Hedging Climate Change News

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The Problem

- A primary function of financial markets is to allow for risk sharing across different agents

- How would you use financial markets to hedge against realizations of climate risk?

  - **WANTED**: Portfolio that pays off in states with particularly bad climate-econ outcomes

  - How do you identify these states? Which outcomes and at what horizon?

  - Which assets’ payoffs correlate with these?

  - No derivatives with payoffs obviously linked to measurable effects of climate change (rising sea levels, changing temperatures) ...

  - ... particularly for horizons of several decades
Our Approach

**Merton:** When infeasible to directly hedge long-lived risks, it may be possible to replicate the infeasible hedge with a *dynamic strategy*

Sequence of *short-lived portfolios* that hedge *news* about long-term outcome

Replaces idealized (and infeasible) long-dated, *buy+hold derivative* contract with *actively managed portfolio* that pays off upon the arrival of bad news about climate change each period
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1. **What News?** How do we determine incremental shocks to hedge to establish long-lived climate hedge?

2. **Which Assets?** How to identify portfolio best suited to hedge this news?

**Our Contribution**

**Data + Econometrics** to engineer **Climate Hedge Solution**
1. What News?

**Objective:** Identify news about climate change

- Should be **relevant** to and **salient** for investors and hedgers concerned about climate risks
- Many possibilities: traded prices, weather data, disaster events,...
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**Our Choice:** Extract news shocks from texts provided by media outlets. Two complementary approaches.

- 1) Reporting in salient outlet (WSJ) and derive correlation of coverage with Climate Change Vocabulary - “WSJ Climate Change News Index“
  
  ≈ Climate covered in newspaper = bad news about the climate

- 2) Among major media outlets, track fraction of *negative* Climate Change news - “CH Negative Climate Change News Index“

- Many degrees of freedom – here, constrain to obvious choices

- Climate news series on my website for download

- “Proof of Concept” – Exact target depends on application
1. What News?

WSJ CC Index - Climate Change Vocabulary

Construct **Climate Change Vocabulary** from authoritative texts

- 19 climate change white papers from the IPCC, EPA, USGCRP
- 55 climate change glossaries (UN, BBC, IPCC, NASA, EPA, etc.)
1. What News?

WSJ CC Index - Building an Index of Climate Change News

Our first measure (heuristically) describes fraction of *The Wall Street Journal* dedicated to climate change topics each day

In particular, **Cosine Similarity**, $\cos(\theta)$, between each day’s *WSJ* edition and the *Climate Change Vocabulary*, represented as vectors of word counts (TF-IDF).
This is a level measure. Climate change news shocks are AR(1) innovations to monthly index.
1. What News?

CH Negative Climate Change News Index

Our second measure represents fraction of news articles about climate change topics with negative sentiment each day

- Starting in 2008, Crimson Hexagon collects massive corpus from major media outlets and provides fraction of news articles dedicated to certain search terms by “sentiment” of article.
- Use search phrase "Climate Change", restrict to news media and explore share of articles with negative sentiment
Two measures move together but not identically (e.g., idiosyncratic Climategate reporting by WSJ)
2. Which Assets?

**Objective:** Build portfolio that maximally hedges climate news shocks

*Primary Challenges: Short sample, No “easy” hedges*

Our solution:

- Impose structure/parsimony on estimation (confronts limited time series)
- Construct hedge from a large universe of assets

Emphasize *out-of-sample* performance

- Reliable solution must work in unknown future (mechanical success in-sample)

Emphasize *interpretability* of portfolio

- What types of assets constitute good hedges

Define a simple asset pricing model:

- $CC_t$: climate change factor defined as AR(1) innovation in new index
- $v_t$: $p$ other (tradable or non-tradable) risk factors

\[
\begin{align*}
\mathbf{r}_t &= \left( \beta_{CC} \gamma_{CC} + \beta_{CC} (CC_t - E[CC_t]) \right) + \left( \beta \gamma + \beta v_t \right) + \mathbf{u}_t
\end{align*}
\]

Define a simple asset pricing model:

- \( CC_t \): climate change factor defined as AR(1) innovation in new index
- \( v_t \): \( p \) other (tradable or non-tradable) risk factors

Want: Hedge portfolio with unit exposure to \( CC_t \), zero to all other factors
→ Mimicking portfolio regressions + time varying risk exposures

\[
\begin{align*}
\mathbf{r}_t &= (\mathbf{\beta}_{cc} \mathbf{\gamma}_{cc} + \mathbf{\beta}_{cc} (CC_t - E[CC_t])) + (\mathbf{\beta} \mathbf{\gamma} + \beta \mathbf{v}_t) + \mathbf{u}_t \\
\end{align*}
\]

\[
CC_t = \xi + w' Z_{t-1}' r_t + e_t
\]

- \( Z_t \): a vector of individual firm level characteristics at \( t \)
- \( r_t \): a vector of individual firm level return at \( t \)
Two-step Estimation Approach to Construct Hedge Portfolio

**Step 1:** Form characteristic-sorted portfolio using market characteristics (Size, B/M) and environmental characteristics (MSCI Score, Sustainalytics Score)

**Step 2:** Mimicking portfolio regression of $CC_t$ on characteristic-sorted portfolio $Z'_{t-1}r_t$

$$CC_t = \xi + w'Z'_{t-1}r_t + e_t$$

The fitted value $\hat{w}'Z'_{t-1}r_t$ is time series of returns to *hedging portfolio* of climate news shocks

* Given historical (time $t$) estimates of $w$ and current (time $t$) firm chars, now feasible to construct out-of-sample hedge of time $t + 1$ climate news

