

DO NOT DISTRIBUTE OR QUOTE WITHOUT PERMISSION



# Corporate Climate: Using Machine Learning to assess Climate Risk Disclosures and Susceptibility

Eric L. Talley & Julian Nyarko

# Climate Disclosure Regulation

## Recent History

- 2010: SEC Interpretive Guidance Regarding Disclosure Related to Climate Change
  - 17 CFR PARTS 211, 231, 241 (2/8/10)
- Issuers must disclose trends/events/uncertainties reasonably likely to have significant effects on business operations or financial position, including:
  - **Physical Impacts of Climate Change:** Actual & potential material impacts of physical climate change events on personnel, assets & distribution chains.
  - **Legislation and Regulation:** Impact of existing & pending legislation / regulation related to climate change (within & between jurisdictions).
  - **Indirect Market Consequences of Regulation / Trends:** Supply/demand shock risks for activities with significant greenhouse gas implications (high or low).



**SEC Issues Interpretive Guidance on Disclosure Related to Business or Legal Developments Regarding Climate Change**

**FOR IMMEDIATE RELEASE**  
2010-15

Washington, D.C., Jan. 27, 2010 — The Securities and Exchange Commission today voted to provide public companies with interpretive guidance on existing SEC disclosure requirements as they apply to business or legal developments relating to the issue of climate change.

Federal securities laws and SEC regulations require certain disclosures by public companies for the benefit of investors. Occasionally, to assist those who provide such disclosures, the Commission provides guidance on how to interpret the disclosure rules on topics of interest to the business and investment communities. The Commission's interpretive releases do not create new legal requirements nor modify existing ones, but are intended to provide clarity and enhance consistency for public companies and their investors.

The interpretive release approved today provides guidance on certain existing disclosure rules that may require a company to disclose the impact that business or legal developments related to climate change may have on its business. The relevant rules cover a company's risk factors, business description, legal proceedings, and management discussion and analysis.

"We are not opining on whether the world's climate is changing, at what pace it might be changing, or due to what causes. Nothing that the Commission does today should be construed as weighing in on those topics," said SEC Chairman Mary Schapiro. "Today's guidance will help to ensure that our disclosure rules are consistently applied."

**Video: Open Meeting**



Chairman Schapiro Discusses the Interpretive Guidance: [Windows Media Player QuickTime](#)

[Text of Chairman's Statement](#)

Could this affect rate of Climate Change?

