Virtual Seminar on Climate Economics

Organizing Committee:
Glenn Rudebusch (Brookings Institution)
Michael Bauer (University of Hamburg)
Stephie Fried (Arizona State University)
Òscar Jordà (UC Davis, Federal Reserve Bank of San Francisco)
Fernanda Nechio (Federal Reserve Bank of San Francisco)
Toan Phan (Federal Reserve Bank of Richmond)

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

September 2022

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
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

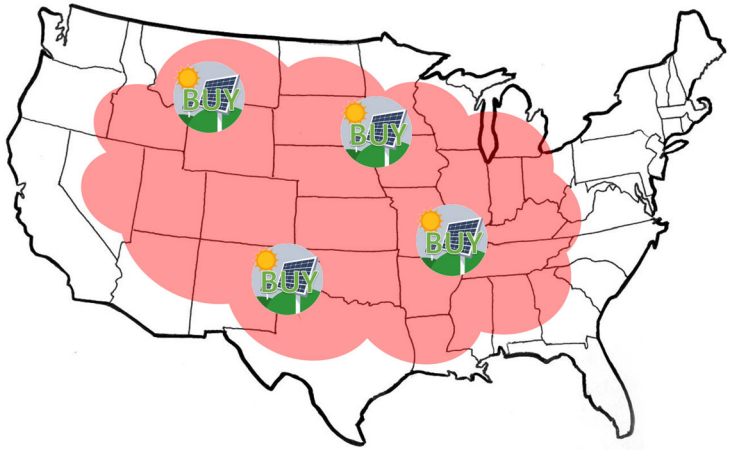
- Introduce new "quantity-based" approach to identify hedge portfolios
- Still trying to infer investors' narrative from the data
- Expand data used to inform hedge portfolio by moving beyond limited time series
- Exploits cross-sectional variation in investor trading responses to idiosyncratic climate news or climate attention shocks

$\rightarrow$ 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 $\rightarrow$ 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
- 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."

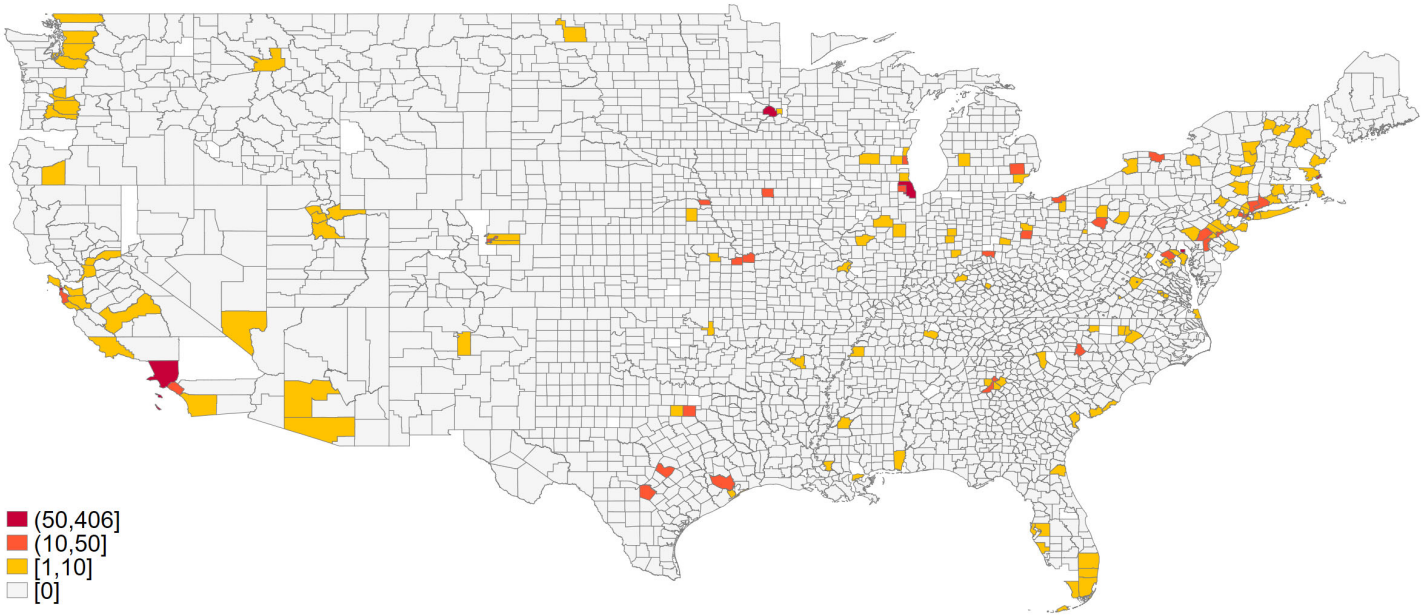
- We capture changes in climate beliefs & attention by measuring differences in language over time

