



# HEDGING CLIMATE CHANGE NEWS

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# The Problem

Consequences of climate change beginning to directly affect population

This is prompting investors to hedge their climate change exposure



Source: Goldman Sachs

But designing a hedge portfolio is *hard*!

- ▶ **WANTED:** payoffs 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

- ▶ Cochrane (1995): health insurance

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

Great Idea! ...*in theory*

# Our Approach

Leaves us with two very difficult questions to tackle:

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

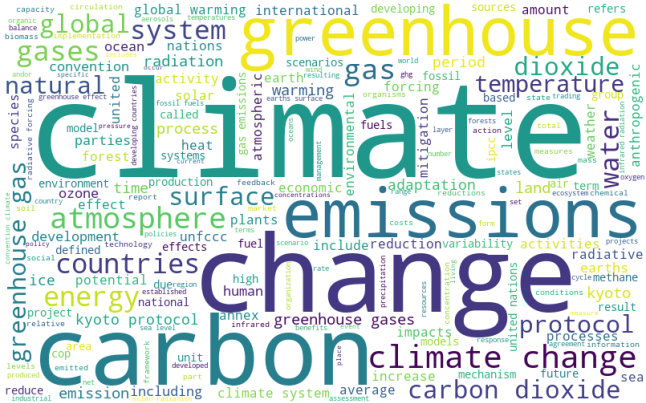
- ▶ Should be **relevant** to and **salient** for investors and hedgers concerned about climate risks
- ▶ There are many possibilities: traded prices (e.g., Anderssen et al. 2016), weather data, disaster events,...

**OUR CHOICE:** Extract news shocks from texts provided by media outlets. Two complementary approaches.

- ▶ 1) Analyze reporting in most salient outlet (WSJ) and derive correlation of coverage with Climate Change Vocabulary - “WSJ Climate Change News Index”
- ▶ 2) Among major media outlets, track fraction of *negative* Climate Change news - “CH Negative Climate Change News Index”
- ▶ Note: Many degrees of freedom here – constrain to obvious choices

# 1. What News?

## WSJ CC Index - Climate Change Vocabulary



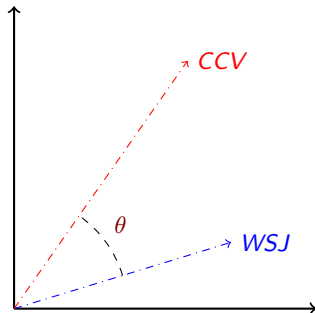
# Construct CLIMATE CHANGE VOCABULARY from authoritative texts

- ▶ 19 climate change white papers on from the IPCC, EPA, USGCRP
- ▶ 55 climate change glossaries (UN, BBC, IPCC, NASA, EPA, etc.)

# 1. What News?

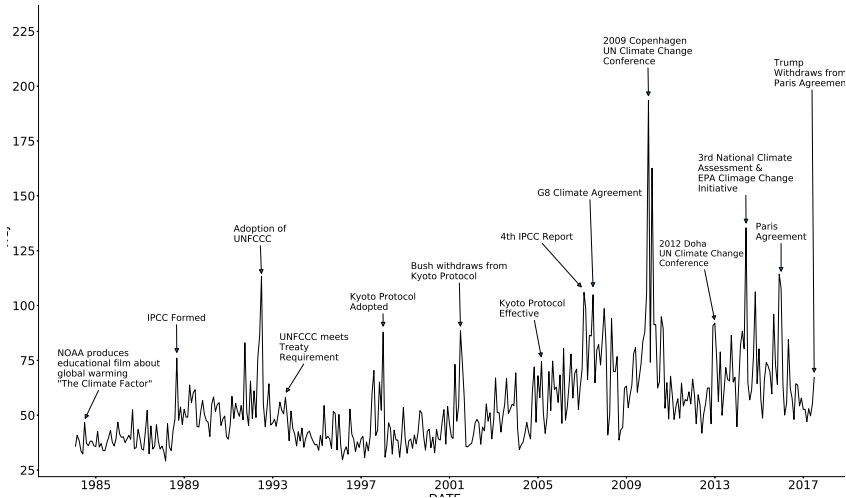
WSJ CC Index - Building an Index of Climate Change News