Accurate Risk Disclosure

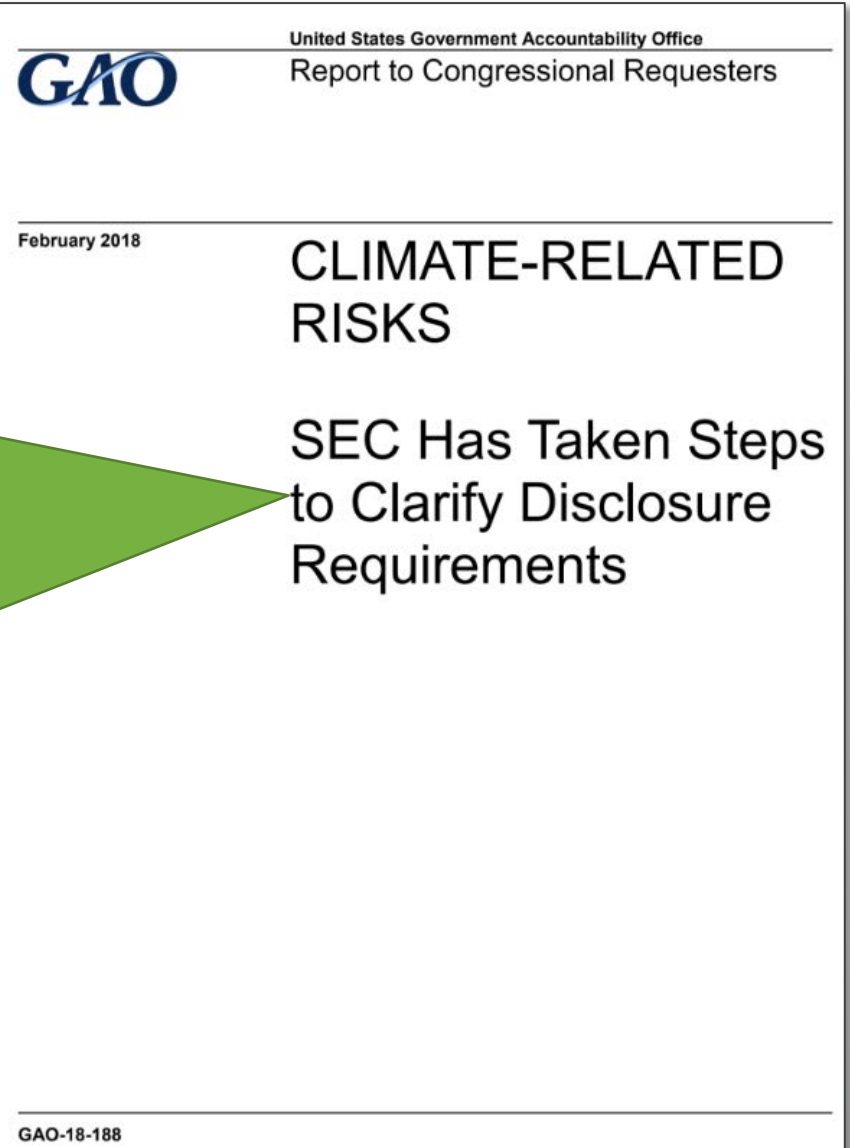
Better Price Discovery

Social Cost Internalization

# GAO Report (2018)

## Key Problems Cited by GAO:

1. Interpretation & Detection: Companies may report similar climate-related disclosures in different sections of the filings, and climate-related disclosures in some filings contain disclosures using generic language, not tailored to the company, and do not include quantitative metrics.
2. Information Asymmetry: SEC relies largely in information that comes from issuers themselves. Difficult to make a case for requiring more information, as SEC lacks an independent yardstick to determining who *should* be disclosing



## Goals of this Project:

1. Develop better tools to determine which public companies *are / have been* making climate risk disclosures as envisioned by the SEC's 2010 interpretive guidance
2. Develop an objective framework for assessing which companies *should be* making such disclosures (still tentative)
3. Compare (1) and (2).



Which public companies *are / have been* making climate risk disclosures envisioned by the SEC's 2010 interpretive guidance?

# Who's Making Climate Disclosures?

- Problem: SEC “guidance” unhelpful to locate climate risk disclosures.
  - MD&A, Risk Factors, Legal Proceedings, Business Description, Notes.
  - Usually buried in the 10K/20F (but not always there)
- One Existing Data Source (Coburn & Cook 2014)
  - Limited in reach / scope (key-word generated; difficult to replicate)
  - Unreliable quality / consistency
- Our Challenge: Build a better ~~Mouse-trap~~ Machine-Learning Classifier
  - Boolean keyword search to identify *candidate* disclosures from EDGAR database (currently last 4 years)
  - “Lawyer” classification of randomly selected sample (~1,000) of candidates
  - Use manually classified data base to train ML classifier
  - (see, e.g., Talley & O’Kane 2012; Rauterberg & Talley, 2017; Nyarko 2018)

# Classifier Performance – Monte-Carlo Simulation (1,000 Iterations within manual coded sample; 80/20 Validation)

**2017**

**Climate change and greenhouse gas restrictions.** Due to concern over the risks of climate change, a number of countries have adopted, or are considering the adoption of, regulatory frameworks to reduce greenhouse gas emissions. These include adoption of cap and trade regimes, carbon taxes, restrictive permitting, increased efficiency standards, and incentives or mandates for renewable energy. These requirements could make our products more expensive, lengthen project implementation times, and reduce demand for hydrocarbons, as well as shift hydrocarbon demand toward relatively lower-carbon sources such as natural gas. Current and pending greenhouse gas regulations or policies may also increase our compliance costs, such as for monitoring or sequestering emissions.

**Preparedness.** Our operations may be disrupted by severe weather events, natural disasters, human error, and similar events. For example, hurricanes may damage our offshore production facilities or coastal refining and petrochemical plants in vulnerable areas. Our facilities are designed, constructed, and operated to withstand a variety of extreme climatic and other conditions, with safety factors built in to cover a number of engineering uncertainties, including those associated with wave, wind, and current intensity, marine ice flow patterns, permafrost stability, storm surge magnitude, temperature extremes, extreme rain fall events, and earthquakes. Our consideration of changing weather conditions and inclusion of safety factors in design covers the engineering uncertainties that climate change and other events may potentially introduce. Our ability to mitigate the adverse impacts of these events depends in part upon the effectiveness of our robust facility engineering as well as our rigorous disaster preparedness and response and business continuity planning.

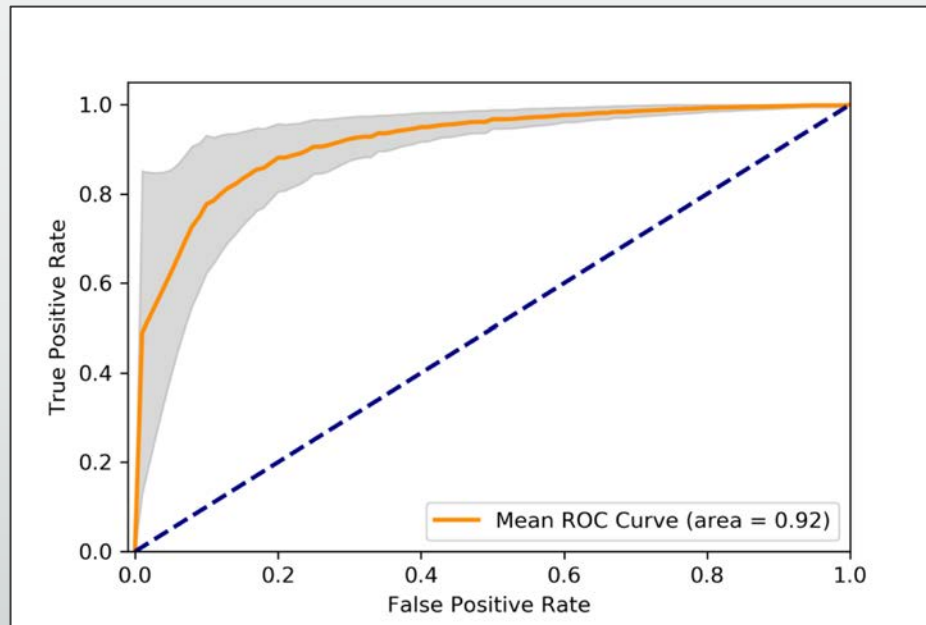
□ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF  
THE SECURITIES EXCHANGE ACT OF 1934**  
For the transition period from           to  
Commission File Number 1-2256