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

$$ActiveChanges^{I}_{f,t} = \left(\frac{\Delta^{Active} IndPFShare^{I}_{f,t,t-1}}{IndMarketShare^{I}_{t}} \right),$$

- 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

$$ActiveChanges^{I}_{f,t} = \beta^{I}_{t} S_{f,t} + \delta^{I}_{t} + \epsilon^{I}_{f,t},$$

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

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

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

  - R^{I}_{t} is the industry portfolio return
  - R^{f}_{t} 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

$\rightarrow$ 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

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

  $\rightarrow$ Out of sample hedges approximate performance achievable in real time

Quantifying Climate Risk

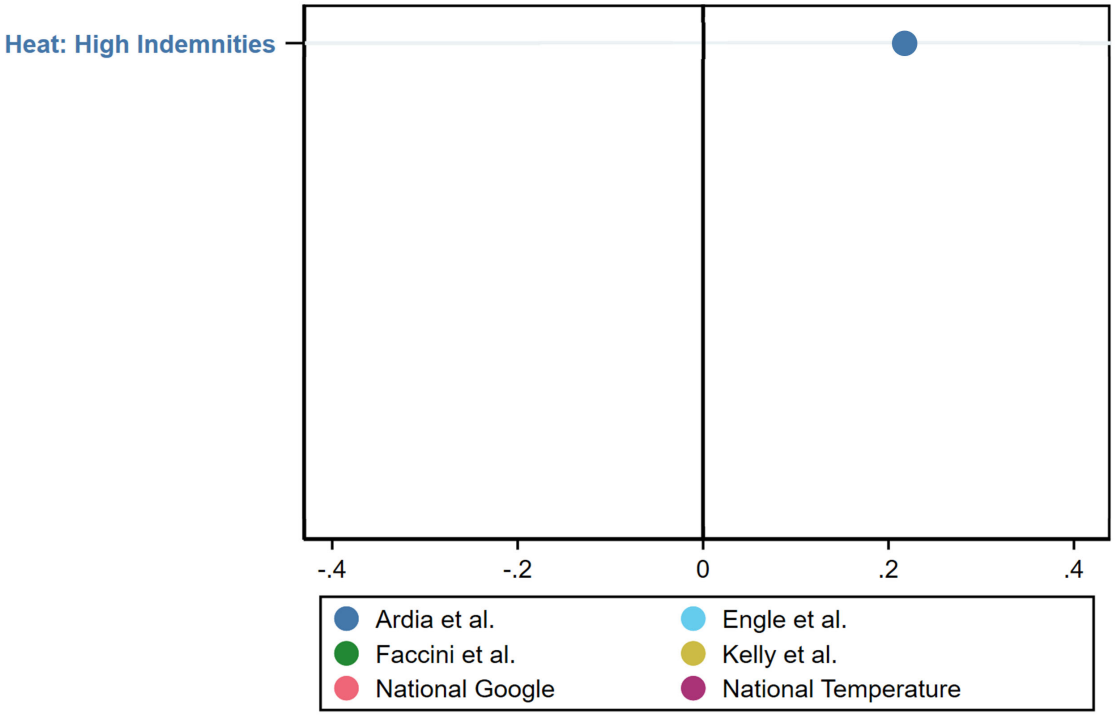
Many approaches representing a distinct mix of climate risks:

- **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

$\rightarrow$ Moderate correlation between innovations in the various climate news measures

