

A Quantity-Based Approach to Constructing Climate Risk Hedge Portfolios

Georgij Alekseev
NYU Stern

Stefano Giglio
Yale & NBER

Quinn Maingi
NYU Stern

Julia Selgrad
NYU Stern

Johannes Stroebel
NYU Stern & NBER

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Motivation

- Climate change poses a risk to economic activity, asset values, and potentially financial stability
- Key Question: Can you use financial markets to transfer exposures to various climate risks?
 - Physical Risk (e.g., rising sea levels, floods, and wildfires)
 - Transition Risk (e.g., regulation and technological change)

Motivation

- Climate change poses a risk to economic activity, asset values, and potentially financial stability
- Key Question: Can you use financial markets to transfer exposures to various climate risks?
 - Physical Risk (e.g., rising sea levels, floods, and wildfires)
 - Transition Risk (e.g., regulation and technological change)
- No dedicated derivative or insurance contracts that offer a direct & long-dated hedge against specific climate risks
- Alternative approach (Engle et al., 2020): Sequence of short-lived portfolios that hedge *news* about climate risks
 - Dynamic strategy replicates long-dated buy & hold contract

Motivation

To implement this strategy, you need to address two questions:

- ① What news series should be your hedge target?
 - Following Engle et al. (2020), researchers have constructed various climate news series based on textual analyses of newspaper coverage
 - This paper does not innovate on this dimension

Motivation

To implement this strategy, you need to address two questions:

- ① What news series should be your hedge target?
 - Following Engle et al. (2020), researchers have constructed various climate news series based on textual analyses of newspaper coverage
 - This paper does not innovate on this dimension
- ② How do you construct the optimal hedge portfolio (i.e., a portfolio that will outperform on realizations of bad news about climate risk)?
 - Need to determine different assets' climate risk exposures
 - Existing approaches do not work well with limited time-series data
 - **This paper:** Propose new approach based on trading responses to idiosyncratic news shocks received by some investors

Existing Hedge Approaches

- **Approach I: “Narrative Approach”**

- Based on researchers’ beliefs about business models, etc.

“Solar companies should do well when there is news about stricter limits on carbon emissions [a realization of negative transition risk].”

- Direction hard to predict beyond a few obvious examples, but ideally use all assets for diversification
- Engle et al. (2020): Systematic approach to form long-short portfolios on E-Score (or data on carbon emissions, etc.)
 - Required data usually not available or low quality
 - Scores unreliable & barely correlated across providers (Billio et al., 2020)
 - Currently: Modest and unstable hedge performance
 - Disclosure requirement such as newly proposed SEC rule will help, but hard to systematically capture strategy (Shell vs. Exxon)

Existing Hedge Approaches

- **Approach II: “Mimicking Portfolio Approach”**

- Proposed by Lamont (2001) to hedge macro shocks such as inflation
- Infer hedge portfolio based on past relationship between news and prices
- Project climate news series on a set of asset or portfolio returns, use fitted β^Z to construct portfolios

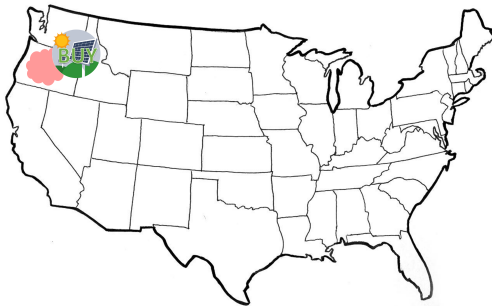
$$ClimateNews_t = \beta^Z \mathbf{Z}_t + e_t$$

- **Conceptually:** Extract investor “narratives” from time-series data
- **Challenge:** Short time series makes out-of-sample results unstable; particularly so for climate risk, which
 - ① Was likely not priced 10 years ago;
 - ② Does not feature very frequent “news”;
 - ③ Features structural changes (Exxon now vs. Exxon under Trump)