**EXXON MOBIL CORPORATION**

International accords and underlying regional and national regulations covering greenhouse gas emissions continue to evolve with uncertain timing and outcome, making it difficult to predict their business impact. For many years, the Corporation has taken into account policies established to reduce energy-related greenhouse gas emissions in its long-term *Outlook for Energy*. The climate accord reached at the Conference of the Parties (COP 21) in Paris set many new goals, and many related policies are still emerging. Our *Outlook* reflects an environment with increasingly stringent climate policies and is consistent with the aggregation of Nationally Determined Contributions which were submitted by signatories to the United Nations Framework Convention on Climate Change (UNFCCC) 2015 Paris Agreement. Our *Outlook* seeks to identify potential impacts of climate-related policies, which often target specific sectors, by using various assumptions and tools including application of a proxy cost of carbon to estimate potential impacts on consumer demands. For purposes of the *Outlook*, a proxy cost on energy-related CO<sub>2</sub> emissions is assumed to reach about \$80 per tonne on average in 2040 in OECD nations. China and other leading non-OECD nations are expected to trail OECD policy initiatives. Nevertheless, as people and nations look for ways to reduce risks of global climate change, they will continue to need practical solutions that do not jeopardize the affordability or reliability of the energy they need.

COLUMBIA LAW SCHOOL

Estimate	Mean	SD
CCR	93.82	1.62
Precision	0.95	0.02
Recall	0.98	0.01
F <sub>1</sub> Score	0.97	0.01
AUROC	0.92	0.04



# Bigram Word Clouds

## Machine Classified Climate Risk Disclosures





## Comparing our Classifier to (Coburn & Cook 2014): Correcting an Evident Significant False Positive Rate

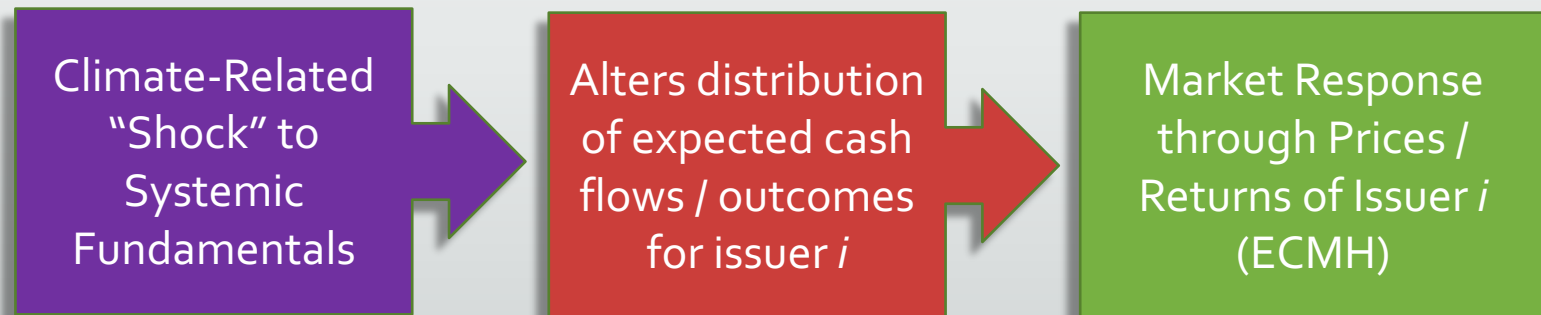
	$Pos_{Cook}$	$Neg_{Cook}$	Not in Cook
$Pos_{NT}$	5,388 (58.65)	13	2,704
$Neg_{NT}$	487 (42.44)	4	528
Not in NT	4,586 (14.90)	10,200	

Manual audits of divergent classifications leads us to be confident that our classifier significantly outperforms Coburn/Cook

Which public companies *should be* making climate risk disclosures?

# Disclosure Duty ↔ Materiality of Climate Risk

- Material Facts: Facts that a reasonable shareholder would consider important in making portfolio / voting decisions. *TSC v. Northway*, 426 U.S. 438 (1976)
  - See Regulation S-K Items 101, 103, 303, and 503(c)
  - Assesses both probabilities and magnitudes (*SEC v Texas Gulf Sulfur Co.*, 401 F. 2d 833, 849 (2d Cir. 1968))



# Climate Risk and Returns

- Factor Models in Arbitrage Pricing Theory

$$(R_A - r_f) = \alpha_A + \beta_{1A} \cdot F_1 + \dots + \beta_{KA} \cdot F_K + \varepsilon_A$$

- Examples:

- 1-Factor (CAPM):  $F_1 = (R_{Mkt} - r_f) \equiv ERP$
- 3-Factor (Fama-French 1993):  $F_1 = ERP$ ;  $F_2 = (R_B - R_S) \equiv BMS$ ;  $F_3 = (R_H - R_L) \equiv HML$

