	27	38	28	50
2019Q1	25	40	31	59
2019Q2	22	35	27	62
2019Q3	17	28	30	59
2019Q4	8	16	30	70
2020Q1	7	15	33	79
2020Q2	10	20	34	72
2020Q3	10	20	29	64
2020Q4	7	13	30	64
2021Q1	6	11	36	71
2021Q2	17	26	41	79
2021Q3	29	45	45	104
2021Q4	37	61	43	101
2022Q1	39	69	39	88

Note: This table displays the summary statistics of climate shocks, including heat shocks and natural disasters. # County presents the number of counties experiencing heat shocks or natural disasters, with at least one firm being impacted. # Firm presents the number of firms impacted by heat shocks or natural disasters. If two types of shocks happen in the same month and same county, we classify corresponding county and firms into group of natural disasters.

Table 6: Climate Hedge Performance

Panel A: Climate Hedge Performance of Shock Portfolios

Percentile	Correlation	TV	NEWS	GOOGLE	NYT	CPU	MCCC	ClimatePolicy	IntSummit	GlobWarm	NatDis	Chneg
10%	Pearson	0.222	0.295	0.188	0.159	0.102	0.209	0.209	0.262	0.377	0.391	0.811
10%	Spearman	0.328	0.414	0.260	0.310	0.207	0.296	0.404	0.361	0.346	0.221	0.762
20%	Pearson	0.218	0.247	0.154	0.181	0.041	0.205	0.215	0.349	0.602	0.419	0.336
20%	Spearman	0.219	0.311	0.119	0.294	0.005	0.226	0.425	0.518	0.361	0.382	0.333
30%	Pearson	0.193	0.305	0.209	0.210	0.047	0.226	0.128	0.229	0.628	0.453	0.322
30%	Spearman	0.201	0.344	0.136	0.282	0.019	0.224	0.282	0.486	0.429	0.161	0.286

Panel B: Climate Hedge Performance of Baseline and Shock Portfolios

Percentile	Correlation	TV	NEWS	GOOGLE	NYT	CPU	MCCC	ClimatePolicy	IntSummit	GlobWarm	NatDis	Chneg
10%	Pearson	0.207	0.314	0.149	0.249	-0.066	0.323	0.286	0.315	0.629	0.491	0.277
10%	Spearman	0.142	0.326	0.059	0.316	-0.075	0.261	0.496	0.379	0.511	0.418	0.024
20%	Pearson	0.094	0.118	0.196	0.274	-0.061	0.105	0.099	0.128	0.559	0.458	0.243
20%	Spearman	0.011	0.117	0.163	0.332	-0.107	0.021	0.400	0.179	0.318	0.296	0.238
30%	Pearson	0.088	0.147	0.109	0.205	-0.089	0.030	0.056	0.036	0.568	0.219	0.422
30%	Spearman	0.023	0.127	0.000	0.243	-0.158	-0.020	0.236	0.175	0.368	-0.089	0.619

Note: This table displays the monthly correlations between the returns of climate hedge portfolios and AR(1) innovations of various climate index series. The portfolios are constructed with sorting thresholds set at 10%, 20%, and 30%, respectively. All climate index series are coded so that higher numbers indicate negative climate news. Consequently, positive correlation coefficients indicate successful hedges. Panel A shows the climate hedge performance based on stocks that have experienced natural disasters. Panel B shows the climate hedge performance based on a combination of a 30% shock portfolio from Panel A and stocks that have not experienced natural disasters. For climate news series, such as TV, NEWS, GOOGLE, NYT, CPU, and MCCC, the sample period of hedge portfolio is from 2017Q4 to 2022Q1. For climate news series, such as ClimatePolicy, IntSummit, GlobWarm, NatDis, the sample period of hedge portfolio is from 2017Q4 to 2018Q4. For climate news series, such as Chneg, the sample period of hedge portfolio is from 2017Q4 to 2018Q2.

Table 7: Factor Exposures of Baseline Portfolios

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	P10%	P20%	P30%	P10%	P20%	P30%
Mkt-RF	-0.197 (0.17)	-0.225*** (0.08)	-0.113* (0.06)	-0.182 (0.21)	-0.214** (0.09)	-0.112 (0.07)
SMB	-0.045 (0.29)	0.007 (0.14)	-0.062 (0.12)	-0.076 (0.29)	0.006 (0.16)	-0.018 (0.14)
HML	-0.238 (0.17)	-0.234*** (0.08)	-0.189** (0.08)	-0.238 (0.24)	-0.250** (0.12)	-0.224** (0.10)
RMW				0.001 (0.28)	-0.040 (0.17)	0.078 (0.15)
CMA				0.046 (0.44)	0.061 (0.20)	0.096 (0.17)
Constant	0.462 (0.66)	0.361 (0.38)	0.090 (0.31)	0.425 (0.63)	0.347 (0.39)	0.028 (0.31)
Observations	54	54	54	54	54	54
R-squared	0.097	0.283	0.219	0.099	0.285	0.227

Note: This table presents the regression results of monthly returns of the climate hedge portfolios on Fama-French factors. Columns (1) – (3) shows results for the Fama-French three-factor model. Columns (4) – (6) shows results for the Fama-French five-factor model. The sample period is between 2017Q4 and 2022Q1. Heteroskedasticity-robust standard errors in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 8: Factor Exposures of Complete Portfolios

VARIABLES	(1) P10%	(2) P20%	(3) P30%	(4) P10%	(5) P20%	(6) P30%
Mkt-RF	-0.161* (0.09)	-0.166** (0.07)	-0.102* (0.05)	-0.172 (0.12)	-0.181** (0.08)	-0.111* (0.06)
SMB	-0.068 (0.17)	-0.029 (0.10)	-0.058 (0.09)	-0.063 (0.17)	-0.012 (0.12)	-0.019 (0.10)
HML	-0.098 (0.09)	-0.127* (0.07)	-0.141** (0.06)	-0.079 (0.12)	-0.109 (0.09)	-0.153** (0.07)
RMW				0.071 (0.16)	0.039 (0.13)	0.078 (0.12)
CMA				-0.048 (0.24)	-0.065 (0.15)	0.023 (0.13)
Constant	-0.034 (0.37)	0.164 (0.28)	0.001 (0.25)	-0.040 (0.38)	0.185 (0.30)	-0.028 (0.26)
Observations	54	54	54	54	54	54
R-squared	0.142	0.242	0.218	0.149	0.246	0.224

Note: This table presents the regression results of monthly returns of the climate hedge portfolios on Fama-French factors. Columns (1) – (3) shows results for the Fama-French three-factor model. Columns (4) – (6) shows results for the Fama-French five-factor model. The sample period is between 2017Q4 and 2022Q1. Heteroskedasticity-robust standard errors in parentheses. Significance levels: *** p < 0.01; ** p < 0.05; * p < 0.1.

Online Appendix

Online Appendix A: Additional Results

Online Appendix B: Extreme Heat and Natural Disaster Shocks: Validity Test

Online Appendix C: ChatGPT Prompts and Outputs

Online Appendix D: Case Studies

OA A1: Summary Statistics of Political Risk Hedge Portfolios

Quarter	Political exposure	Refined political exposure	Positive political exposure	Negative political exposure	Hedge portfolios
2017Q1	668	518	250	268	-
2017Q2	2502	1723	871	852	-
2017Q3	2189	1496	734	761	-
2017Q4	1553	692	353	339	404
2018Q1	1725	1224	600	623	402
2018Q2	1808	1214	588	626	423
2018Q3	2277	1607	832	775	370
2018Q4	2654	1795	906	889	392
2019Q1	2608	1943	975	968	451
2019Q2	2676	1819	945	874	473
2019Q3	2598	1839	930	909	480
2019Q4	2641	1906	972	933	480
2020Q1	2533	1850	928	922	485
2020Q2	1176	906	461	445	485
2020Q3	2641	2133	1058	1075	481
2020Q4	2675	2095	1043	1052	502
2021Q1	2755	2232	1094	1138	518
2021Q2	2780	1485	744	740	533
2021Q3	2766	2145	1071	1074	528
2021Q4	2493	1998	1021	977	553
2022Q1	-	-	-	-	557

Note: This table presents summary statistics of political risk hedge portfolios by quarter. The sample period of conferences with political risk exposure is from 2017Q1 to 2021Q4. The sample period of hedge portfolios is from 2017Q4 to 2022Q1. Political exposure represents the number of conferences with at least one conversation related to political risk. Refined political exposure shows the number of conferences after filtering out extreme and no-response conversations. Extreme conversations are identified as those with a duration of less than/equal to one minute or greater than/equal to ten minutes. No-response conversations are identified as those with zero or missing market response. Positive (Negative) political exposure indicates the number of conferences with a positive (negative) average market reaction to the political risk conversations. Hedge portfolios indicates the number of stocks in the hedge portfolios.