This Paper: Quantity-Based Hedge Approaches

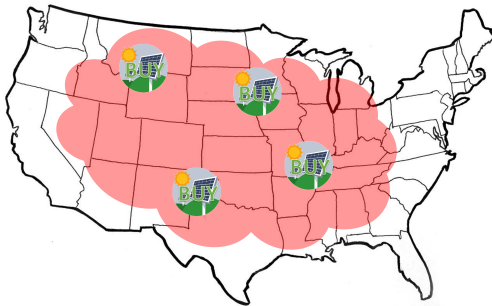
- Introduce new “quantity-based” approach to identify hedge portfolios
 - Still trying to infer investors’ narrative from the data
 - Expand data used to inform hedge portfolio by moving beyond limited time series
 - Exploits cross-sectional variation in investor trading responses to idiosyncratic climate news or climate attention shocks
- Every period: Many data points (in the limit, one from each investor)

This Paper: Quantity-Based Hedge Approaches



- Suppose climate change awareness or concern increases in Oregon
- Observe: Oregon-based investors disproportionately buy solar stocks
 - No price changes because affected investor base is small
- Still informative about what would hedge a national news shock

This Paper: Quantity-Based Hedge Approaches



- What if we had a similar *national* shift in climate change awareness or concern (e.g., the arrival of news we want to hedge)?
 - All investors now buy solar stocks → prices rise
 - Solar stocks thus hedge the national climate news series

Quantity-Based Hedge Approaches

- Focus on *mutual fund managers*: Observe their holding/trading
 - Approach expands to other investors with observable holdings data that can be linked to idiosyncratic shocks
- Source of idiosyncratic changes in investor climate beliefs/attention
 - ① Local extreme heat events
 - ② Mentions of climate change concerns by mutual fund managers in strategy statements to investors.
- Which *industries* are disproportionately bought & sold in a quarter by mutual fund managers with idiosyncratic climate belief shocks?
 - Approach expands to individual equities, other asset classes, etc.

Quantity-Based Hedge Approaches

- **Finding I:** Long-short portfolios on this characteristic outperform other approaches to hedging various climate risk news series
- **Finding II:** Approach also works well for hedging national house price and unemployment series
 - Based on insight from Kuchler and Zafar (2019) of local extrapolation

Roadmap

- 1 Constructing Local Heat Shocks
- 2 Determining Fund Industry Changes
- 3 Building the Hedge Portfolio
- 4 Choosing a Climate News Series
- 5 Hedge Performance
- 6 Conclusion

Approach 1: Local Heat Shocks

- **Objective:** Shocks that are localized, but shift climate attention / climate beliefs of local population

Approach 1: Local Heat Shocks

- **Objective:** Shocks that are localized, but shift climate attention / climate beliefs of local population
- Many studies show that local **heat** shocks shift climate change beliefs (Joireman et al., 2010; Li et al., 2011; Deryugina, 2013; etc.)
- Construct three local heat shocks using data from SHELDUS (Spatial Hazard Events and Losses Database) and PRISM temperature data:
 1. Injuries or fatalities
 2. High crop indemnity payments
 3. Extreme monthly temperature maximum (relative for county)
- The three classes of heat shocks are only weakly correlated
- Each heat shock predict Google searches for “Climate change”

Approach 2: Investor Report Measure

- Mutual funds publish semi-annual N-CSR filings. Include copy of report to stockholders and disclosure of proxy voting policies
- Search filings for climate-change-related words

“Climate change remains a concern in the form of more severe weather-related events.”

“We find that [...] the sector as a whole is failing to capture the risks and opportunities of climate change.”

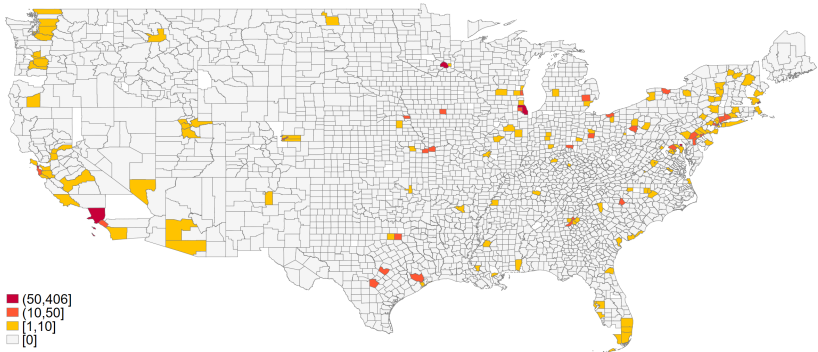
- We capture changes in climate beliefs & attention by measuring differences in language over time