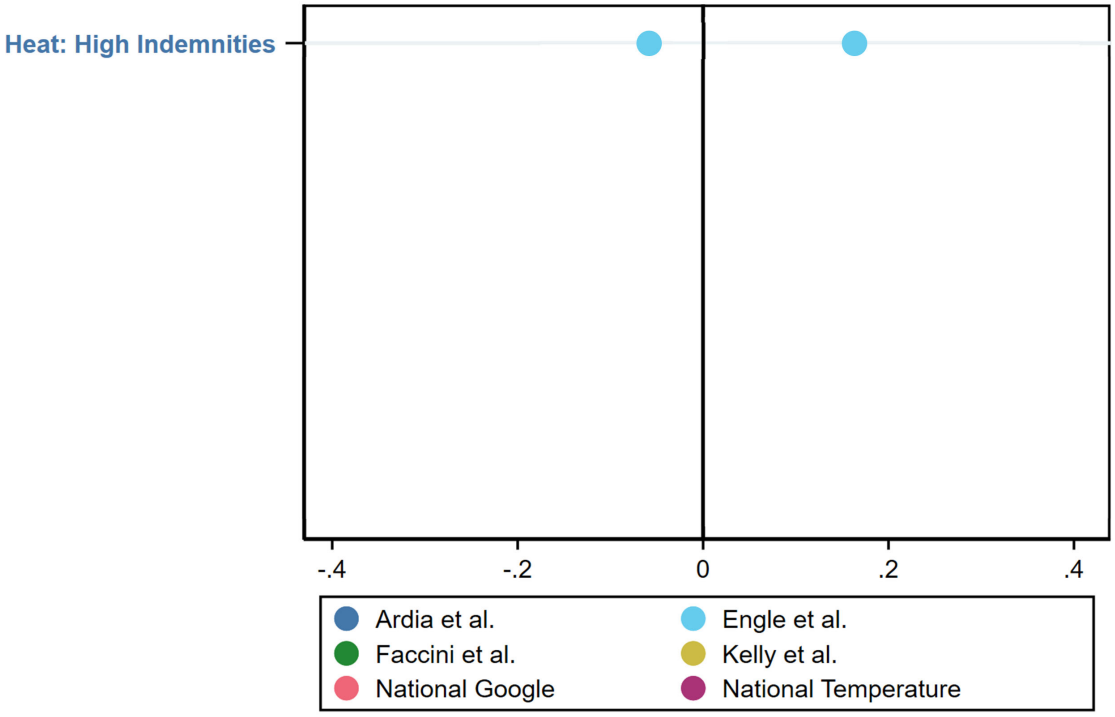
Hedge Performance - Main Results

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



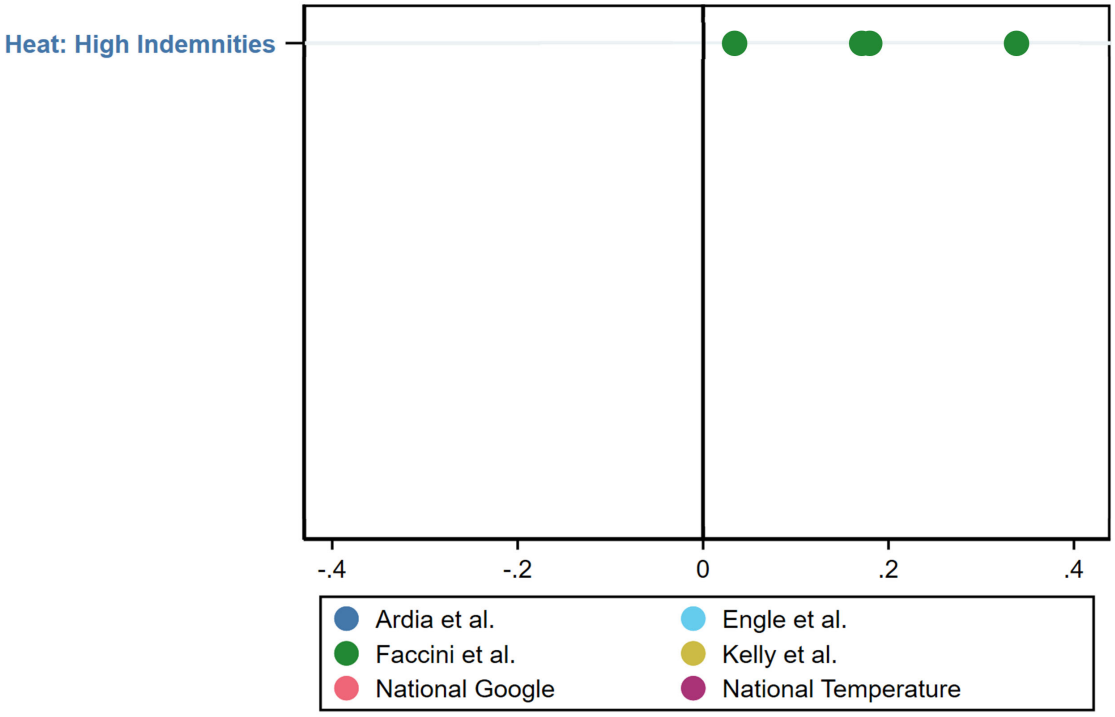
Hedge Performance - Main Results

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



