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

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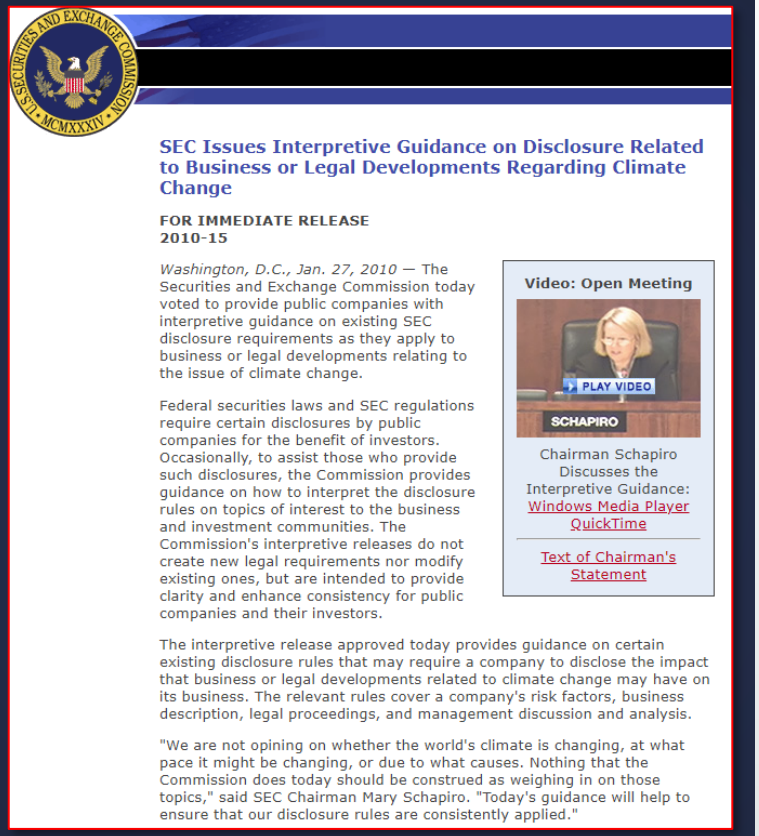
Climate Disclosure Regulation Recent History

- 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.

Video: Open Meeting

Chairman Schapiro Discusses the Interpretive Guidance: Windows Media Player QuickTime

Text of Chairman's Statement

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.