OA A2: Industrial Distribution of Political Risk Hedge Portfolios.

GICS	Industry	Number of firms			
		Avg.	Min	Median	Max
1010	Energy	20.1	11	20	28
1510	Materials	16.7	13	16	21
2010	Capital Goods	38.4	29	37	48
2020	Commercial & Professional Services	22.8	18	22.5	29
2030	Transportation	8.3	1	8.5	12
2510	Automobiles & Components	5.7	3	5	9
2520	Consumer Durables & Apparel	15.9	9	17	23
2530	Consumer Services	20.1	13	18.5	27
2550	Retailing	15.6	10	16	20
3010	Food & Staples Retailing	2.6	1	2	6
3020	Food, Beverage & Tobacco	6.8	4	6.5	12
3030	Household & Personal Products	2.9	1	3	5
3510	Health Care Equipment & Services	46.2	33	43.5	59
3520	Pharmaceuticals, Biotechnology & Life Sciences	68.1	45	70	91
4010	Banks	10.0	5	10.5	15
4020	Diversified Financials	29.1	22	27	47
4030	Insurance	8.1	6	7	18
4510	Software & Services	42.5	30	42.5	53
4520	Technology Hardware & Equipment	33.0	24	33.5	40
4530	Semiconductors & Semiconductor Equipment	18.1	10	18	23
5010	Telecommunication Services	8.1	3	8	12
5020	Media & Entertainment	16.1	7	18	24
5510	Utilities	5.9	1	6	8
6010	Real Estate	9.8	7	9	15

Note: This table shows the industrial distribution of political risk hedge portfolios. The average, minimum, median, and maximum value of stocks for each industry are at quarterly level. The sample period is between 2017Q3 to 2022Q1.

OA A3: Decomposition of Political Risk Hedge Portfolios

Quarter	Incumbent	New entrant	Exit	Positive	Negative	Position change
2017Q4	0	404	0	203	201	0
2018Q1	368	34	36	202	200	0
2018Q2	308	115	94	210	213	3
2018Q3	237	133	186	185	185	4
2018Q4	231	161	139	194	198	10
2019Q1	270	181	122	225	226	14
2019Q2	309	164	142	236	237	15
2019Q3	346	134	127	239	241	22
2019Q4	340	140	140	241	239	26
2020Q1	327	158	153	244	241	36
2020Q2	322	163	163	244	241	39
2020Q3	359	122	126	240	241	36
2020Q4	308	194	173	253	249	38
2021Q1	344	174	158	262	256	40
2021Q2	338	195	180	265	268	51
2021Q3	422	106	111	261	267	59
2021Q4	346	207	182	276	277	54
2022Q1	369	188	184	280	277	54

Note: This table displays a decomposition of political risk hedge portfolios by quarter. Incumbent (New entrant) represents the number of stocks that were (were not) held in the last quarter. Exit represents number of stocks were held in the last quarter but are absent in this quarter. Positive (Negative) shows the number of stocks in portfolios with a positive (negative) average market reaction to climate change. Position change indicates the number of stocks in given quarter changed their position in the portfolios. Past four quarters are used to construct quarterly portfolios except for 2017Q4. Three historical quarters are used to construct the portfolios in 2017Q4

OA A 4: Factor Exposures of Political Risk Hedge Portfolios

VARIABLES	(1) P10%	(2) P20%	(3) P30%	(4) P10%	(5) P20%	(6) P30%
Mkt-RF	-0.001 (0.04)	-0.010 (0.03)	-0.024 (0.02)	0.018 (0.05)	-0.001 (0.04)	-0.022 (0.03)
SMB	-0.290*** (0.07)	-0.125** (0.06)	-0.125** (0.05)	-0.376*** (0.08)	-0.154** (0.07)	-0.147*** (0.05)
HML	0.009 (0.04)	-0.041 (0.03)	-0.025 (0.02)	0.147** (0.06)	0.011 (0.05)	0.029 (0.04)
RMW				-0.157 (0.10)	-0.061 (0.08)	-0.040 (0.06)
CMA				-0.150 (0.12)	-0.048 (0.09)	-0.068 (0.07)
Constant	-0.280 (0.24)	-0.041 (0.15)	-0.064 (0.11)	-0.195 (0.23)	-0.012 (0.16)	-0.031 (0.11)
Observations	54	54	54	54	54	54
R-squared	0.199	0.126	0.233	0.246	0.137	0.255

Note: This table presents the regression results of monthly returns of the political risk hedge portfolios on Fama-French factors. Columns (1) – (3) shows the results for the Fama-French three-factor model. Columns (4) – (6) shows the results for the Fama-French five-factor model. The sample period is between 2017Q4 and 2022Q1. Heteroskedasticity-robust standard errors in parentheses. Significance levels: *** p < 0.01; ** p < 0.05; * p < 0.1.

OA A5: Summary Statistics of Pandemic Risk Hedge Portfolios

Quarter	Pandemic exposure	Refined pandemic exposure	Positive pandemic exposure	Negative pandemic exposure	Hedging portfolios
2020Q1	1052	648	328	320	-
2020Q2	965	666	347	319	-
2020Q3	2193	1594	820	774	219
2020Q4	2149	1499	725	774	383
2021Q1	1967	1428	715	713	431
2021Q2	1750	799	414	385	453
2021Q3	1645	1101	562	539	450
2021Q4	1235	648	404	435	451
2022Q1	-	-	-	-	421

Note: This table presents summary statistics of pandemic risk hedge portfolios by quarter. The sample period of conferences with pandemic risk exposure is from 2020 Q1 to 2021 Q4. The sample period of pandemic risk hedge portfolios is from 2020 Q3 to 2022 Q1. Pandemic exposure represents the number of conferences with at least one conversation related to pandemic risk. Refined pandemic exposure shows the number of conferences after filtering out extreme and no-response conversations. Extreme conversations are identified as those with a duration of less than/equal to one minute or greater than/equal to ten minutes. No-response conversations are identified as those with zero or missing market response. Positive (Negative) political exposure indicates the number of conferences with a positive (negative) average market reaction to the pandemic risk conversations. Hedge portfolios indicates the number of stocks in the hedge portfolios.

OA A6: Industrial Distribution of Pandemic Risk Hedge Portfolios.