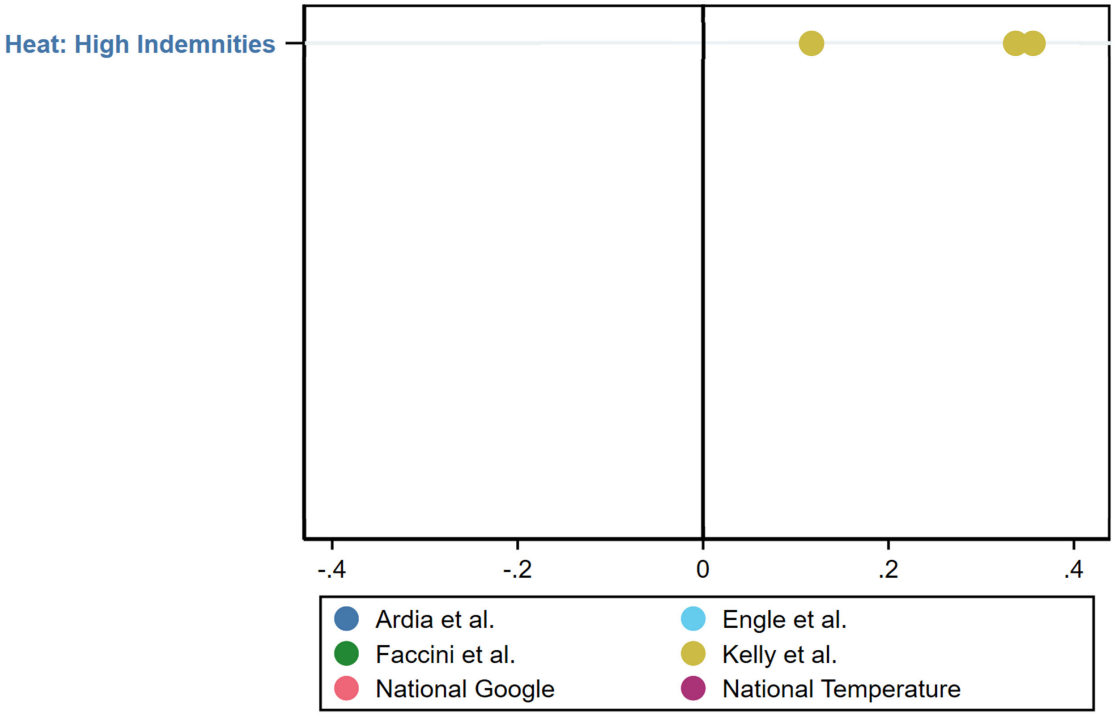
Hedge Performance - Main Results

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



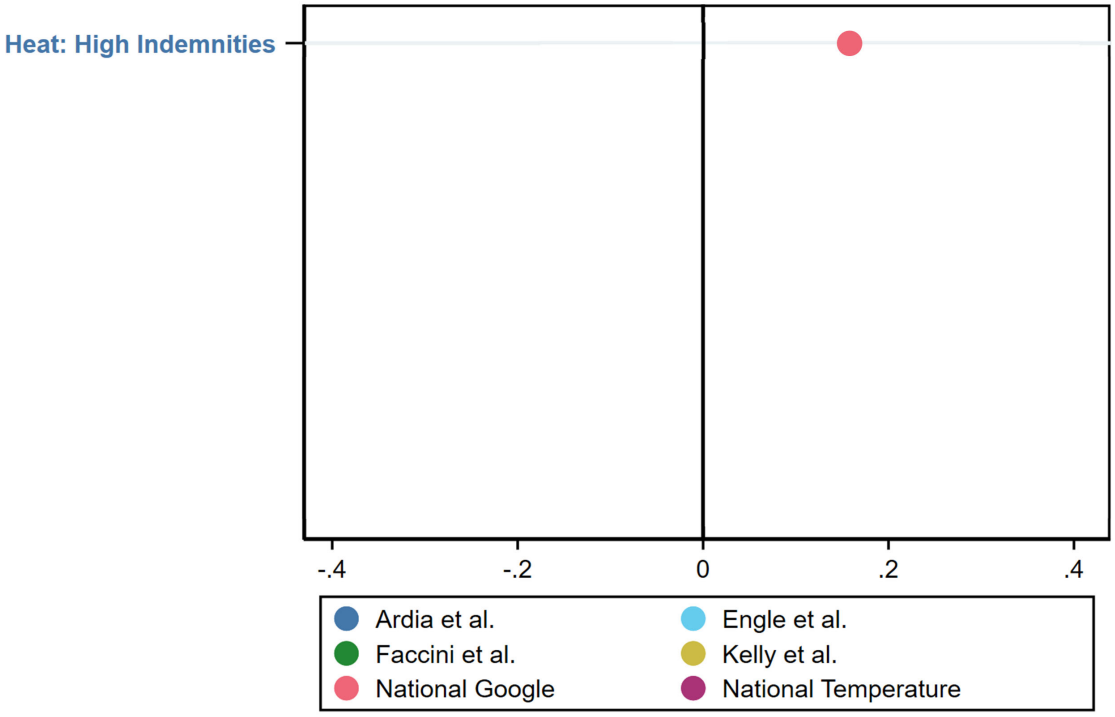
Hedge Performance - Main Results