* Can study which stocks the portfolios buys and sells at each $t$
Data

- **Firm-Level Climate Exposures: Environmental Score**
  - **MSCI (ex KLD):** aggregates 23 environment assessment criteria (e.g., “Carbon Emissions,” “Energy Efficiency”)
  - **Sustainalytics:** aggregates environmental sustainability scores in 59 categories (e.g., “Waste Reduction,” “Low Carbon Intensity”)
  - Substantial within-industry variation.
  - Use both absolute and cross-sectionally ranked measures
  - Recently: Many more measures of firm-level risk exposure

- **Stock return and Characteristics : CRSP/Compustat**

- **Period : September 2009 to December 2016**
## Results

### Full-Sample Regression: WSJ Climate Change News Index

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
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<tbody>
<tr>
<td>( Z^{SUS_A'}_{t-1} r_t )</td>
<td>1.416***</td>
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<td></td>
<td>(0.436)</td>
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<tr>
<td>( Z^{SUS_R'}_{t-1} r_t )</td>
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<td>67.789***</td>
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<td></td>
<td></td>
<td>(17.834)</td>
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<tr>
<td>( Z^{MSCI_A'}_{t-1} r_t )</td>
<td></td>
<td></td>
<td>12.658*</td>
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<td></td>
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<td>(6.849)</td>
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<td>( Z^{MSCI_R'}_{t-1} r_t )</td>
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<td>53.743*</td>
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<td>(27.401)</td>
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<td>( r_{t}^{XLE} )</td>
<td>0.085</td>
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<td></td>
<td>(0.810)</td>
<td></td>
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<tr>
<td>( r_{t}^{PBD} )</td>
<td>0.208</td>
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<td></td>
<td>(0.630)</td>
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<tr>
<td>( Z^{HML'}_{t-1} r_t )</td>
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<td>2.309</td>
<td>-5.862</td>
<td>-5.941</td>
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<tr>
<td>( Z^{SIZE'}_{t-1} r_t )</td>
<td>-5.680**</td>
<td>-6.034**</td>
<td>-5.511*</td>
<td>-5.459**</td>
<td>-2.765</td>
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<td></td>
<td>(2.350)</td>
<td>(2.289)</td>
<td>(2.773)</td>
<td>(2.696)</td>
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<td>( Z^{MKT'}_{t-1} r_t )</td>
<td>0.783</td>
<td>0.789</td>
<td>0.841</td>
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<td>(0.642)</td>
<td>(0.628)</td>
<td>(0.692)</td>
<td>(0.680)</td>
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<tr>
<td>Constant</td>
<td>2.894</td>
<td>2.673</td>
<td>4.659*</td>
<td>4.891*</td>
<td>5.959**</td>
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<td>(2.681)</td>
<td>(2.613)</td>
<td>(2.700)</td>
<td>(2.669)</td>
<td>(2.897)</td>
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<td>R-Squared</td>
<td>0.153</td>
<td>0.187</td>
<td>0.083</td>
<td>0.088</td>
<td>0.047</td>
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<td>N</td>
<td>88</td>
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- Portfolios based on the Sustainaltyics E-Scores hedge 19% of the in-sample variation in climate news
- Outperforms hedges based on XLE and PBD
How Closely Does Hedge Portfolio Track Climate Change News?

Out-of-sample evaluation: WSJ Climate Change News Index

Since 2012

<table>
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<tr>
<th></th>
<th>CC&lt;sup&gt;HEDGE&lt;/sup&gt;</th>
<th>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;SUS, A&lt;/sup&gt;</th>
<th>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;SUS, R&lt;/sup&gt;</th>
<th>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;MSCI, A&lt;/sup&gt;</th>
<th>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;MSCI, R&lt;/sup&gt;</th>
<th>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;ETF&lt;/sup&gt;</th>
<th>r&lt;sub&gt;t&lt;/sub&gt;&lt;sup&gt;XLE&lt;/sup&gt;</th>
<th>r&lt;sub&gt;t&lt;/sub&gt;&lt;sup&gt;PBD&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC&lt;sup&gt;HEDGE&lt;/sup&gt;</td>
<td>1.000</td>
<td>0.174</td>
<td>0.206</td>
<td>0.013</td>
<td>0.019</td>
<td>-0.005</td>
<td>0.068</td>
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<td>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;SUS, A&lt;/sup&gt;</td>
<td>1.000</td>
<td>0.973</td>
<td>0.688</td>
<td>0.677</td>
<td>0.427</td>
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<td>0.621</td>
<td>0.624</td>
<td>0.349</td>
<td>0.004</td>
<td>0.272</td>
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<td>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;MSCI, A&lt;/sup&gt;</td>
<td>1.000</td>
<td>0.998</td>
<td>0.861</td>
<td>-0.097</td>
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<td>H&lt;sub&gt;OOS&lt;/sub&gt;&lt;sup&gt;ETF&lt;/sup&gt;</td>
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<td>-0.141</td>
<td>0.190</td>
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Conclusion

Propose approach for protecting investor portfolios against adverse effects of climate change

Obstacles to practical climate hedge solution abound. We navigate by

- Taking short-term dynamic perspective on fundamentally long-lived risk
- Identifying shocks to long-lived effects by measuring climate change news that is relevant and salient for market participants

Results promising: Stable out-of-sample hedges, courtesy of

- (Very) parsimonious statistical model...
- ...exploiting third-party climate sensitivity assessments of assets

Many unexplored degrees of freedom

- Measuring climate news; E-Scores; Hedge Assets
- Exciting follow-on work