GICS	Industry	Number of firms			
		Avg.	Min	Median	Max
1010	Energy	12.6	6	13	18
1510	Materials	13.3	10	13	17
2010	Capital Goods	30.6	16	32	36
2020	Commercial & Professional Services	19.7	8	21	25
2030	Transportation	8.0	6	7	11
2510	Automobiles & Components	4.7	3	5	7
2520	Consumer Durables & Apparel	16.1	8	17	21
2530	Consumer Services	20.1	16	20	24
2550	Retailing	14.0	10	15	18
3010	Food & Staples Retailing	2.2	1	2	3
3020	Food, Beverage & Tobacco	9.3	7	9	11
3030	Household & Personal Products	3.0	1	3	4
3510	Health Care Equipment & Services	45.7	19	49	56
3520	Pharmaceuticals, Biotechnology & Life Sciences	61.7	31	67	73
4010	Banks	7.7	1	8	12
4020	Diversified Financials	21.4	9	23	32
4030	Insurance	6.7	2	7	9
4510	Software & Services	38.4	16	41	49
4520	Technology Hardware & Equipment	22.3	7	25	27
4530	Semiconductors & Semiconductor Equipment	12.6	5	14	19
5010	Telecommunication Services	3.4	2	3	5
5020	Media & Entertainment	15.0	12	15	18
5510	Utilities	4.4	1	4	7
6010	Real Estate	6.9	5	6	11

Note: This table shows the industrial distribution of stocks with pandemic risk hedge portfolios. The average, minimum, median, and maximum value of stocks for each industry are at quarterly level. The sample period is between 2020Q3 to 2022Q1.

OA A7: Decomposition of Pandemic Risk Hedge Portfolios

Quarter	Incumbent	New entrant	Exit	Positive	Negative	Position change
2020Q3	0	219	0	109	110	0
2020Q4	158	225	61	191	192	3
2021Q1	295	136	88	217	214	4
2021Q2	320	133	111	227	226	17
2021Q3	369	81	84	225	225	26
2021Q4	286	165	164	225	226	46
2022Q1	283	138	168	212	209	67

Note: This table displays a decomposition of pandemic risk hedge portfolios by quarter. Incumbent (New entrant) represents the number of stocks that were (were not) held in the last quarter. Exit represents number of stocks were held in the last quarter but are absent in this quarter. Positive (Negative) shows the number of stocks in portfolios with a positive (negative) average market reaction to pandemic risks. Position change indicates the number of stocks in given quarter that have previously altered their position within the portfolios. Past four quarters are used to construct quarterly portfolios except for 2017Q4. Three historical quarters are used to construct the portfolios in 2017Q4.

OA A8: Factor Exposures of Pandemic Risk Hedge Portfolios

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	P10%	P20%	P30%	P10%	P20%	P30%
Mkt-RF	-0.011 (0.18)	-0.052 (0.09)	-0.036 (0.05)	0.110 (0.13)	-0.012 (0.08)	-0.001 (0.04)
SMB	0.397 (0.31)	0.012 (0.12)	0.030 (0.07)	0.108 (0.28)	-0.058 (0.12)	-0.035 (0.07)
HML	0.098 (0.14)	-0.053 (0.06)	-0.069* (0.04)	-0.068 (0.18)	-0.088 (0.08)	-0.108** (0.05)
RMW				-0.433 (0.26)	-0.120 (0.12)	-0.103 (0.06)
CMA				0.543 (0.33)	0.176 (0.11)	0.168** (0.06)
Constant	0.183 (0.73)	0.045 (0.31)	-0.039 (0.20)	0.019 (0.63)	-0.041 (0.32)	-0.122 (0.17)
Observations	21	21	21	21	21	21
R-squared	0.145	0.0305	0.113	0.324	0.141	0.348

Note: This table presents the regression results of monthly returns of the pandemic risk hedge portfolios on Fama-French factors. Columns (1) – (3) shows the results for the Fama-French three-factor model. Columns (4) – (6) shows the results for the Fama-French five-factor model. The sample period is between 2017Q4 and 2022Q1. Heteroskedasticity-robust standard errors in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

OA A9: Hedge Performance

Panel A: Political Risk performance

Percentile	Correlation	EPU
10%	Pearson	0.208
10%	Spearman	0.200
20%	Pearson	0.219
20%	Spearman	0.306
30%	Pearson	0.168
30%	Spearman	0.168

Panel B: Pandemic Risk performance

Percentile	Correlation	Infection
10%	Pearson	0.305
10%	Spearman	0.265
20%	Pearson	0.300
20%	Spearman	0.384
30%	Pearson	0.257
30%	Spearman	0.173

Note: This table displays the monthly correlations between the returns of political risk and pandemic risk hedge portfolios and AR(1) innovations of political or pandemic index series. The portfolios are constructed with sorting thresholds set at 10%, 20%, and 30% respectively. All target index series are coded so that higher numbers indicate negative news. Consequently, positive correlation coefficients indicate successful hedges. Panel A (B) shows the political (pandemic) risk hedge performance. For political risk news series (EPU), the sample period of hedge portfolio is from 2017Q4 to 2022Q1. For pandemic risk news series (Infection), the sample period of hedge portfolio is from 2020Q3 to 2022 Q1.

OA B: Extreme Heat and Natural Disaster Shocks: Validity Test

VARIABLES	(1) <i>Abs(Return)</i>	(2) <i>Log(1+Duration)</i>
<i>I(Natural Disaster)</i>	0.001* (0.00)	0.050*** (0.02)
Observations	4,006	4,006
Firm F.E.	Yes	Yes
Year*Quarter	Yes	Yes
Cluster	Firm	Firm
Adjusted R-squared	0.285	0.261

Note: This table shows the results of OLS regression by estimating the following regression at the conversation level.

$$Abs(Return)_{i,t}/Log(1 + Duration) = \beta_0 + \beta_1 I(Natural Disaster)_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

The sample consists of all 4,006 climate change conversations identified by ChatGPT-4. The dependent variable is *Abs(Return)*, which is defined as the absolute value of return. *Log(1+Duration)* is one plus the time duration of a conversation. All regressions include a constant term. Heteroskedasticity-robust standard errors are reported in parentheses and clustered at the firm level. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

OA C1: Prompts to ChatGPT-4

Please classify the following conversations based on their relevance to climate change, labeling them as either Related to Climate Change or Not Related to Climate Change. Additionally, provide a probability score indicating the likelihood of each conversation being related to climate change, expressed as a decimal from 0 to 1.

Conversations: {Contents}.

Respond in json format with three keys “classification”, “probability score” and “Reasons”.

OA C2: Examples of Conversations Related to Climate Change

1. Agilent Technologies, Inc. (A) Q1 2020 earnings call

Brandon Couillard: Mike, just on a separate topic.

Mike McMullen: Sure.

Brandon Couillard: Can you sort of speak to the Twist settlement last week? Why only \$25 million? And should we expect any legal savings from having that case out of the way now to reinvest those dollars?

Mike McMullen: Yes. So first of all, just a few comments on the settlement. So we are very pleased with the agreement that was reached with Twist. As you know, we think it's in the best interest of our shareholders to rigorously protect our IP. And not only in addition to receiving a payment from Twist, they also had to procure a license from us for certain aspects of our oligo synthesis technology. And we are really a company that's committed to doing innovation in the right way. So we are really pleased with how the settlement goes. And Bob relative to the treatment of the legal expenses and outlook for the rest of the year? I think we have that in pro forma, right?

Bob McMahon: Yes. We will pro forma that.

Mike McMullen: Yes. So you will see both the settlement come in, Brandon, as well as the costs associated with that, I guess, in our Q2 results.

Bob McMahon: That's right.

Brandon Couillard: Thanks. And maybe one more higher-level question for you, Mike.

Mike McMullen: Sure.

Brandon Couillard: I mean you mentioned sustainability, that recognition. Clearly, that's becoming a much bigger focus I think for the investment community. Can you just help us contextualize that focus may help contribute to your growth or cash flow or differentiate you in terms of the customer base?