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



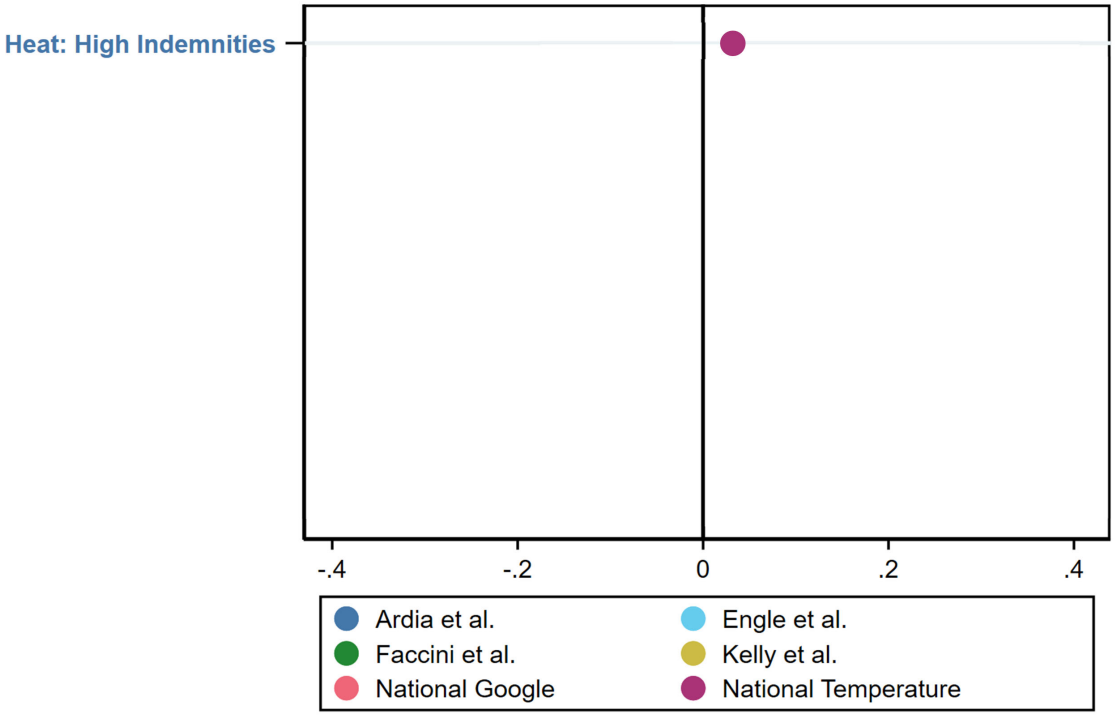
Hedge Performance - Main Results

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



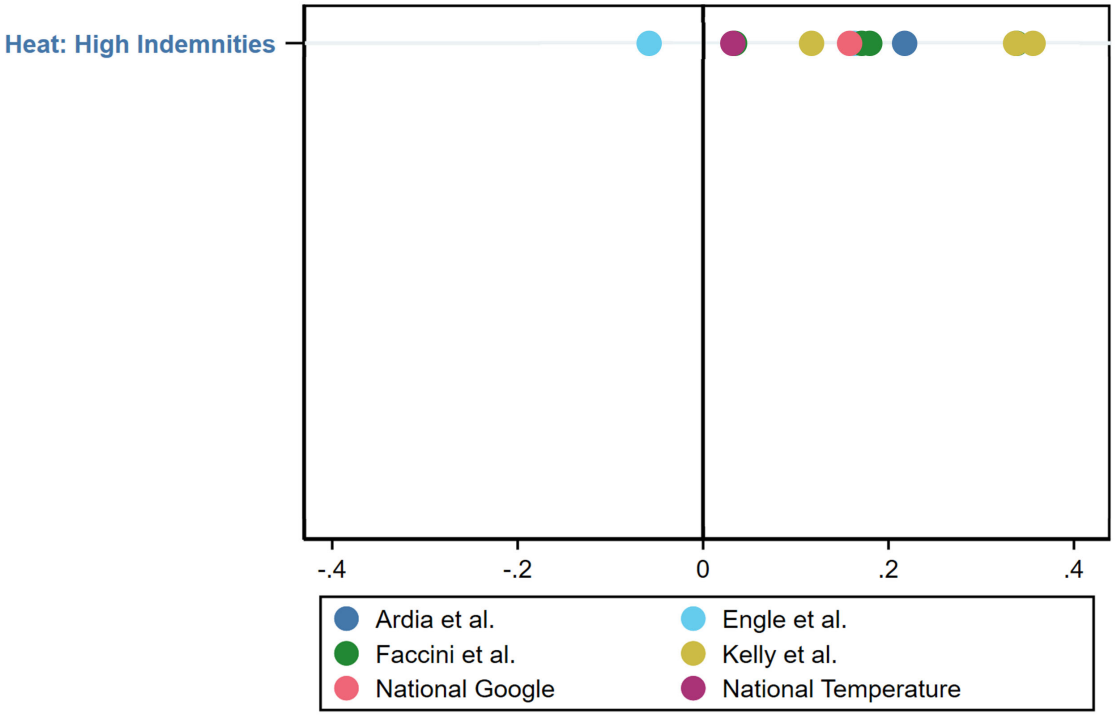