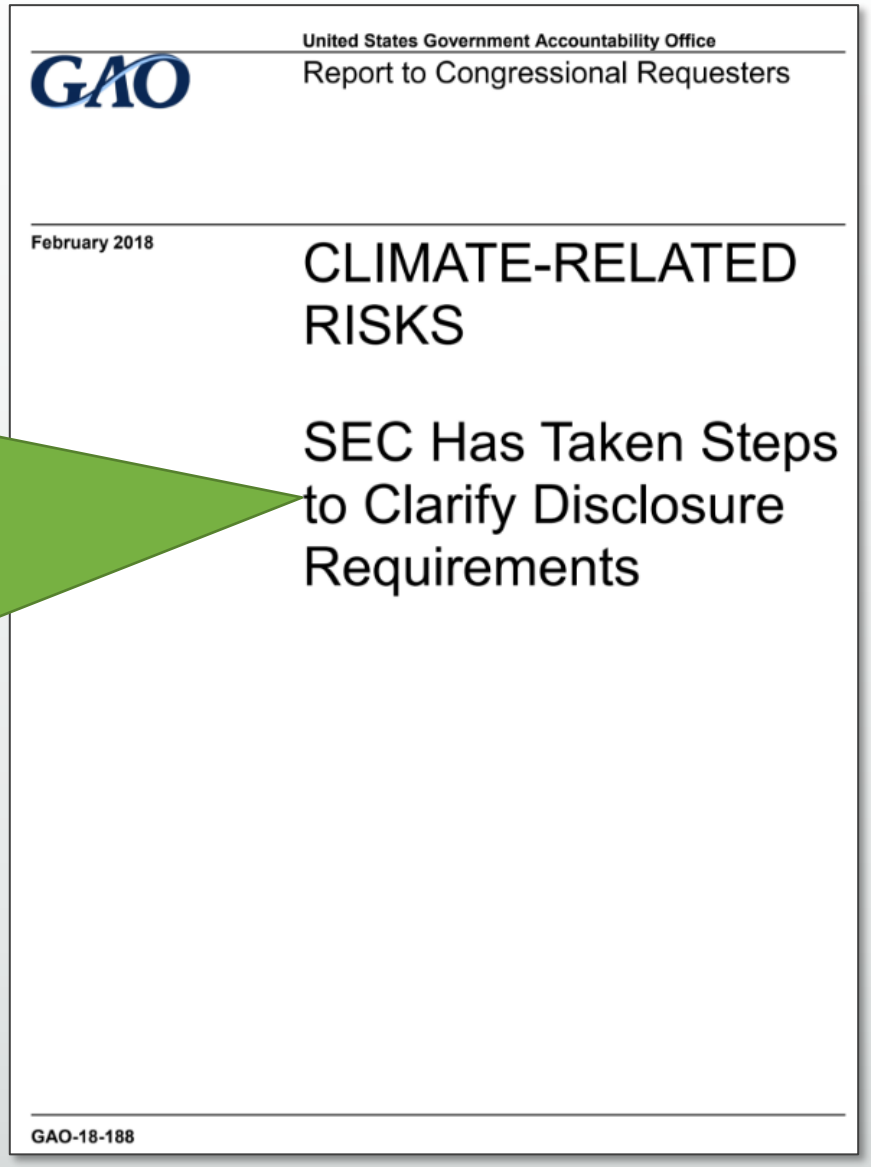
"We are not opining on whether the world's climate is changing, at what pace it might be changing, or due to what causes. Nothing that the Commission does today should be construed as weighing in on those topics," said SEC Chairman Mary Schapiro. "Today's guidance will help to ensure that our disclosure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

Could this affect rate of Climate Change?

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


United States Government Accountability Office

GAO

Report to Congressional Requesters

February 2018

CLIMATE-RELATED RISKS

SEC Has Taken Steps to Clarify Disclosure Requirements

GAO-18-188

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)