Determining Fund Industry Changes

- Which assets are disproportionately bought/sold by mutual fund managers exposed to these idiosyncratic shocks?
 - Focus here on equities, but in principle could include many other assets
 - Focus here on 24 industry portfolios (GICS 4-digit), but could do this for individual equities (sparser holdings)
- We measure industry-level holding changes in three-month intervals
 - Thomson Reuters Mutual Fund Holdings S12 database
 - Restrict to the subset of *Equity Domestic Non-Sector* funds
 - Mutual fund adviser locations parsed from SEC filings (N-SAR until 2017; N-CEN from 2018)

Determining Fund Industry Changes

- Sample characteristics:
 - 2,496 unique mutual funds, 276 unique counties
 - 25.8% in NY; 14.3% in MA; 10.3% in CA



Determining Fund Industry Changes

$$ActiveChanges_{f,t}^I = \left(\frac{\Delta^{Active} IndPFShare_{f,t,t-1}^I}{IndMarketShare_t^I} \right),$$

- Active changes in industry I portfolio share (i.e., holding prices fixed)
- Normalization by industry market share:
 - Increase in holdings of a small industry more meaningful, since more likely to induce price changes in aggregate (our objective)

Industry Climate Quantity Betas

- Industry I 's “climate quantity beta” is then determined by regressing

$$ActiveChanges_{f,t}^I = \beta_t^I S_{f,t} + \delta_t^I + \epsilon_{f,t}^I,$$

where $S_{f,t}$ is an idiosyncratic climate belief/attention shock

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- The β^I coefficients give the portfolio weights in the hedge portfolio:

$$QP_{S,t} = \sum_I \widehat{\beta}_{S,t}^I (R_t^I - R_t^f)$$

- R_t^I is the industry portfolio return
- R_t^f denotes the risk-free rate

Industry Climate Quantity Betas

- While the shocks are almost independent sources of information, they select similar hedge portfolios
- Correlation among climate quantity betas calculated over 2015-2019

	Fat./Inj.	Indemnities	Extreme Temperature	Report: CC
Fat./Inj.	1.00			
Indemnities	0.57	1.00		
Extreme Temperature	0.34	0.65	1.00	
Report: CC	0.21	0.29	0.18	1.00

- Similar industries selected in split samples across time, space, funds
- Strong consistent signal from these quantity responses

Industry Climate Quantity Betas

GICS	Description	Avg.	Fat./Inj.	Indemnities	Extreme Temp.	Report: CC
2510	Auto & Components	0.85	1.00	0.80	1.00	0.60
4520	Tech. Hardw. & Equip.	0.75	0.74	1.00	0.59	0.67
4010	Banks	0.42	0.65	0.21	-0.20	1.00
2010	Capital Goods	0.36	0.27	0.46	-0.13	0.82
3010	Food & Staples Retailing	0.35	0.58	0.48	0.09	0.27
3020	Food, Bev. & Tobacco	0.34	0.34	0.57	-0.09	0.52
5510	Utilities	0.28	0.35	0.31	-0.08	0.55
3520	Pharma., Biotech., & Life Sc.	0.27	0.34	0.09	-0.03	0.70
4030	Insurance	0.24	-0.07	0.42	0.07	0.56
5010	Communication Services	0.20	0.67	0.29	-0.34	0.16
4530	Semiconductors & Equip.	0.19	0.71	0.17	-0.07	-0.06
2030	Transportation	0.19	0.49	0.73	-0.76	0.29
6010	Real Estate	0.14	-0.08	0.17	0.20	0.27
5020	Media & Entertainment	0.08	-0.13	0.39	-0.11	0.18
3030	Household & Pers. Prod.	0.06	0.38	-0.12	-0.21	0.18
1010	Energy	0.05	0.49	0.45	-0.45	-0.27
4020	Diversified Financials.	0.00	0.47	0.34	-0.17	-0.62
3510	Health Care Equip. & Serv.	-0.01	0.03	-0.14	-0.52	0.60
2550	Retailing	-0.03	-0.44	0.15	-0.01	0.19
1510	Materials	-0.10	-0.00	0.09	0.19	-0.67
2530	Consumer Services	-0.15	-0.65	0.05	-0.10	0.08
2520	Consum. Durables & Apparel	-0.15	0.50	-0.56	-0.92	0.36
4510	Software & Services	-0.18	0.38	0.03	-0.14	-1.00
2020	Commercial & Prof. Serv.	-0.81	-1.00	-1.00	-1.00	-0.24