Mike McMullen: Yes. It's a great question. So as I mentioned in my call script, we have been doing these things because we thought it was the right thing to do and now people are really paying attention to it. So I think it helps on multiple aspects of the business. So first of all, relative to our new products which have a very favorable environmental impact, there is real compelling reason for customers because a lot of our most important customers have their own sustainability initiatives and they are very interested. I have several European customers I am visiting next month and they want to hear about our sustainability plans. So when you talk to them about how we are reducing the footprint, the electrical consumption, that some of our products don't even use gases and that we have eliminated the use of gases and gas chromatography in the case the NPIs and we are reducing the size of the packaging. And by the way, that also comes with the benefit to Agilent's P&L. So it really helps in terms of our customer relationships and our ability to drive sales into those accounts. And also it is really quite helpful for recruiting of new employees into the company. New employees when they are looking at potentially joining the company really want to know what Agilent stands for when we talk to them about our culture and what we do as a company in the local community, what we do for the environment, our views on diversity and inclusion. I think it really is a powerful message to attract new employees to Agilent, but also for those who are part of the Agilent team to really be proud of the company they work for and be energized about where the company is going forward. I think we have talked before, I am a big fan of sports and if you build a great

team, you get great things happen in the marketplace or on the field. And I think that really is really one of the major benefits you get here which is what it does for your team. So it really is a multitude of impact for the customers, I mean for the company and something we really believe in.

Brandon Couillard: Okay. Thank you.

Responses of ChatGPT

“classification”: “Related to Climate Change”,

“probability score”: 0.85,

“Reasons”:[“The conversation mentions sustainability and environmental impact of new products, indicating a focus on reducing environmental footprint.”, "Discussion about the company’s sustainability initiatives and how they align with customers’ sustainability goals suggests relevance to climate change mitigation efforts.", “Mentions of reducing electrical consumption, eliminating the use of gases in certain processes, and reducing packaging size are specific actions related to reducing environmental impact.”]

2. Alcoa Corporation (AA) Q3 2020 Earnings Call

David Gagliano: Hi. A lot of my questions have already been answered, but I guess I just wanted to pick up on the last line of question with regards to the EcoSource and the alumina low-carbon content. How do you plan to price this and what are you hearing from customers? Or do you plan to price EcoSource differently than the rest of the alumina?

Roy C. Harvey: That's a good question, Dave, and I'm going to be honest, I'm not going to give you much of an answer, because that is something that we're working on as we speak and something that we're discussing with our customers. And so, realistically, to talk about a strategy, that is not in the cards. I would tell you that we think there is real value, both to the certification of carbon content, as well as the ASI certification that really takes it a step further into social responsibility and environmental awareness, etc. So I would argue that there is space for a premium. We're just still working on exactly how that will look as we deal with this on a customer by customer basis.

David Gagliano: Okay, thanks. And then just one clarification question regarding fourth quarter. In the Aluminum segment, obviously, you called out the \$50 million incremental headwind, excluding FX and commodity changes. If you assume current FX and commodity changes, would those changes offset that \$50 million headwind? And the other part of that, for the Alumina segment, the down quarter-over-quarter in 4Q, does that take into consideration the FX that, that flow through 3Q results as well?

William F. Oplinger: Yeah. So, all of them exclude FX. So whenever we give guidance, Dave, it's exclusive with metal prices and FX. As far as the Alumina fees [Phonetic] goes, we said it would be really the energy side and some of the mix. And as far as your question in regard to whether Aluminum FX would offset that \$50 million, clearly, at this point, it's early in the quarter. Metal prices are better, premiums are a little bit worse than where they were in the third quarter. We gave you sensitivities to all of that. So as we go through the quarter, what you can do is just build in your sensitivities and determine where we end up based on that \$50 million.

Responses of ChatGPT

“classification”: “Related to Climate Change”,

“probability score”: 0.85,

“Reasons”:[“The conversation discusses low-carbon content alumina, indicating a focus on reducing carbon emissions.”, “Mentions of certification of carbon content and environmental awareness suggest relevance to climate change mitigation efforts.”, “The discussion about pricing strategies for eco-friendly products implies an economic approach to addressing climate change.”]

OA C3: Examples of Conversations Unrelated to Climate Change

1. CBL & Associates Properties Inc (CBL) Q2 2019 Earnings Call

Caitlin Burrows: Hi, again. Just one in terms of the same store NOI outlook for the rest of this year. If you look at the first half it seems to have held up a little bit better than the second half expectation. So just wondering what's driving the second half expectation at this point and to what extent is it known pieces versus general conservatism?

Stephen Lebovitz: I mean, we spend a lot of time evaluating where we're going to be for the rest of the year. And I mean we want to be realistic and we still are confident we'll be within the range. But yes, we're negative five and a half or five three year to-date, so we're going to see weaker performance in third and fourth quarter because these bankruptcies are going to kick in for the full year. But we are confident that we'll be within the range that we gave guidance and its all sources. I mean, it's everything across the board from the renewal activity and the lease spreads which were which were better. And that's helped for sure. Sales being up, helps in terms of percentage rent projections. And there is a lot of leasing going on. We tend to get bogged down with the negatives and the bankruptcies. But there's a lot of leasing going on whether it's the non-retail or it's a non-apparel or categories that are performing strongly. And there are plenty of those. And we're doing we're doing good new leasing with retailers and users that we feel like are going to be successful long term.

Caitlin Burrows: Got it. And actually maybe since you did bring it up on the leasing spread side. Yes, it looks like there was an improvement in that this quarter. So I guess do you -- I guess think that's sustainable? Or you see that continuing, perhaps, it was just related to the leases in the quarter? Any other commentary on that.

Stephen Lebovitz: Yes. I mean, it's always hard one quarter. I mean typically the first quarter we have the most renewals. So our overall spreads are impacted by that. And the strength of that and this year for sure with portfolio deals and the kind of weaker retail climate that was tough* I mean, this quarter didn't have as large of a sample. I think we're just going to be cautious towards the rest of the year and see and we hope that it'll stay in the range it is. We've said we want to be kind of in the negative single digits as opposed to -- so we're kind of hopefully going to stay in that range. I'm not sure it'll be as good as this quarter, but hopefully it'll be better than what we saw in the first quarter and what we saw last year.

* Climate change-related keywords as identified by Sautner et al. (2023)

Responses of ChatGPT

“Classification”: “Not Related to Climate Change”,

“Probability score”: 0.05,

“Reasons”:[“The conversation focuses on financial performance, specifically net operating income (NOI) outlook, leasing activities, and sales projections.”, “There is no mention of climate change, environmental impacts, or related policies.”, “The discussion is centered around business operations, financial guidance, and market conditions rather than environmental concerns.”]

2. Ameresco, Inc. (AMRC) Q2 2018 Earnings Call

Chip Moore: Echo my congratulations on the continued momentum and very strong visibility here guys. Maybe we could talk a little bit more about Island Palm. It seems like a great announcement, I think, you talked about potential for more opportunities, particularly in the military housing market maybe you can expand on that addressable market a bit more?

George Sakellaris: We -- the only drawback it's a great deal and a great partnership that we have with Lendlease, and we are envisioned more projects coming down the pipeline with them, actually we have about three projects that we are working on, right now. But I will caution you, because we announced this partnership for more than two years ago and it took us couple of years to get to this point, but the potential is very large and we hope that we will continue working with Lendlease. And we are very encouraged that we will have a substantial business in it from this part of the market segment.

John Granara: Yes, so as George said, we do have three projects in our awarded backlog. I would say that the Island Palm project is larger, and I don't expect the remaining three to be the same size. But we are working with Lendlease and evaluating their entire portfolio. And as we identify projects, you'll see them come in our awarded backlog for us and so it's -- you'll see the -- you'll be able to see it come in our awarded backlog in terms of -- from a visibility standpoint--

Chip Moore: Got it. And just looking further out, is there a potential that you could look for some more partnerships with infrastructure companies like Lendlease? How do you think about that?

George Sakellaris: Again, actually we did one with [Indiscernible]. It's not a partnership, it's just individual project for that particular client and we will look at the other ones as well. But our primary focus right now, is with the Lendlease opportunities to develop their sites first.

Chip Moore: Okay, that's good. May be last one from in Canada getting some momentum back, good to see. You called out that nice utility project. Beyond that, what makes you more optimistic and what you see in Canada? Thanks guys.

George Sakellaris: It's the pipeline that we have right now, especially in the federal sector in Canada is very encouraging and--

John Granara: Yes, I'd say in particular the federal market is quite active right now; we've traditionally played pretty well in that market, in Canada. So, that's where we're optimistic.