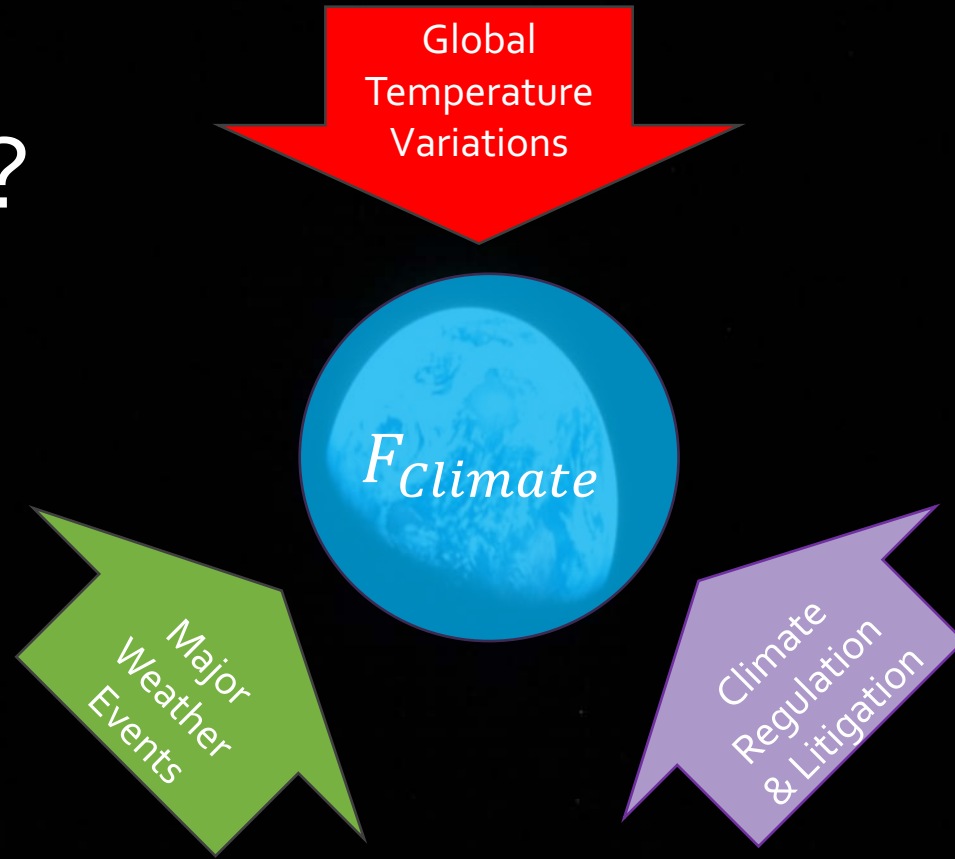
- Thought Experiment: A Climate Factor?

- Design statistical factor tailored to Climate Risk. ***F<sub>Climate</sub>***
- Nest within accepted asset pricing models (e.g., CAPM / F-F)
- Estimate "Climate Betas" for public companies
- "Significant" Estimated Climate  $\beta \Leftrightarrow$  Climate risk material  $\Leftrightarrow$  Should Disclose (if APT model correctly specified)

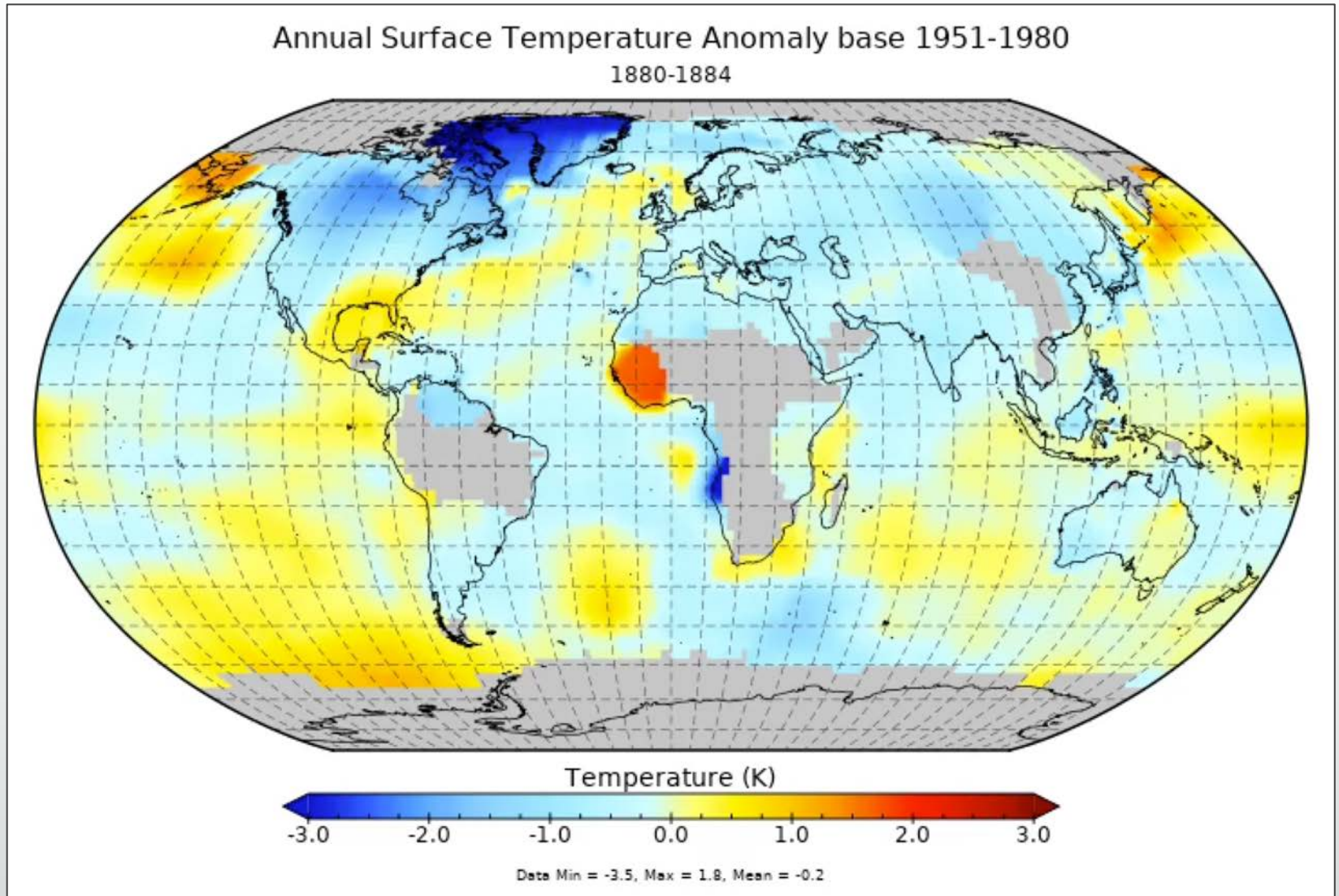
...so all that's left to do is come up with  $F_{Climate}$ ...