Table: Most recent (2015-2019) industry climate beta coefficients

Hedge Performance?

- Can these quantity portfolio returns hedge national climate news?
- We test performance against a range of climate news series produced in the literature
 - Measure of success: Out-of-sample correlation with news innovations
 - Test period: Monthly innovations between 2015-2019
 - For data-driven approaches (quantity or mimicking portfolio): Use 5-year rolling window
- Out of sample hedges approximate performance achievable in real time

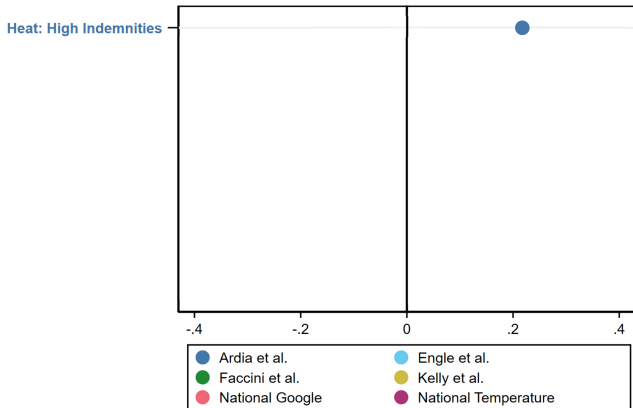
Quantifying Climate Risk

Many approaches representing a distinct mix of climate risks:

- **Engle et al. (2020):** WSJ news index (count news) and Crimson Hexagon Negative News (adds sentiment)
 - **Ardia et al. (2021):** Expand on WSJ by including multiple media outlets and identifying sentiment
 - **Faccini et al. (2021):** International summits, global warming, natural disasters, and narrative
 - **Kelly (2021):** Machine learning signed indices for general, physical, and transitional risk
 - National Google search trends
 - National temperature innovations
- Moderate correlation between innovations in the various climate news measures