George Sakellaris: And we see more technological advanced projects right combined heat and power*, streetlight upgrades and battery storage and microgrids. So, as the market expands, we feel pretty good that we're in a good position to take advantage of the opportunities.

* Climate change-related keywords as identified by Sautner et al. (2023)

Responses of ChatGPT

“Classification”: “Not Related to Climate Change”,

“Probability score”: 0.2,

“Reasons”: [“The conversation primarily focuses on business partnerships, project developments, and market opportunities in the construction and infrastructure sectors.”, “There is a brief mention of technological advanced projects including combined heat and power, streetlight upgrades, battery storage, and microgrids, which could be related to energy efficiency and renewable energy. However, this mention is not the main focus of the conversation and does not explicitly link these technologies to climate change mitigation or adaptation efforts.”, “The overall context and details provided do not directly address climate change issues, policies, impacts, or actions.”]

OA D: Case Studies

Case Study 1: OGE Energy Corporation

1. Company Background

OGE Energy Corporation (NYSE: OGE), headquartered in Oklahoma, operates as the parent company of Oklahoma Gas and Electric (OG&E), which was established in 1902, making it Oklahoma's oldest and largest investor-owned electric utility. OG&E services approximately 887,000 electric customers across Oklahoma and Western Arkansas, covering key urban areas such as Oklahoma City and Tulsa. As of 2023, the company's energy generation portfolio comprises 66% natural gas, 26% coal, and 8% from renewable sources. In 1997, OGE Energy restructured into a holding company, positioning OG&E and Enogex under its umbrella. The focus of this case is on the operational and regulatory environment of OGE and OG&E, particularly how federal emissions reductions and climate policies impact their shift towards renewable energy. OG&E also pioneered the adoption of a Smart Grid system in the region, enhancing its electricity supply network with advanced digital communication technologies to improve responsiveness to changes in local electricity usage.

In 2019 and 2020, OGE Energy Corporation participated in the Climate Disclosure Project, an international non-profit organization that facilitates the disclosure of environmental impacts by companies. OGE's submissions during these years highlighted several climate change-related risks affecting their operations, including regulatory mandates impacting products and services, investor reactions to climate change, severe weather conditions, and the potential premature retirement of assets. Conversely, they also identified several opportunities arising from climate change, such as increased capital through regulated adjustments, heightened demand for services due to extreme weather, and shifting consumer preferences towards renewable energy sources.

2. Analysis of Earnings Call Conversations

2.1. The long position

This case study will focus on examining the strategic adjustments in OGE's investment portfolio, particularly from a long position in the first quarter of 2019 to a short position by the fourth quarter of 2020. By analyzing earnings calls from both Q1 2019 and Q4 2020, the study aims to uncover the underlying reasons for this significant shift in portfolio strategy.

In February 2019, OGE had a long portfolio position, meaning climate-related news led to a significant positive reaction from OGE investors. Investors believed that OGE was perceived as capable of handling risks and responding well to climate-related opportunities. During the 2019 Q1 earnings call, CEO Robert Sean Trauschke referenced "a great [grid modernization] program in Arkansas." Trauschke is referencing OG&E's Arkansas grid modernization project, which was completed in Q1 of 2019 and was likely the reason for the company's long portfolio position. Trauschke also says that OGE plans "to share with Oklahoma...of the real customer benefits that we're seeing." He references OGE's intent to expand the grid modernization project from Arkansas to Oklahoma.

The grid modernization program presents several potential benefits:

- **Resilience Against Extreme Weather:** The program aims to enhance the grid's resilience against increasingly frequent and intense extreme weather events. This includes fortifying the grid to withstand such events or facilitating rapid recovery, thereby minimizing the duration of power outages.
- **Integration of Renewable Energy:** By modernizing the grid, it becomes more capable of managing the variable loads and decentralized generation that are typical of renewable energy sources like wind and solar. This adaptability is crucial for increasing the use of renewable energy, which plays a vital role in reducing reliance on fossil fuels and combating climate change.
- **Energy Efficiency Improvements:** Modernization efforts also lead to improved energy efficiency. This is achieved through reduced transmission losses and the implementation of more effective demand response programs, which together lower overall energy consumption and subsequent greenhouse gas emissions.
- **Support for Electrification:** A modernized grid is better equipped to support the widespread electrification of transportation and other sectors, a critical component in reducing carbon emissions and achieving climate goals.

Overall, grid modernization is a forward-thinking approach toward developing a sustainable and climate-resilient energy system. Trauschke's testimony to the project's success and the company's plans to modernize grids in Oklahoma is positive climate news for investors.⁶ The stock return reaction to this conversation was 3.7%.

2.2. The short position

In November 2020, OGE shifted from a long to a short position, likely because investors were concerned about the company's inadequate response to climate-related risks and opportunities. This shift coincided with the broader industry response to the COVID-19 pandemic, where many energy companies restructured to embrace a lower-carbon future. A 2020 Deloitte survey indicated that over 90% of oil and gas firms were developing sustainable strategies, with half already investing in clean energy.⁷ However, during a November 2020 earnings call, when asked about the company's strategy for the upcoming decade of increasing electrification, OGE's CEO Trauschke provided general statements about being well-positioned and making progress on CO₂ reductions but failed to outline specific initiatives. This lack of detail was mirrored in OGE's 2020 Climate Disclosure Project (CDP) questionnaire, which highlighted only a plant efficiency rating as a climate initiative, lacking specific or innovative strategies for transitioning to a sustainable, low-carbon future. Furthermore, OGE's reported goal to cut emissions by 50% by 2030 was not verified by the Science-Based Targets initiative, casting doubts on its specificity and accountability.

This earning call conversation also indicates looming regulatory and transition risks that could be viewed as negative news by investors. As indicated by the CEO, "Now as you think about any kind of CO₂ tax or things like that, we're not waiting, as I've mentioned, to 2050." This statement acknowledges the looming possibility of regulatory measures like CO₂ taxes, which could increase operational costs or necessitate significant investments to comply with new regulations aimed at reducing carbon emissions. The CEO also mentions, "We've made huge inroads already. And we've been able to do that without affecting the

⁶ For more information on modern power grid, see https://www.edf.org/energy/modern-power-grid-can-deliver-cleaner-energy?gad_source=1.

⁷ <https://www2.deloitte.com/us/en/insights/industry/oil-and-gas/oil-gas-energy-sector-disruption.html>

economic vitality of our communities." This reflects on the transition costs involved in moving towards electrification and decarbonization.

OGE's shift in portfolio position demonstrates investors' adverse reaction to companies that are responding inadequately to climate risks. While investors praised OG&E's grid modernization project for its positive climate impact in 2019, they reacted adversely to Trauschke's potentially greenwashed answers and the lack of climate initiatives for OGE post-COVID. The stock return reaction to this conversation was -2.1%.

3. Appendix: Earnings Call Conversations

2019 Q1 Conversation

BofA, Merrill Lynch, Research Analyst, Richard Jude Ciciarelli: this is actually Richie Ciccarella here for Julien. just wanted to touch base on your grid modernization program in Oklahoma.

OGE CEO: Robert Sean Trauschke:

"we have a great program underway in Arkansas that's achieving -- i mean, really exceeding our expectations. so we're going to conclude that first phase here next month, and we're going to share that with Oklahoma kind of the real customer benefits that we're seeing. we want to make sure that we get these 2 Oklahoma filings resolved. we're making a concerted effort to keep our filings very simple and straightforward in really around singular issues."

Cicarelli: got it. and i mean assuming -- i mean not trying to put the cart before the horse but assuming you could be successful in a grid mod request, is \$600 million still kind of the full run rate level?

Trauschke: sure. that's a very comfortable rate.