Our first measure 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)





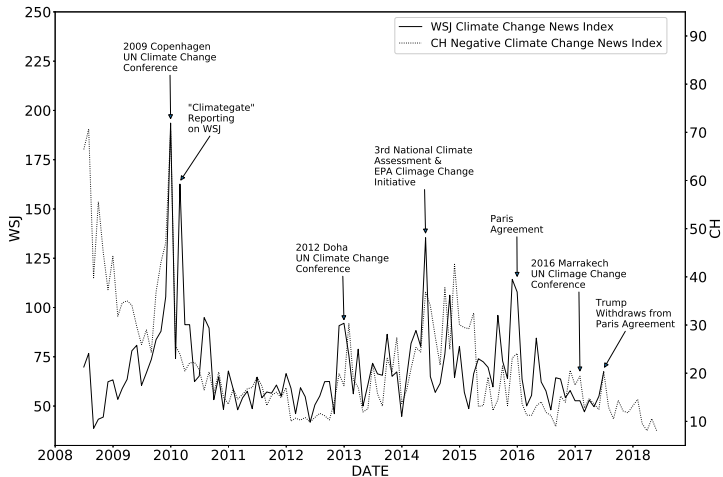
This is a *level* measure. Climate change news shocks are AR(1) *innovations* to monthly index

# 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

## 2. Which Assets? Econometric Methodology.

Define a simple asset pricing model:

$$\underbrace{r_t}_{n \times 1} = \left( \underbrace{\beta_{CC}}_{n \times 1} \underbrace{\gamma_{CC}}_{1 \times 1} + \underbrace{\beta_{CC}}_{n \times 1} \underbrace{(CC_t - E[CC_t])}_{1 \times 1} \right) + \left( \underbrace{\beta}_{n \times p} \underbrace{\gamma}_{p \times 1} + \underbrace{\beta}_{n \times p} \underbrace{v_t}_{p \times 1} \right) + \underbrace{u_t}_{n \times 1}$$

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

Our object:

- ▶ Find a hedge portfolio with unit exposure to  $CC_t$ , zero to all other factors

Different possible approaches:

- ▶ Fama-MacBeth regressions
- ▶ Mimicking-portfolio
- ▶ Giglio and Xiu (2018) study their relation in large- $n$  setting

## 2. Which Assets? Econometric Methodology.

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

What we do: mimicking portfolio regressions + time varying risk exposures

- ▶  $Z_t$  : a vector of individual firm level characteristics at  $t$
- ▶  $r_t$  : a vector of individual firm level return at  $t$

Rationale:

- ▶ Free to measurement error
- ▶ Requires a “large enough” span of the portfolios  $Z'r$  (Giglio and Xiu, 2018)
- ▶ By conditioning portfolio weights with firm characteristics, the model captures the time variation in risk exposures (Kelly et al, 2018)

## 2. Which Assets? Econometric Methodology.

### 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
- ▶ Stock return and Characteristics : CRSP/Compustat
- ▶ Period : September 2009 to December 2016



# Results

## Full-Sample Regression : CH Negative Climate Change News Index

	(1)	(2)	(3)	(4)	(5)
$Z_{t-1}^{SUS-A'} r_t$	0.266* (0.141)				
$Z_{t-1}^{SUS-R'} r_t$		12.286** (5.864)			
$Z_{t-1}^{MSCI-A'} r_t$			1.089 (2.173)		
$Z_{t-1}^{MSCI-R'} r_t$				6.641 (8.696)	
$r_t^{XLE}$					-0.092 (0.252)
$r_t^{PBD}$					0.036 (0.196)
$Z_{t-1}^{HML'} r_t$	-4.536** (2.272)	-4.390* (2.260)	-5.934*** (2.182)	-5.919*** (2.177)	-5.520** (2.519)
$Z_{t-1}^{SIZE'} r_t$	-0.137 (0.761)	-0.179 (0.753)	0.210 (0.880)	0.100 (0.856)	0.501 (0.770)
$Z_{t-1}^{MKT'} r_t$	0.315 (0.208)	0.314 (0.206)	0.287 (0.219)	0.295 (0.216)	0.297 (0.400)
Constant	-0.115 (0.868)	-0.137 (0.859)	0.313 (0.857)	0.306 (0.847)	0.376 (0.902)
R-Squared	0.125	0.133	0.090	0.094	0.089
N	88	88	88	88	88