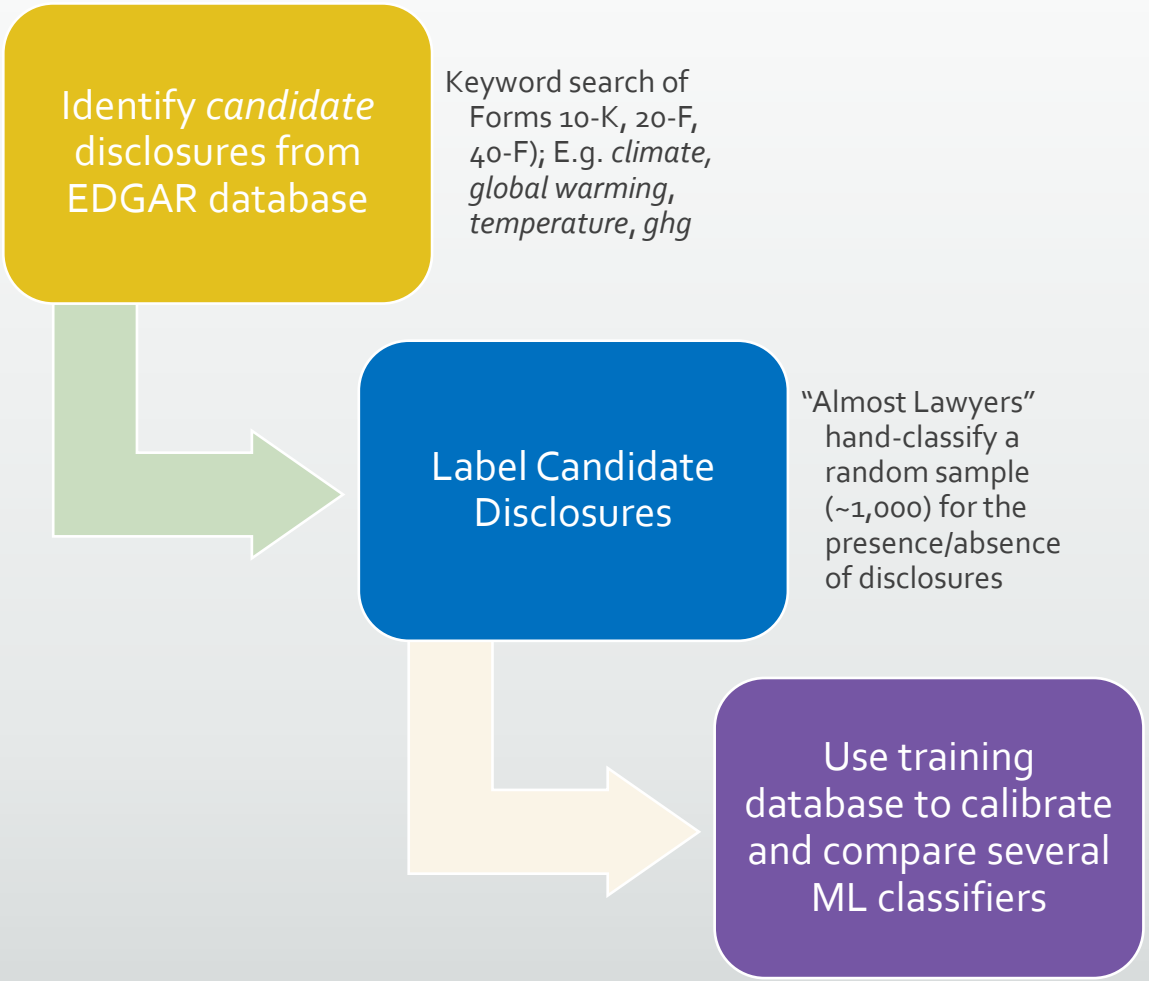
3. Compare (1) and (2).

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: Use tools from Machine Learning to build a more reliable tool for detecting climate risk disclosures

Our Approach in a Nutshell



Accuracy of Best-Performing ML Classifier

Estimate	Mean	SD
CCR	93.82	1.62
Precision	0.95	0.02
Recall	0.98	0.01
F_1 Score	0.97	0.01
AUROC	0.92	0.04

Disclosures by Industry

Julian: Is it possible to get a relative measure (e.g., the fraction of the total number of issuers in each industry making a CR disclosure? Hard to interpret absolute #s

Industry	# Filings	# Disclosures	Freq. Disclosures
Mining	352	292	0.83
Transportation	431	297	0.69
Construction	48	26	0.54
Trade	367	141	0.38
Manufacturing	1,470	497	0.34
Public Admin.	3	1	0.33
Finance	1,597	266	0.17
Other	592	98	0.17
Services	734	118	0.16

Disclosures Come in

Can you list the issuer for each disclosure? Also, might be funny to make a joke about "can you guess which lawyer is paid by the hour and which one is paid by the job?"