# *WTF* Climate?

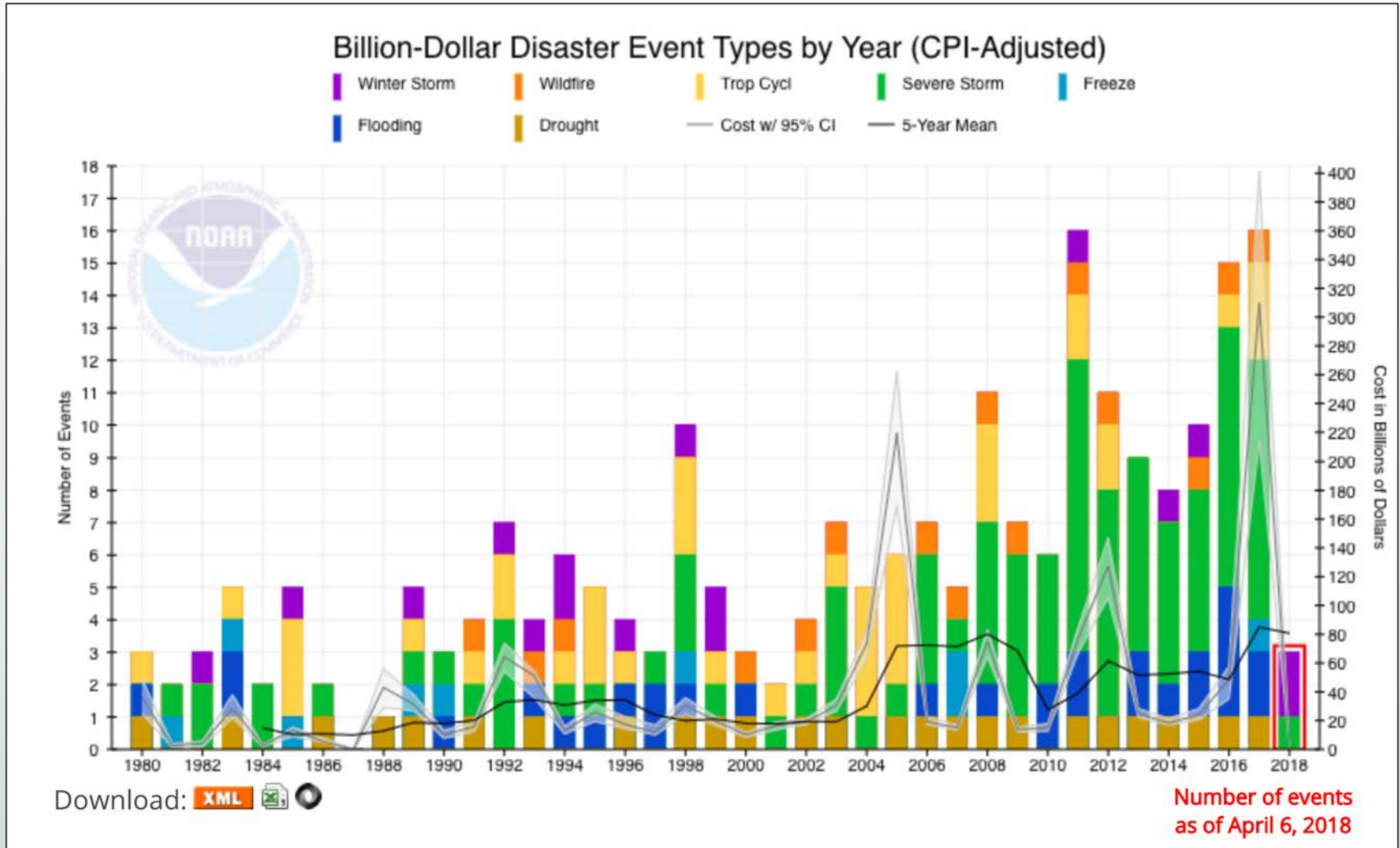


# Global Surface Temperature Data (GISS)



Source: NASA Goddard Institute of Space Sciences (GISS)  
5° x 5° grids, 1880-pres, average by month

