Virtual Seminar on Climate Economics

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A Quantity-Based Approach to Constructing Climate Risk Hedge Portfolios

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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)

- 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 $\beta^Z$ to construct portfolios
    \[ \text{ClimateNews}_t = \beta^Z \text{Z}_t + e_t \]
  - **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 $\rightarrow$ 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

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

- 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

$$ActiveChanges_{i,t}^I = \beta_{t}^I S_{f,t} + \delta_{t}^I + \epsilon_{f,t}^I,$$

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

- The $\beta^I$ coefficients give the portfolio weights in the hedge portfolio:

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

- $R_{t}^I$ 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

<table>
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<tr>
<th></th>
<th>Fat./Inj.</th>
<th>Indemnities</th>
<th>Extreme Temperature</th>
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- Similar industries selected in split samples across time, space, funds

→ Strong consistent signal from these quantity responses
# Industry Climate Quantity Betas

<table>
<thead>
<tr>
<th>GICS</th>
<th>Description</th>
<th>Avg.</th>
<th>Fat./Inj.</th>
<th>Indemnities</th>
<th>Extreme Temp.</th>
<th>Report: CC</th>
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<tr>
<td>2510</td>
<td>Auto &amp; Components</td>
<td>0.85</td>
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<td>3020</td>
<td>Food, Bev. &amp; Tobacco</td>
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<td>0.34</td>
<td>0.57</td>
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<td>Utilities</td>
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<td>0.31</td>
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<td>3520</td>
<td>Pharma., Biotech., &amp; Life Sc.</td>
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<td>Insurance</td>
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<td>Semiconductors &amp; Equip.</td>
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<td>−1.00</td>
<td>−1.00</td>
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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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Out-of-sample correlation between hedge portfolio and climate news innovation

Heat: High Indemnities
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

![Graph showing correlation between hedge portfolio and climate news innovation](image)

Legend:
- Ardia et al.
- Faccini et al.
- Engle et al.
- Kelly et al.
- National Google
- National Temperature
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Out-of-sample correlation between hedge portfolio and climate news innovation
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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

![Graph showing 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