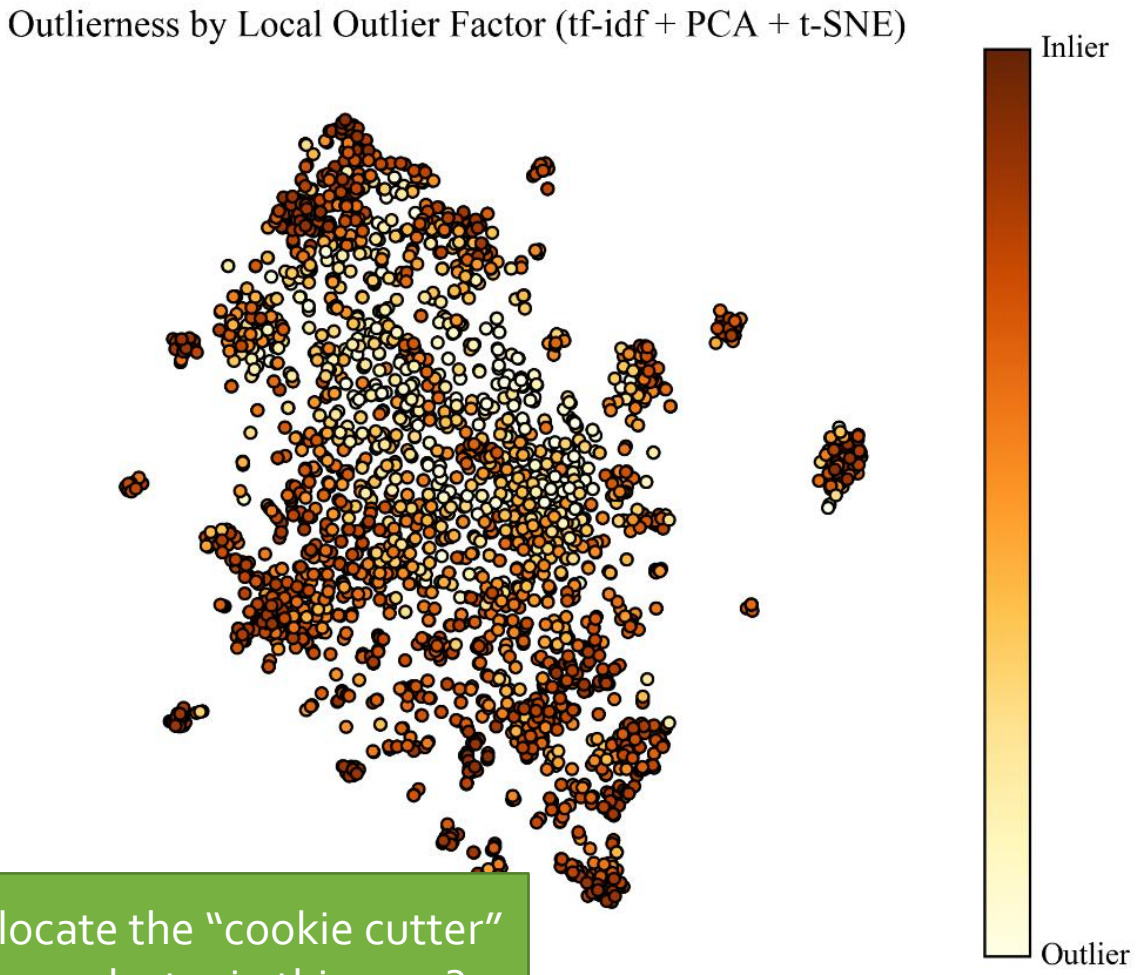
Issuer Name

Changes or additions to laws and regulations, including those related to climate change, could increase our expenses.

Issuer Name

To date, legislative and regulatory initiatives relating to greenhouse gas emissions have not had a material impact on our business. However, Congress has been actively considering climate change legislation. More directly, USEPA has begun regulating greenhouse gas emissions under the federal Clean Air Act. In response to the Supreme Court's decision in Massachusetts v. EPA, 549 U.S. 497 (2007) (holding that greenhouse gases are air pollutants covered by the Clean Air Act), USEPA made a final determination that greenhouse gases endangered public health and welfare, 74 Fed. Reg. 66,496 (Dec. 15, 2009). This finding led to the regulation of greenhouse gases under the Clean Air Act. Currently, USEPA has promulgated final rules relating to greenhouse gases that will affect our businesses. USEPA promulgated the so-called "Tailoring Rule" which established emission thresholds for greenhouse gases under the Clean Air Act permitting programs, 75 Fed. Reg. 31,514 (June 3, 2010). Both the federal preconstruction review program, known as "Prevention of Significant Deterioration" ("PSD"), and the operating permit program are now implicated by emissions of greenhouse gases. These programs, as modified by the Tailoring Rule, could require some new facilities to obtain a PSD permit depending on the size of the new facilities. In addition, existing facilities as well as new facilities that exceed the emissions thresholds could be required to obtain the requisite operating permits. On June 23, 2014, the United States Supreme Court ruled on challenges to the Tailoring Rule in the case of Utility Air Regulatory Group v. EPA, 134 S. Ct. 2427 (2014). The Court limited the applicability of the PSD program and Tailoring Rule to only new sources or modifications that would trigger PSD for another criteria pollutant such that projects cannot trigger PSD based solely on greenhouse gas emissions. However, if PSD is triggered for another pollutant, greenhouse gases could be subject to a control technology review process. The Court's decision also means that sources cannot trigger a federal operating permit requirement based solely on greenhouse gas emissions. USEPA is still in the process of responding to the Court's decision through rulemakings. Overall, the impact of the Tailoring Rule after the Court's decision is difficult to predict at this point, but it could potentially have significant adverse effects on our operations in the future.