# Major Weather Events (recorded by month / category / \$)



National Climate Data Center (NCDC)

# Climate Litigation / Regulation (1980-2017)

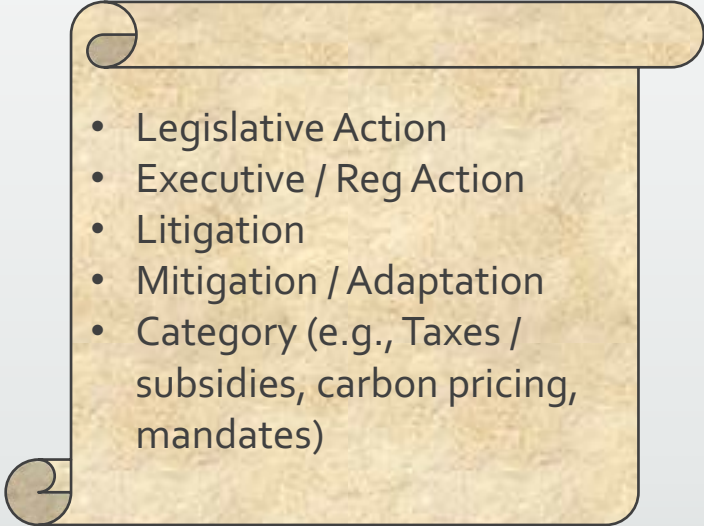
By month, enacting form, objective, category

## ■ LSE Grantham Research Institute

- Non-US-Focused
- Regulation and Litigation Database

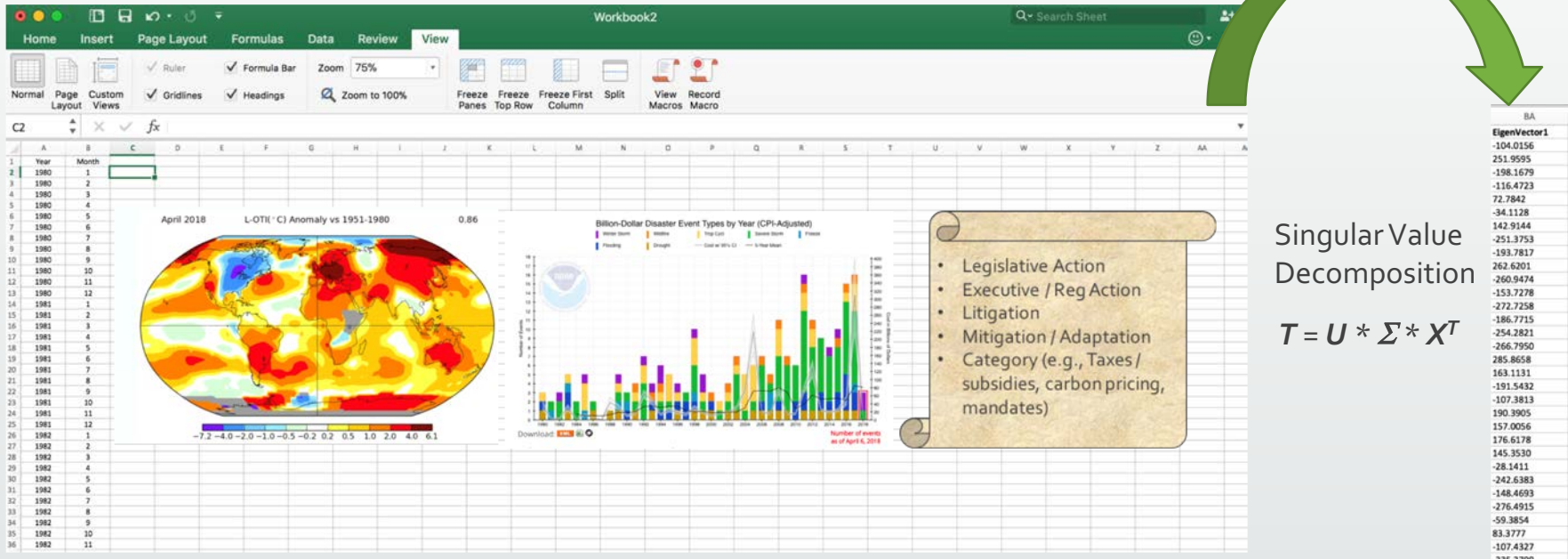
## ■ Columbia University Sabin Center

- US-Focused
- Litigation Database
- Hand-Augmented Legislation/Regulation Database