Hedge Performance - Main Results

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



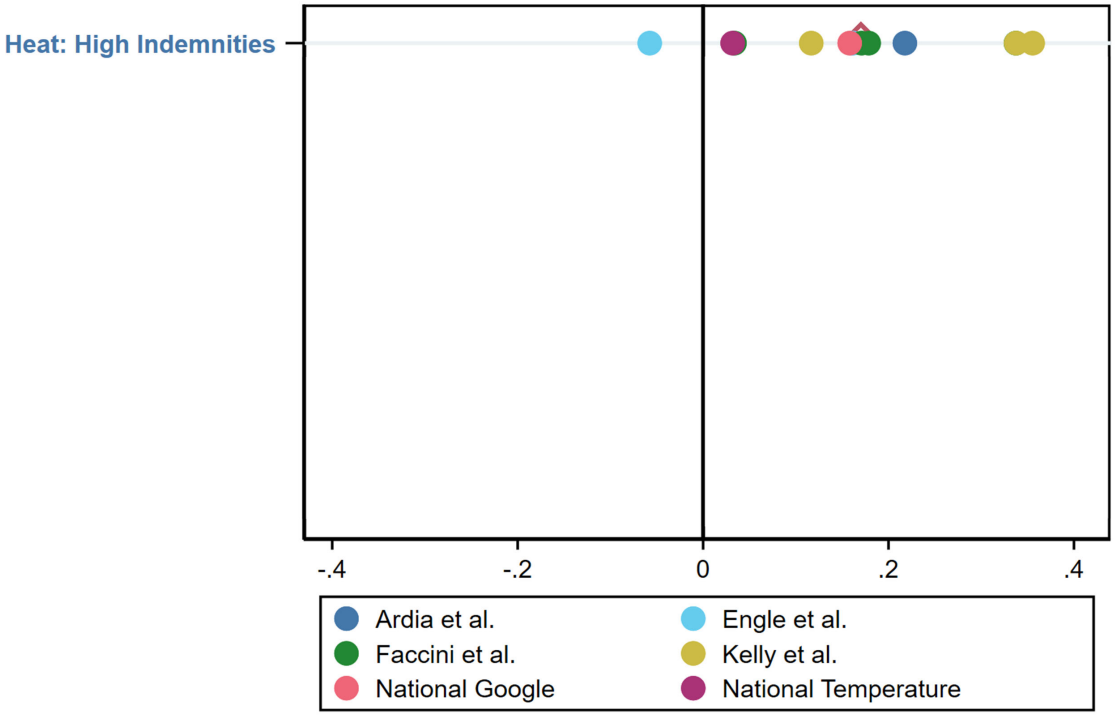
Hedge Performance - Main Results

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



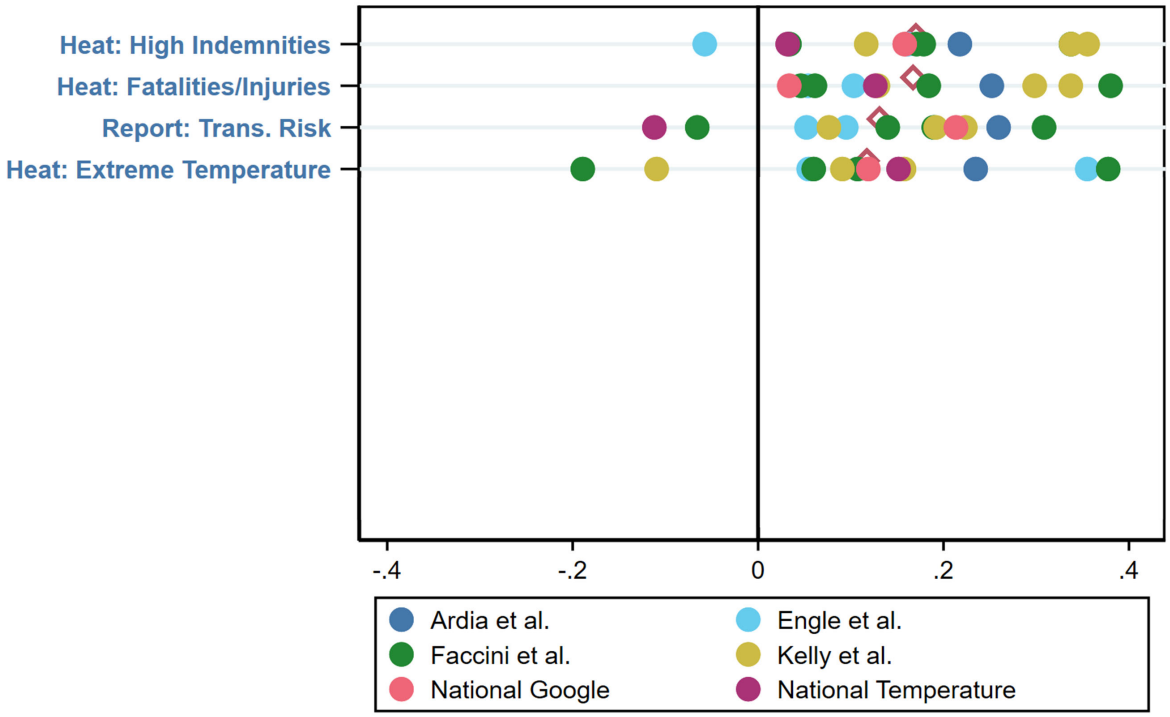