2020 Q4 Conversation

Levi: we'll just leave it at that. and then the last question is just more on the industry. so getting off of enable and looking at like a negative carbon-type environment going forward, whether it's on the oil side and maybe to a lesser degree on the nat gas side. and then the country, whether it's a bidden administration or a trump administration, it's clearly going to move towards electricity, and there's going to be a big transformation within -- in the sector over the next decade. can you maybe just talk about that and how oge management and the board is kind of looking at what the opportunities are over the next decade as the country becomes more electrified, a better way to put it?

Trauschke: yes. Andy, and i appreciate -- i understand this question now, so i got this one. no, i think -- and Andy, we've had this discussion. i mean, i think your thesis and your thinking about this is really quite insightful. the way we think about it is it goes back to that fundamental point about economic development, because i think if we can continue to operate our business as -- with affordability and reliability in mind, we can attract more people to our service territory. we're able to compound that idea that you have because i agree with you. i think there's going to be much more electrification, whether in the home, in the vehicles and processes, things like that, and manufacturing. and then you compound that with a growing service territory, you get that multiplier effect. so we think this idea of actual load growth today that is separate and aside from electrification is huge. and so we believe we are very, very well positioned. now as you think

about any kind of co2 tax or things like that, we're not waiting, as i've mentioned, to 2050. we're plowing through that, and we've made huge inroads already. and we've been able to do that without affecting the economic vitality of our communities. and so you should expect us to continue to march down that path as well. and those are investment opportunities. everything you're talking about are investment opportunities, whether it's decarbonization, whether it's because of economic development or, as you profess, just more electricity sales. i think it's bright.

Case Study 2: Clean Energy Fuels Corporation

1. Company Background

Clean Energy Fuels Corporation, established in 1997 and based in Newport Beach, California, is spearheaded by CEO Andrew J. Littlefair, one of its co-founders. The company focuses on designing, building, financing, and operating natural gas filling stations for vehicle fleets across North America, promoting the use of compressed natural gas (CNG) and liquefied natural gas (LNG). As a leader in the transition to more sustainable fuel options, Clean Energy Fuels champions renewable natural gas (RNG) derived from organic waste, such as livestock manure and landfill methane. This cleaner alternative not only reduces carbon emissions by an average of 300% compared to diesel but also aligns with environmental standards set by the EPA and the California Air Resources Board. Operating 600 fueling stations, Clean Energy Fuels supports 25,000 trucks, buses, and other large vehicles daily, offering conversion services for vehicles to switch from traditional fuels to RNG. This initiative directly addresses the 28% greenhouse gas emissions attributed to the U.S. transportation sector, offering a zero-emissions solution through RNG.

2. Analysis of Earnings Call Conversations

2.1. The short position

In our climate risk hedging portfolio, Clean Energy Fuels Corporation had a short position in quarter 1 of 2018 and switched to a long position in quarter 4 of 2018. This case study will analyze the Q and A portions of earnings calls in 2017 and 2018 to determine why the portfolio position changed.

In the Q2 and Q3 2017 earnings calls, it became apparent that investors were concerned about Clean Energy Fuels' responsiveness to evolving climate-related regulations and market trends. CEO Andrew J. Littlefair's unclear statements regarding the impact of potential regulations in Washington and California—specifically, the VETC tax extender and California's Senate Bill 1—contributed to a -1.5% response from investors. These regulatory uncertainties, coupled with the strong push towards zero emissions by the California Air Resources Board (CARB) and a burgeoning preference for electric vehicles as evidenced by the growth of companies like BYD and Proterra in 2017, underscored a sentiment that Clean Energy was not aligning with the accelerating shift towards electric transportation. Littlefair's remarks about the "romance around the electric vehicle" and perceived biases in Sacramento further indicated that Clean Energy might be lagging in adapting to a market that increasingly favors electric over natural gas solutions, positioning the company unfavorably among climate-conscious investors.

2.2. The long position

In the period between Q1 and Q4 of 2018, Clean Energy Fuels made significant strides in clarifying its strategies and mitigating the initial uncertainties that had led to a short position earlier in the year. CEO Andrew Littlefair outlined how regulatory changes and environmental policies, particularly California's Senate Bill 1 (SB1) under the Clean Air Act, were positively impacting the company. The bill's provision of funding for Clean Energy Fuels showcased the benefits of regulatory support, which had not been as clear to investors in 2017.

During 2018, the natural gas market saw a production increase due to expanded fracking activities, which drove down prices and bolstered the development of the natural gas sector in both the US and Europe. This shift resulted in a more favorable market environment for Clean Energy's offerings. Additionally,

significant agreements, such as the partnership with Total, one of Europe's largest natural gas suppliers, further reinforced the company's market position.

Littlefair elaborated on Clean Energy's strategic partnerships, notably with Total Energies Gas and Power and the Harbor Trucking Association, emphasizing how these collaborations enhance the company's positioning within climate-focused initiatives. The Harbor Trucking Association, which operates a fleet of trucks serving West Coast ports, is committed to reducing fossil fuel emissions. Through this partnership, Clean Energy expands its market opportunities while reinforcing its commitment to emission reductions. Total, recognized as the largest natural gas supplier in the U.K., partners with Clean Energy, positioning it as their preferred fuel provider for member companies. This collaboration has also enabled Clean Energy to introduce a leasing program, enhancing the accessibility of natural gas trucks for a broader range of operators.

In Q3 of 2018, Littlefair introduced the "Zero Now Lease Program," designed to equalize or undercut the costs of diesel trucks, making natural gas vehicles a more viable option for fleets. This program, combined with the availability of 110 fueling stations that accommodate Class 8 trucks and discounts on RNG for new converts, has significantly bolstered Clean Energy's market stance. These strategic moves, along with a clear understanding and response to regulatory challenges, have contributed to a notable shift in Clean Energy's portfolio position. Overall, the market responded positively to these developments, with an average stock price increase of 1.2% across the earnings calls from Q1 to Q3 of 2018.

3. Appendix: Earnings Call Conversations

Q2 of 2017 Earnings Call

Eric Andrew Stine, Craig-Hallum Capital Group LLC, Senior Research Analyst:

“people get the significance of natural gas and the near-zero engine. just wondering, in terms of policymakers and regulators, are they starting to get that message? or is it still something where you are fighting the fact that you've got a lot of claims -- or just people talking a lot about electric and other technologies?”

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President and Director:

“well, look, yes, there's no doubt that there's a romance around the electric vehicle, and there's -- and let's just give everybody their due. they -- people believe that, that is -- it's almost a spiritual argument that they really believe that the zero -- that electric vehicles at zero. well, it turns out that our fuel is actually cleaner than theirs, their someday electric truck, and we're ready to go today. i would say, though, the sort of empowered clean air folks, certainly in Sacramento, have a bias toward electric.”

“so yes, i -- yes, we still are -- it's one of the reasons i make these remarks today, is because i think people sometimes get lost in -- somebody's going to bring to market an electric truck a few years from now that may be 2.5x or 3x what we have today and isn't any cleaner. so i think that is -- and the zero emission natural gas truck that we're talking about now, the cummins westport product, that's only been now coming to market now. so it's new. but i think it's beginning to change. a lot of the sessions at the conference in long beach talked about game changer. i think the renewable natural gas with this new engine is a game changer. i think the clean air regulators are having to take notice.”

Q3 of 2017 Earnings Call

Eric Andrew Stine, Craig-Hallum Capital Group LLC, Senior Research Analyst: i was wondering if we could just start with redeem and bp. i mean, i know it's been a few months, but maybe how your view of their commitment has evolved here over time.