- Portfolios based on the Sustainalytics E-Scores hedge 13% of the in-sample variation in negative climate news
- Outperforms hedges based on XLE and PBD

# Results

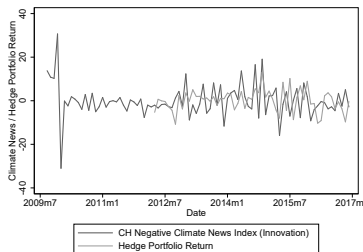
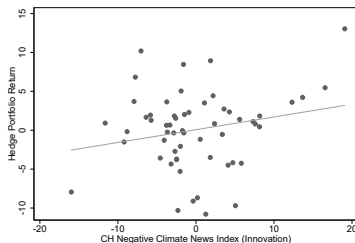
## Full-Sample Regression : WSJ Climate Change News Index

	(1)	(2)	(3)	(4)	(5)
$Z_{t-1}^{SUS-A'} r_t$	1.416*** (0.436)				
$Z_{t-1}^{SUS-R'} r_t$		67.789*** (17.834)			
$Z_{t-1}^{MSCI-A'} r_t$			12.658* (6.849)		
$Z_{t-1}^{MSCI-R'} r_t$				53.743* (27.401)	
$r_t^{XLE}$					0.085 (0.810)
$r_t^{PBD}$					0.208 (0.630)
$Z_{t-1}^{HML'} r_t$	1.221 (7.019)	2.309 (6.873)	-5.862 (6.878)	-5.941 (6.858)	-6.772 (8.093)
$Z_{t-1}^{SIZE'} r_t$	-5.680** (2.350)	-6.034** (2.289)	-5.511* (2.773)	-5.459** (2.696)	-2.765 (2.474)
$Z_{t-1}^{MKT'} r_t$	0.783 (0.642)	0.789 (0.628)	0.841 (0.692)	0.789 (0.680)	0.091 (1.285)
Constant	2.894 (2.681)	2.673 (2.613)	4.659* (2.700)	4.891* (2.669)	5.959** (2.897)
R-Squared	0.153	0.187	0.083	0.088	0.047
N	88	88	88	88	88

- Portfolios based on the Sustainability 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 : CH Negative Climate Change News Index



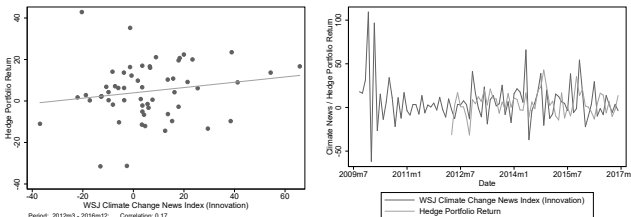
Since 2012	$CC^{NegNews}$	$H_{OOS}^{SUS\_A}$	$H_{OOS}^{SUS\_R}$	$H_{OOS}^{MSCI\_A}$	$H_{OOS}^{MSCI\_R}$	$H_{OOS}^{ETF}$	$r_t^{XLE}$	$r_t^{PBD}$
$CC^{NegNews}$	1.000	0.217	0.183	0.179	0.175	0.157	-0.066	0.063
$H_{OOS}^{SUS\_A}$		1.000	0.992	0.869	0.865	0.780	-0.412	0.061
$H_{OOS}^{SUS\_R}$			1.000	0.852	0.850	0.767	-0.353	0.112
$H_{OOS}^{MSCI\_A}$				1.000	0.998	0.961	-0.387	0.096
$H_{OOS}^{MSCI\_R}$					1.000	0.960	-0.367	0.127
$H_{OOS}^{ETF}$						1.000	-0.410	0.119