- 
- Legislative Action
  - Executive / Reg Action
  - Litigation
  - Mitigation / Adaptation
  - Category (e.g., Taxes / subsidies, carbon pricing, mandates)



# Cobbling together a statistical climate factor



Singular Value  
Decomposition

$$T = U * \Sigma * X^T$$

$F_{Climate}$

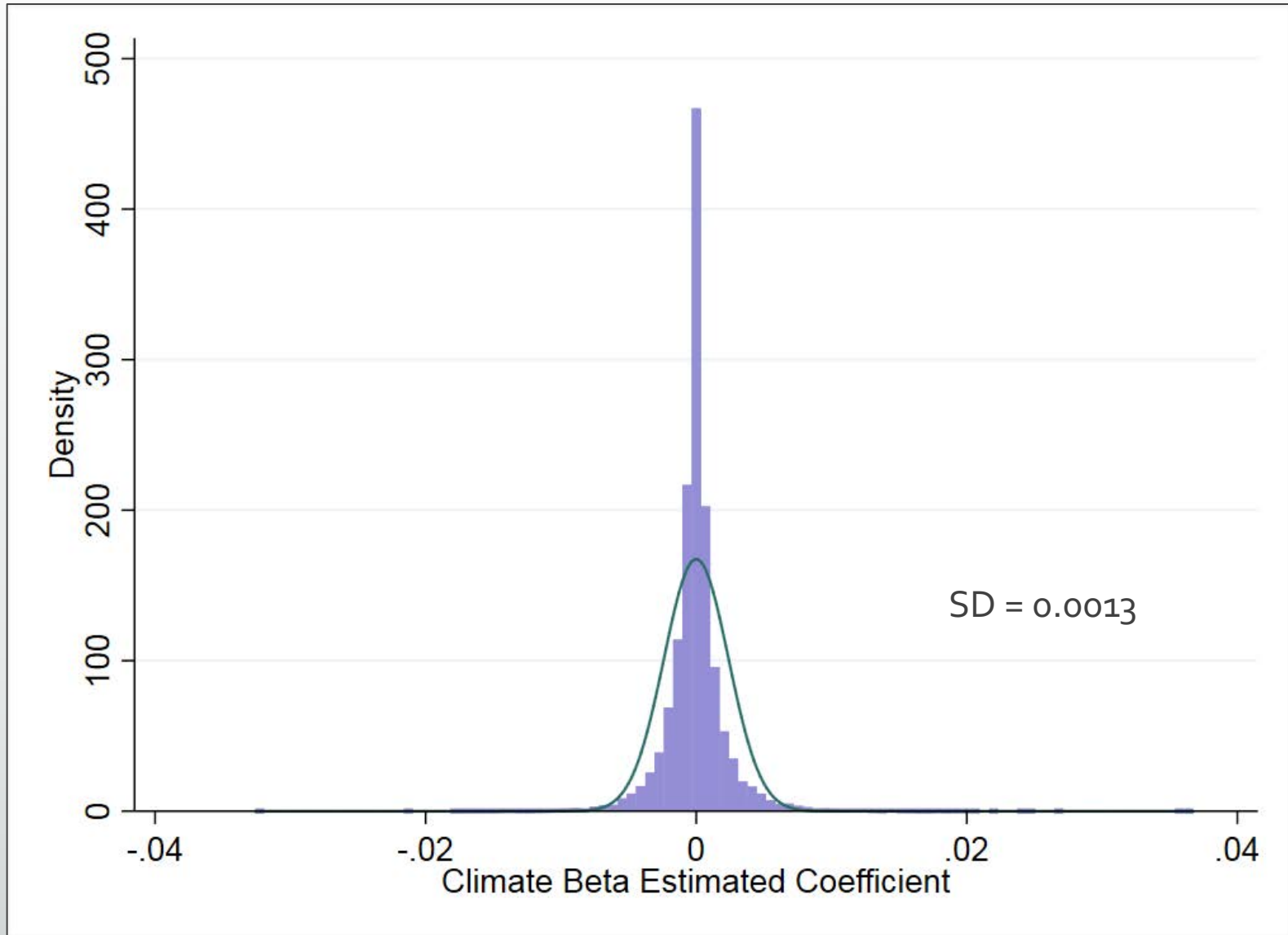
# Empirical Strategy

- For issuers listed between 2009-2017, estimate a modified Fama-French model that includes  $F_{Climate}$ :

$$(R_i - r_f) = \alpha_i + \beta_{1i} \cdot ERP + \beta_{2i} \cdot BMS + \beta_{3i} \cdot HML + \beta_{4i} \cdot F_{Climate} + \varepsilon_i$$

- Max estimation period: 1995-2017; must include  $\geq 4$  full years of data
- Results in estimated climate  $\beta$ s for ~12,500 issuers

# Estimated Climate Betas: Firm-Level Distribution (n=12,425)



What issuers should be disclosing (but are not\*)?  
 (Criterion: Estimated Climate  $\beta$  statistically  $\neq 0$ )

		Significant Climate Beta		
		0	1	
Disclosure Made	0	1,681	94	1,775
	1	2,172	150	2,322
		3,853	244	4,097