Hedge Performance - Main Results

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



Hedge Performance - Main Results

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

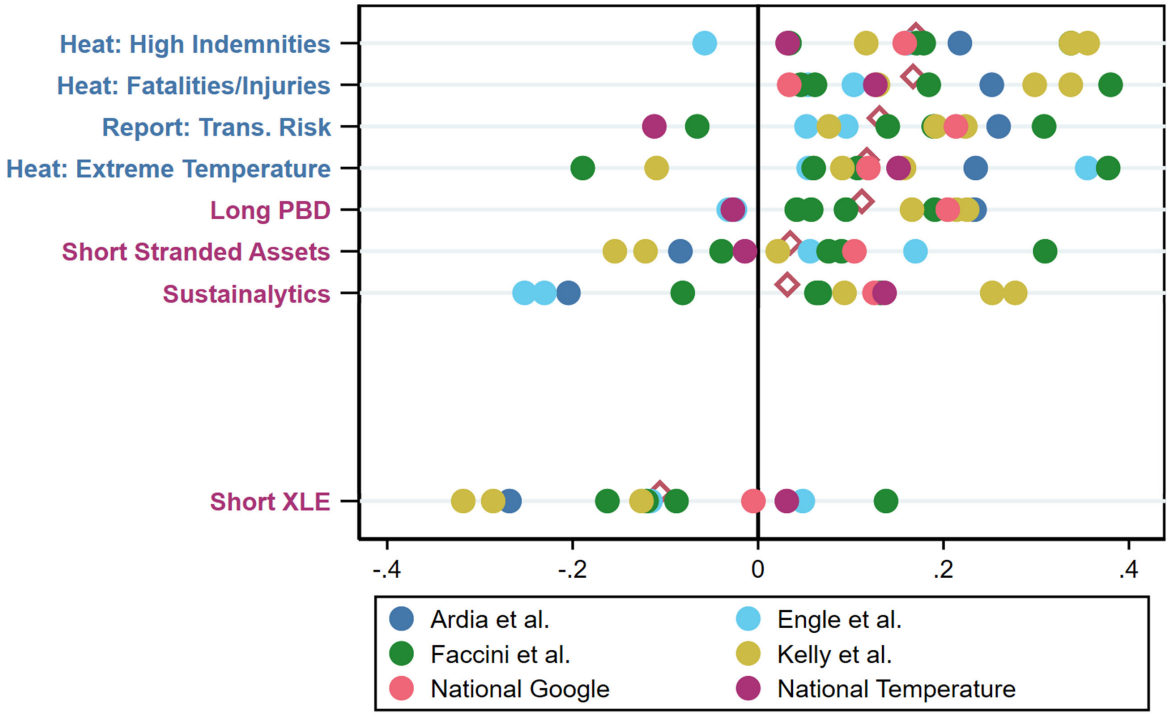