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President and Director

“I think, if i got all your question, on cap-and-trade. there's a recent study out, and we can get it for you, eric, by someone that follows a lot of this on the biomethane business and renewables in the state of california. over time, it looks like there's potential for there to be 2 billion gallons of biomethane annually produced from different sources, and this will be all kinds of sources in the state of california. and having the cap-and-trade program and frankly the low carbon fuel standard, which is sort of part and parcel with - - although it is in separate pieces of legislation. having those 2 pieces be extended by the legislature until 2030, i think, really gives certainty that this is going to be the de-carbonizing of -- california's going to continue. you'll remember, you don't have to go back but a year ago when the prices were a little wobbly of the low carbon fuel standard because people weren't sure if it was going to be re-upped or not. so this gives stability for those looking to make investments on the transportation side and certainly on the production side. so i think it bodes well. in fact, if you look -- i don't want to say this is -- this could be a fluke, but since that's happened, the prices of low carbon fuel standard have actually firmed here in the last week or so, last 4, 5 days as some of the most recent trends have been up. so i think it's probably a good thing for the stability of the business going forward.

“we see what's going on in terms of electric and sustainability efforts. and the great news for natural gas is we have a product that's here today that can do the nation's work, but can do it a renewable way, really cleaner than really anything else.”

Stine: i've obviously been following the clean air action plan at the ports pretty closely. and what came out recently, there's been a lot of talk about sb1 in the ports saying that it limits, to some extent, what they can do through 2023 and carb saying no, it does not. i'm just curious how you think -- or where that stands today and how you think that plays out here between now and, say, november 1, i think they're supposed to finalize the plan?

Littlefair:

“i mean, sb1 was a piece of legislation that got passed that had some provisions in it that said that the state air resources board couldn't do -- couldn't add certain equipment to trucks for the next several years. and that was done as part of a legislative recipe in order to pass the gas tax, the increased fuel tax here in california. and some -- but what's very clear in the law in senate bill 1 is that while carb can't, for instance, mandate new traps, new heated catalysts on trucks for the next frankly 18 years, it doesn't stop anybody from passing a new -- it doesn't even stop carb from passing a new emissions standard. and it certainly doesn't encumber the local air districts or even carb from passing different local rules. and it doesn't impede the port of la or other local jurisdictions from passing indirect source rules or other things to be able to clean up their air.”

“so what we're seeing, and i want to be a little careful here, we're seeing somewhat of a confusion and we're seeing some that would rather not maybe be aggressive hiding behind sb1, saying that they're -- it's -- they're unclear as to how it might apply.”

Pavel S. Molchanov, Raymond James & Associates, Inc., Energy Analyst: same question as i asked 3 months ago, which is we're getting into kind of tax reform discussion in d.c. and vetc, i'm sure, will come up. what is the latest that you are hearing on how the vetc will go into the broader reform conversation?

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President and Director: yes, pavel, as you know, we follow that pretty closely. and this legislation and some of the items on the administration's agenda, it's been a wild ride. and as you know now, we're focusing on tax reform. i think it's becoming more clear to many that grand tax reform is probably not in the cards, but that some reduction of rates and perhaps reduction of repatriation of dollars is likely to be the majority piece of legislation in what's being called tax reform as via reduction of rates.

Molchanov: okay. and then kind of turning to the electric bus question. a lot of headlines regarding the la metro starting to diversify their fleet. and i think back in june, they talked about kind of a transformative plan through 2030. what's the latest on how you understand that to be?

Littlefair: “yes. we've been, as you know, involved in that and we're watching that closely and making sure that people understand how clean natural gas is as well as part of that.”

“ most people don't realize that federal transit -- that the buses are paid in large part by the federal government. and so while 85% to 90% of a bus is paid for by the feds, it makes it a little easier to pay the upcharge that today that electric has. and so we'll see how that -- but there's still limited funding for these big transit agencies. and so that's something that's going to have to -- either the electric buses have to get dramatically cheaper or they're going to have to figure out how to be more efficient because the pool of dollars that they have won't necessarily spread over the substantial increase of the cost of these electric buses. we make the case that our renewable -- our natural gas low nox engine, which they just took 300 -- bought 360 of, at the same time, they bought the 95 electrics, is cleaner than electric bus today in los angeles. so it's cheaper, it's cleaner and we think it has a better duty cycle and will operate just as well. so nothing against my friends in the electric business, but i think the jury's out on how that's all going to roll out. and then one other, thing while i've got an open line, i guess, is that i think it's one thing for electric to do -- to be able to participate in a federally funded fleet like the federal transit. i think it's a totally different thing to look at the private sector long-haul trucking or regional trucking or certainly, refuse trucking -- i mean, refuse trucks. i mean, now you're down to a private sector, there is no funding like this and you just can't have 40%, 50%, 60%, or in the case of an over-the-road truck, 200% incremental. it doesn't fly. and so i think we have the best near-term immediate solution with natural gas in the low nox engine.”

Q1 of 2018 Earnings Call:

Eric Andrew Stine, Craig-Hallum Capital Group LLC, Research Division - Senior Research Analyst: i was wondering if we could just start at the ports, with the cap in place, the fees on diesel trucks starting in 2020. just curious what you're seeing on the funding side, whether that did, in fact, start to flow in december, what you see now and when do you think you will start to see these trucks on the road that you can start to fuel.

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President & Director:

“eric, there are some of the new, as i had mentioned, some of the new 12-liter trucks. low nox 12-liters are being sold into the port now. there's been some orders taken. next month, we'll have about 25 new trucks going into a couple of fleets down there. all of the oems will have trucks that will be moving into the ports in the second and third quarter. on the grant funding, there is, as you know, as you followed it over time,

there's lots of different pots of money in the state, prop 1b money and others. there are actually, right now, 140 trucks that are in a -- in the queue to receive prop 1b money.”

Littlefair: yes, well, we still obviously like the redeem fuel, and it's gaining a lot of traction. redeem, the renewable natural gas, it's really the cleanest fuel out there. and when you look at how it's made versus the manufacturing of electricity, it really is renewable and it's cleaner, which is something that people -- it takes a while for people to completely understand that, but it isn't lost on a lot of our fleets that are concerned about sustainability. don't get carried away as you model us, eric, on \$25 million as the run rate. we did see that in the quarter. it is because we have the downstream capability to take a lot of this. we are seeing new renewable natural gas coming to the market, so i'm not saying that this kind of bulge or bump-up won't happen from time to time. i'm not sure i'm prepared to tell you to just assume that that's where the business is right this second in the first quarter or so.

Q2 of 2018 Earnings Call

Robert Duncan Brown, Lake Street Capital Markets, LLC, Research Division - Senior Research Analyst:

what's sort of your sense of what this partnership can bring in those bigger markets in terms of maybe new truck rollouts and new sign-ups for rollouts of trucks themselves?

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President & Director:

volvo has introduced a new natural gas truck there. we've heard rumors, frankly, that volvo is beginning to look at introducing natural gas heavy-duty truck here in the united states.

Eric Andrew Stine, Craig-Hallum Capital Group LLC, Research Division - Senior Research Analyst:

i know in california that's what 80%-plus of all the volumes are redeem. but just curious, what the volume trends are like outside of california? i know you've had a few contracts. you've expanded to a number of states of the republic. but just curious how that's going, but then also are your new customers or new redeem volumes, would you characterize those as new customers altogether? or are those customers that are upgrading to redeem?

Robert M. Vreeland, Clean Energy Fuels Corp. - CFO: yes, rob, so the interest -- yes, no, i would say the interest is absolutely growing outside of california. we have some big transit customers that are looking at it and want the fuel. so percentage-wise, you're right. the bulk of it goes into california right now. but we're moving out. i mean, we've got republic services and dallas dfw, a number of customers. i mean, everybody really loves that fuel. so that's a very big bright spot in the volume for us.

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President & Director:

“we're beginning to see some production and supply coming on with very low carbon intensity fuel. what that means is this is being done from a manure and digesters with very much lower, i guess, 4x or 5x lower than trash depots, landfills. and so that makes this stuff very valuable. and so there is a lot of projects coming on and it bodes well for the expansion of the biomethane.”

Stine: but just how total potentially helps that? i mean, obviously you've got the partnership with bp, but whether total, that helps in any way?