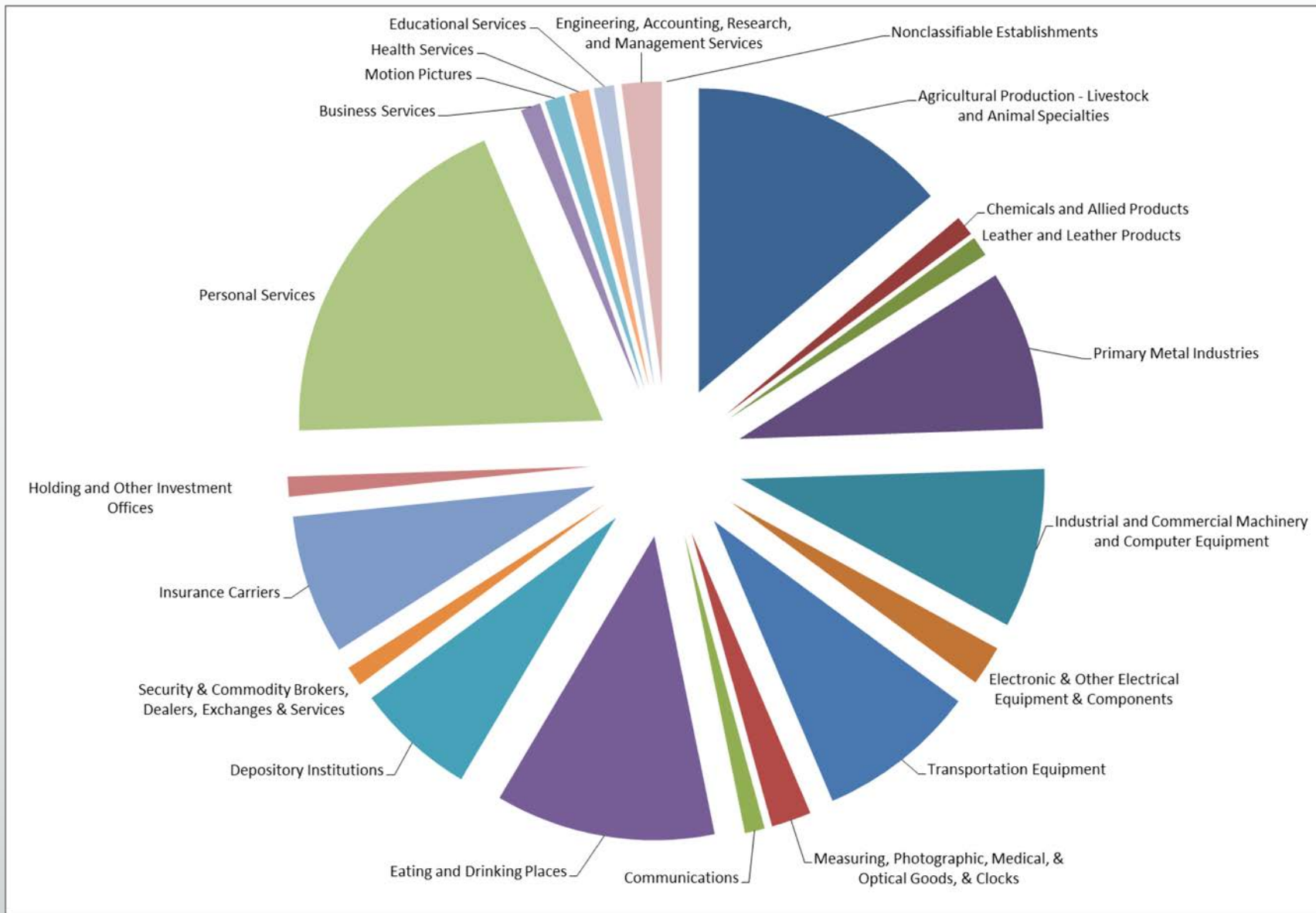
~ 55%

~ 61.5%

\*Note: Using Coburn/Cook Data



# Industry Representation of "Suspect" Non-Disclosers (Criterion: No Disclosure, but estimated $\beta$ statistically $\neq 0$ )



# Concluding Remarks

- Climate risk disclosures are increasingly important, both to investors and policy makers
  - Regulators have thus far been flummoxed in determining both who is making disclosures as well as who should be making them
  - Prime candidate domain for using machine learning.
- Our Analysis Thus Far:
  - Develops a promising and reliable ML platform to detect and classify Climate Risk Disclosures
  - Promising first steps in using Asset Pricing frameworks / statistical climate factors as a normative benchmark
    - Factors seems (mildly) predictive of actual disclosures
    - *Can do much more to calibrate model (e.g., climate modeling; insurance premia; climate portfolio)*
- MUCH MORE TO DO; COMMENTS MOST WELCOME

# MANY THANKS

## References

- Peter M. Clarkson et al., *Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis*, 33 *Account. Organ. Soc.* 303–327 (2008);
- Marlene Plumlee et al., *Voluntary environmental disclosure quality and firm value: Further evidence*, 34 *J. Account. Public Policy* 336–361 (2015).
- Charles H. Cho, Robin W. Roberts & Dennis M. Patten, *The language of US corporate environmental disclosure*, 35 *Account. Organ. Soc.* 431–443 (2010).
- Jim Coburn & Jackie Cook, *Cool Response: The SEC & Corporate Climate Change Reporting* (2014)