Comparison to Existing Hedging Strategies

- **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

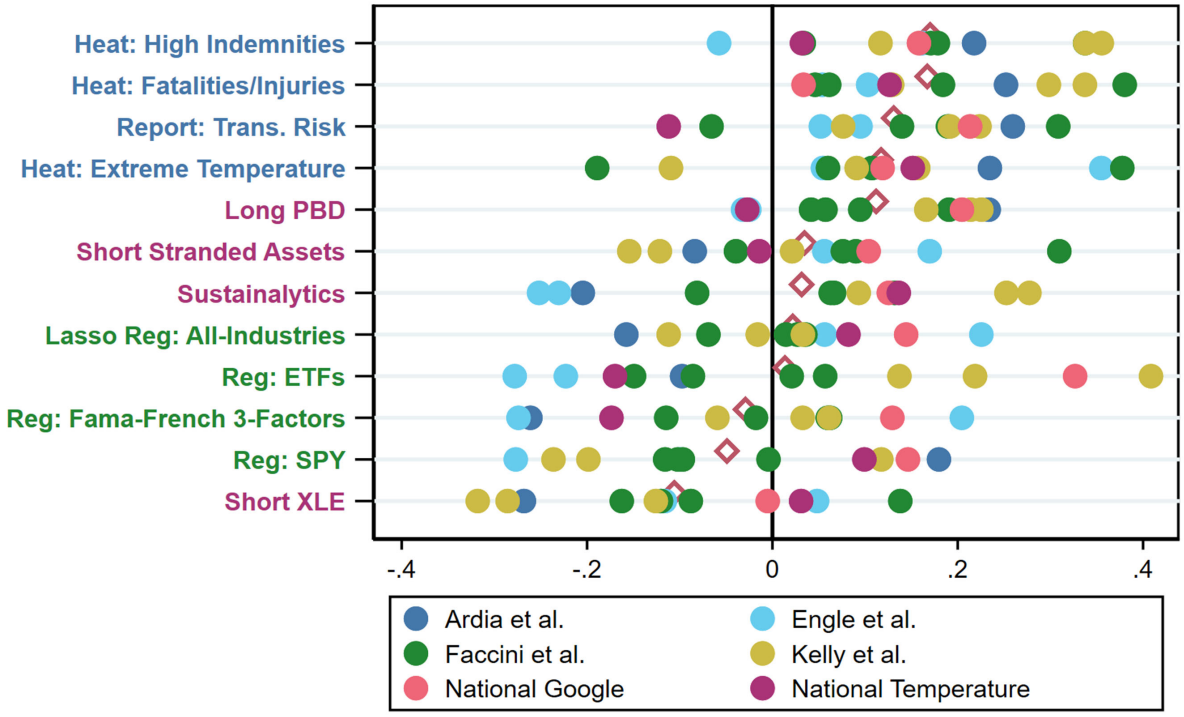


Comparison to Existing Hedging Strategies

- **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