CV	$CC^{WSJ}$	$H_{OOS}^{SUS\_A}$	$H_{OOS}^{SUS\_R}$	$H_{OOS}^{MSCI\_A}$	$H_{OOS}^{MSCI\_R}$	$H_{OOS}^{ETF}$	$r_t^{XLE}$	$r_t^{PBD}$
$CC^{NegNews}$	1.000	0.148	0.154	0.024	0.048	0.053	-0.066	0.063

# How Closely Does Hedge Portfolio Track Climate Change News?

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



Since 2012	$CC^{WSJ}$	$H_{OOS}^{SUS\_A}$	$H_{OOS}^{SUS\_R}$	$H_{OOS}^{MSCI\_A}$	$H_{OOS}^{MSCI\_R}$	$H_{OOS}^{ETF}$	$r_t^{XLE}$	$r_t^{PBD}$
$CC^{WSJ}$	1.000	0.174	0.206	0.013	0.019	-0.005	0.068	0.111
$H_{OOS}^{SUS\_A}$		1.000	0.973	0.688	0.677	0.427	-0.138	0.185
$H_{OOS}^{SUS\_R}$			1.000	0.621	0.624	0.349	0.004	0.272
$H_{OOS}^{MSCI\_A}$				1.000	0.998	0.861	-0.097	0.294
$H_{OOS}^{MSCI\_R}$					1.000	0.852	-0.039	0.350
$H_{OOS}^{ETF}$						1.000	-0.141	0.190

CV	$CC^{WSJ}$	$H_{OOS}^{SUS\_A}$	$H_{OOS}^{SUS\_R}$	$H_{OOS}^{MSCI\_A}$	$H_{OOS}^{MSCI\_R}$	$H_{OOS}^{ETF}$	$r_t^{XLE}$	$r_t^{PBD}$
$CC^{WSJ}$	1.000	0.244	0.300	0.039	0.067	-0.069	0.068	0.111

# Hedge Portfolio: Biggest Longs and Shorts

Sustainalytics E-Score (absolute)		MSCI E-Score (absolute)	
<b>Top Negative Portfolio Weights</b>	<b>SIC2</b>	<b>Top Negative Portfolio Weights</b>	<b>SIC2</b>
General Building Contractors	15	General Building Contractors	15
Water Transportation	44	Nondepository Institutions	61
Coal Mining	12	Auto Repair, Services, & Parking	75
Insurance Agents, Brokers, & Service	64	Communications	48
Holding and Other Investment Offices	67	Water Transportation	44
Insurance Carriers	63	Insurance Carriers	63
<b>Top Positive Portfolio Weights</b>	<b>SIC2</b>	<b>Top Positive Portfolio Weights</b>	<b>SIC2</b>
Railroad Transportation	40	Chemical & Allied Products	28
Transportation by Air	45	Textile Mill Products	22
Furniture & Homefurnishings Stores	57	General Merchandise Stores	53
Textile Mill Products	22	Lumber & Wood Products	24
Building Materials & Gardening Supplies	52	Building Materials & Gardening Supplies	52
Tobacco Products	21	Tobacco Products	21

Sustainalytics E-Score (absolute)		MSCI E-Score (absolute)	
<b>Top Negative Portfolio Weights</b>	<b>SIC2</b>	<b>Top Negative Portfolio Weights</b>	<b>SIC2</b>
Coal Mining	12	Water Transportation	44
Water Transportation	44	Petroleum & Coal Products	29
Insurance Agents, Brokers, & Service	64	Motion Pictures	78
Mining Non-Metallic Minerals, Except Fuels	14	Communications	48
Transportation Services	47	Security & Commodity Brokers	62
Security & Commodity Brokers	62	Oil & Gas Extraction	13
<b>Top Positive Portfolio Weights</b>	<b>SIC2</b>	<b>Top Positive Portfolio Weights</b>	<b>SIC2</b>
Building Materials & Gardening Supplies	52	Pipelines, Except Natural Gas	46
Tobacco Products	21	Tobacco Products	21
Food & Kindred Products	20	Miscellaneous Manufacturing Industries	39
Paper & Allied Products	26	Lumber & Wood Products	24
Textile Mill Products	22	Paper & Allied Products	26
Furniture & Homefurnishings Stores	57	Textile Mill Products	22

# 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