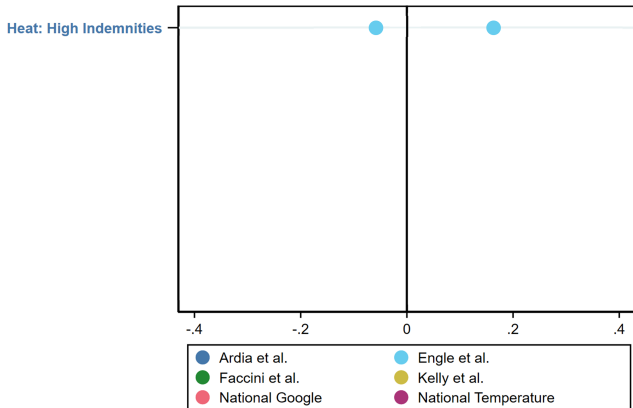
Hedge Performance - Main Results

Out-of-sample correlation between hedge portfolio and climate news innovation



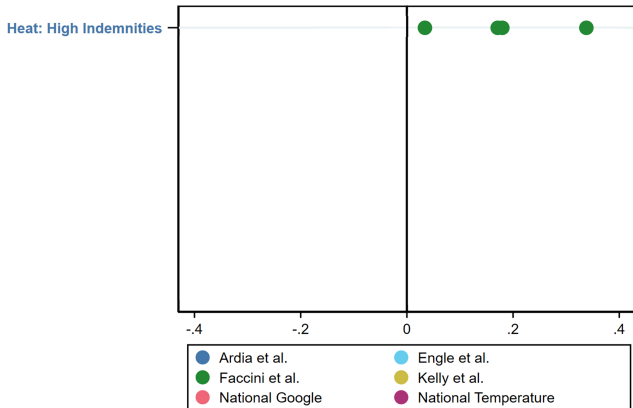
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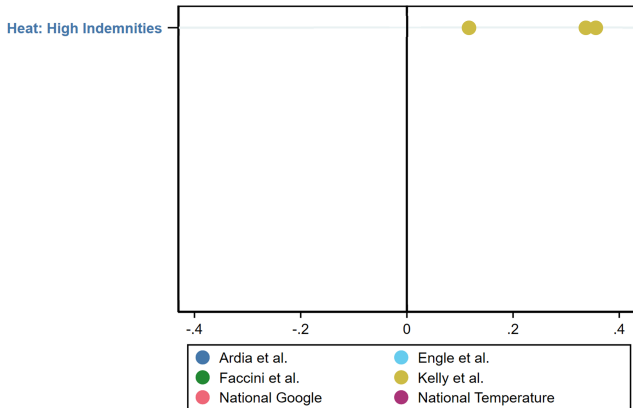
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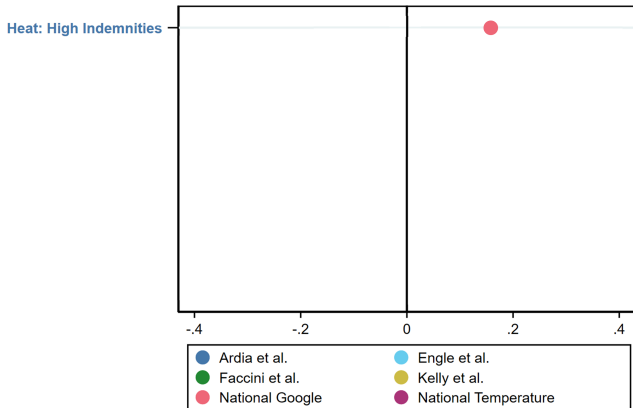
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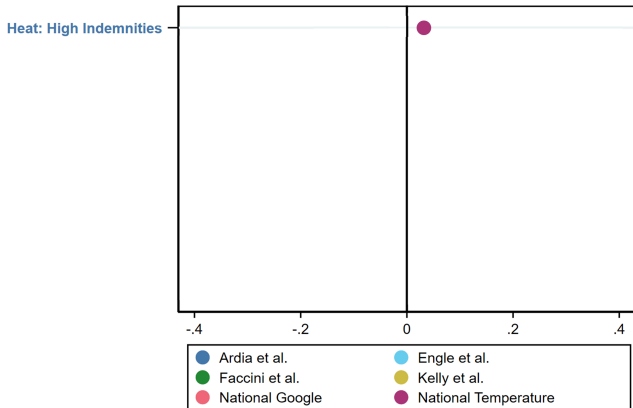
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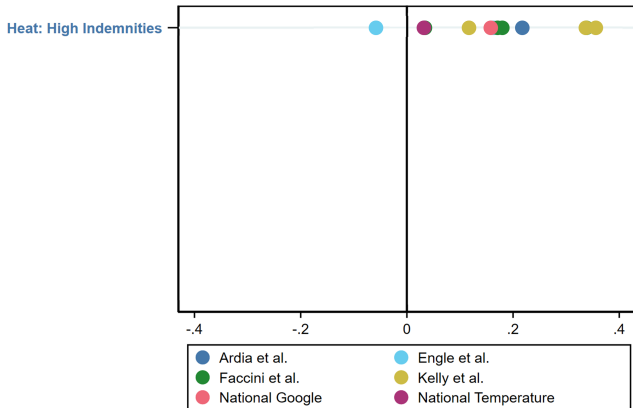
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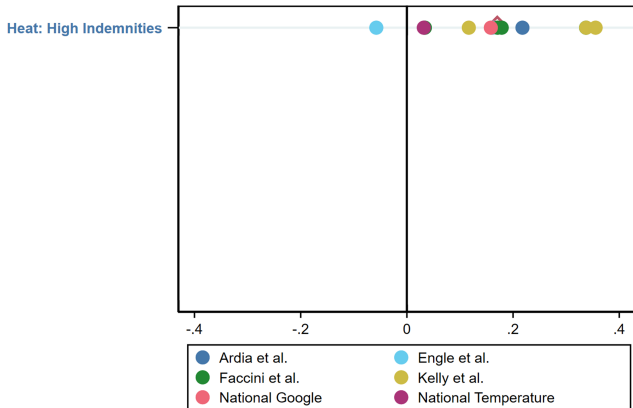
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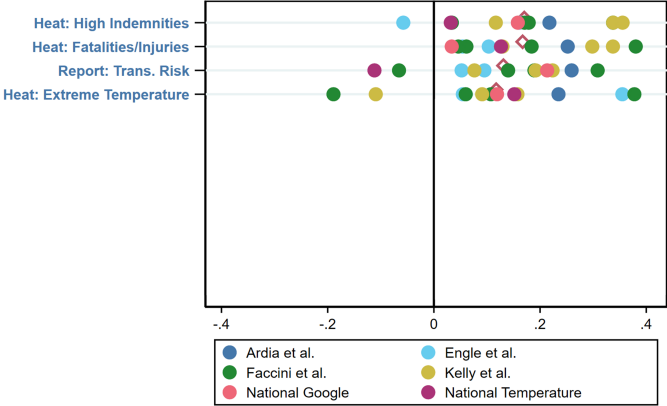
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Hedge Performance - Main Results