Littlefair:

“total in our discussions with the ceo on down, they're very interested in biomethane. they're familiar with it in europe. they have a different credit structure in europe. so they are learning from us on our situation here. they don't have the rins and the low carbon fuel standard there. they have some different economics. they're very interested in it. they know it works. obviously, they're big gas producers, so they're -- and they know that blending the biomethane gives them an advantage and it's something that they see that is very valuable as they displace diesel.”

Stine:

“but clearly natural gas is the one that where the activity is happening. and i know you've had a good foothold at the ports, but with all of the incentive money in california, i know it's kind of a continual battle between whether its hydrogen or battery or some other technology or natural gas, where you've got the near-0 technology available today. so just curious, what kind of progress you're making there or how you feel outside of the ports, because you are in there, but just some of the progress you're making in other parts of california?”

Littlefair: well, rob, in -- for those on the call that don't know what the act expo is, it's the advanced clean transportation show that goes on conference, that goes on here, that's probably the premier show in the united states. and you're right, here in california, there is a lot of -- a lot of grant money available. and i would say there's a frustration -- i've been pretty open about this. there's a frustration and it has been in, at least, the natural gas vehicle industry that we believe that the air resources board has shown a bias toward putting a lot of the dollars -- for instance, the vw fine money, awful lot of that found its way going to electric programs. and of course, as you know, they don't have anything even commercial in the heavy-duty space. and yet a big slice of this grant money finds its way going there, because that's frankly, that's kind of the dream of arb, is wanting to push something that's not commercially ready today.

“however, having said that, there is hundreds of millions of dollars available as well for natural gas. i was looking at -- and these are very complicated, but they break -- well, they're not that complicated, but there are many different buckets. but they break down somewhere between \$40,000 and \$100,000 per vehicle. and kind of depending if you retire a truck or if you get a new truck, and this and that, you get different piles of money. i looked at a list the other day, that it looked like there was -- and this would be one of the bigger numbers we've seen -- about 475 vehicles that have applied and are in the queue for various grant programs here in california. so these are heavy-duty trucks using anywhere between 12,000 to 20,000 gallons a year. so for us, that's really important. some of those, i think -- the number is smaller -- but there is another 120 -- i believe i'm right on that, that are just being funded to operate in the port of l.a. so -- and there is more money behind that and there is more funding cycles coming.

so i guess the answer to your question is, is i believe there's just been too much money set aside for programs that aren't ready yet. i happen to think -- i'm kind of for summing those -- some of those to be funded because i think it's going to prove out that they're not ready for prime time. the vehicles are not efficient, they are too heavy, they don't have the payload, they're not -- they haven't been through the scrutiny and the manufacturing and that you've seen -- that we've gone through over the last 10 years or 15 years. and i think the experience is not going to be good. and i think when you compare that to the natural gas, they're

not going to hold up very well. and my guess is, over the next couple of years, you're going to see more of the money come -- look, california is in a crisis to reduce nox and 70% of the nox problem in california is from heavy-duty trucks and you only have one product today, which is natural gas heavy-duty truck, that can meet that demand and that acts like a real truck, and i think that over time, that's going to become clearer and clearer. and i think that some of these grant monies are going to -- people are going to understand that the cost-effectiveness is not good, putting the money to where it's going right now and it's going to come back over to our way.

Pavel S. Molchanov, Raymond James & Associates, Inc., Research Division - Energy Analyst:

which is the aftc. i know, i think 3 months ago, there was some movement in congress to kind of marry that with biodiesel credit, few other things, tax extenders. that has not happened yet. i'm curious kind of what your read is, and whether anything is remotely possible before the mid-terms?

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President & Director: and then the industry association as well, we feel fairly optimistic in talking to senior members of congress that there appears to be bipartisan support to move the extenders, which the alternative fuel tax is part of, sometime this year.

“kind of feel like there has been more and more understanding and push for alternative fuel technologies with this raising oil price that i think the extenders will get adopted and the alternative fuel tax will get done for 2018. i'm not sure -- i've said this before -- i'm not sure that it goes on much longer than that. but i think you'll see it get adopted for 2018.”

“sure. operator, thank you. i'd like to close the call by reiterating our enthusiasm about having a new partner in total and expanding the use of natural gas fuel to help take on the world's issues with emissions and carbon..”

Q3 of 2018 Earnings Calls

Eric Andrew Stine, Craig-Hallum Capital Group LLC, Research Division - Senior Research Analyst: maybe just starting with the ports, it's been a couple of quarters since you've had the agreement in place with the harbor trucking association.

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President & Director:

“we have a relationship with them to be really their fuel provider of choice for their member companies. i think that's why, eric, we've been very pleased with the 500 grant applications in for the 500 trucks that are now in queue to be funded for the port. i think if we go back over the last couple of quarters as the clean air action plan got unveiled, we said that we thought we'd be doing a good job if we got a few hundred new cummins westport 12-liter trucks put into the port this year, because remember, we're about 1.5 years before the fee goes into effect, and then they have to do this. and so i like the way the uptake's been going. you'll see those first trucks come in the latter part of this -- of the third quarter.”

Stine: and you kind of just touched on it. i know it's kind of been a battle to get natural gas in place versus some of the other technologies, which like electric, which is much more expensive. i mean, do you feel like that's kind of turned or that will turn once you get trucks on the road?

Littlefair:

“the reality is there isn't a heavy-duty truck that works today that you could buy. and i know that we're going to compare favorably to it when it comes out because look, we also know that these truckers operate on very thin margins, certainly in the ports, they really do. and this idea somehow that it's just the same to use an electric truck that carries with it a 2x price tag versus what we're offering and magical multimillion dollar fueling stations are going to be built by the public through public utilities, i just think that as that really begins to roll out and people can't really look at that, we're going to look very well.”

“by the way, i think that's very significant to note that as part of this zero now program on the truck, we're going to be offering a fixed fuel contract to our customers that really runs the term of the lease, never really done -- been done before at a significant discount to diesel. and that's being done in coordination with our friends at total. so that's just one example. we're working closely with our compressors subsidiary, that's now headquartered in italy. total is rolling out fueling stations across europe. we know we have a very good compressor, and so we're working closely with them to see if that would make sense as well. so we've talked to them. it turns out that total now represents 10% -- moving 10% of all the lng around the world.”

Robert Duncan Brown, Lake Street Capital Markets, LLC, Research Division - Senior Research Analyst: on the zero now program, lease program, could you update us on the timeline and how you expect that to roll out in terms of sort of truck kind of volumes and then maybe the size of the fleets you're targeting for customers?

Andrew J. Littlefair, Clean Energy Fuels Corp. - Co-Founder, CEO, President & Director: many of whom have had experience with natural gas. some of whom are current customers. some are not. they tend to be customers that buy a lot of vehicles, that have perhaps as many as thousands of heavy-duty trucks. that profile would be fleets that they burn between 15,000 and 20,000 gallons a year. that's -- they have good credit. they have fixed routes that tend to overlap on our station network, which is fairly easy to do because we have such good coverage. we've broken that list. i'm not going to get into gory details because i don't want to turn over my playbook, but we've broken that list down to the first set of a couple hundred targets.

Brown: okay, great. switching to redeem, how is the rng supply market? do you feel there's any constraints there? or is that developing pretty well?

Littlefair: well, there are constraints, as we sit here in the middle of 2018. however, there is a lot of supply and low -- or high carbon intensity supply coming on stream. the epa set those new compliance for next year at, i think, about a 35% increase over where it is today. i think the industry will meet that. and i think we believe that that'll be the case. you'll see that kind of growth or even a little bit more than that, rob, over the next couple of years. so over the next few years, you'd see that volume continue to grow significantly. but as we sit here today, we need a little bit more supply. we work very closely with our partner, bp, for that supply. as i mentioned in my remarks, we've lined up some additional supply that'll come on later 2018, early 2019, which is good -- with good carbon intensity numbers. so our customers really seem to like it, like this fuel. they really do understand that it's a very compelling tool in sustainability.