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Comparison to Existing Hedging Strategies

- **Narrative portfolios:** Beliefs of how climate change risk affects company returns
 - Long PBD:US (Invesco Global Clean Energy ETF)
 - Short XLE:US (Energy Select SDPR Fund ETF)
 - Short stranded assets portfolio $0.3XLE + 0.7KOL - SPY$
 - Long-Short Sustainalytics E-Score portfolio

Hedge Performance - Main Results

Out-of-sample correlation between hedge portfolio and climate news innovation

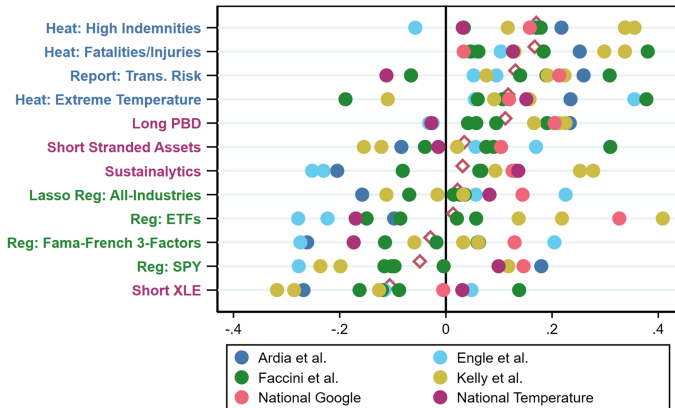


Comparison to Existing Hedging Strategies

- **Mimicking portfolio:** Data driven; regress each news series on base asset returns (five-year rolling window)
 - Projection on SPY
 - Projection on market, size, and value
 - Projection on PBD, XLE, market, size, and value
 - Lasso projection on all industry portfolios

Hedge Performance - Main Results

Out-of-sample correlation between hedge portfolio and climate news innovation



Conclusion

- Propose new approach based on trading responses to news/attention shocks received by some investors
 - Additional information from the cross-section of investors
 - Useful for (i) structural breaks or (ii) new risks such as climate change
- Long-short portfolios on this characteristic outperform other approaches to hedging a variety of climate risk news series
- Approach also works well for hedging national house price and unemployment series