Mapping the Language of Climate Risk Disclosures



Can we locate the "cookie cutter" disclosure cluster in this map?

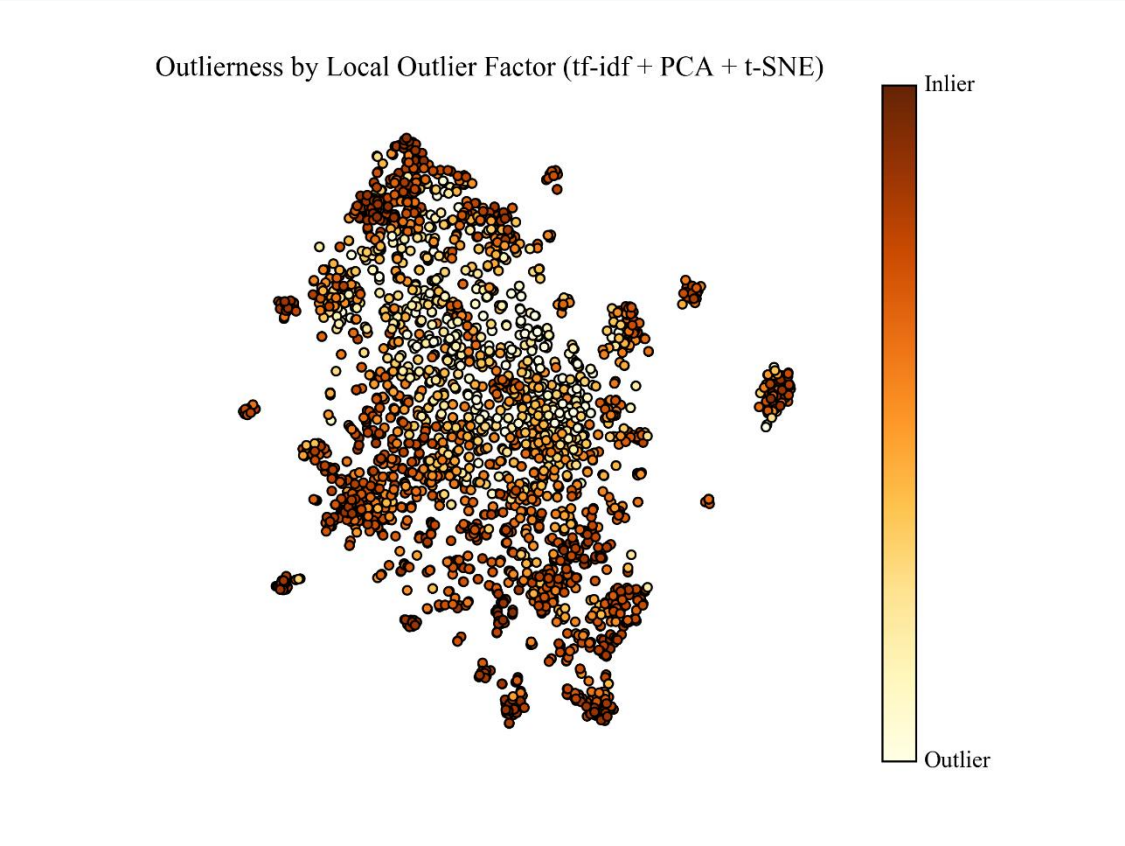
Bigram Word Clouds
Machine Classified Climate Risk Disclosures

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

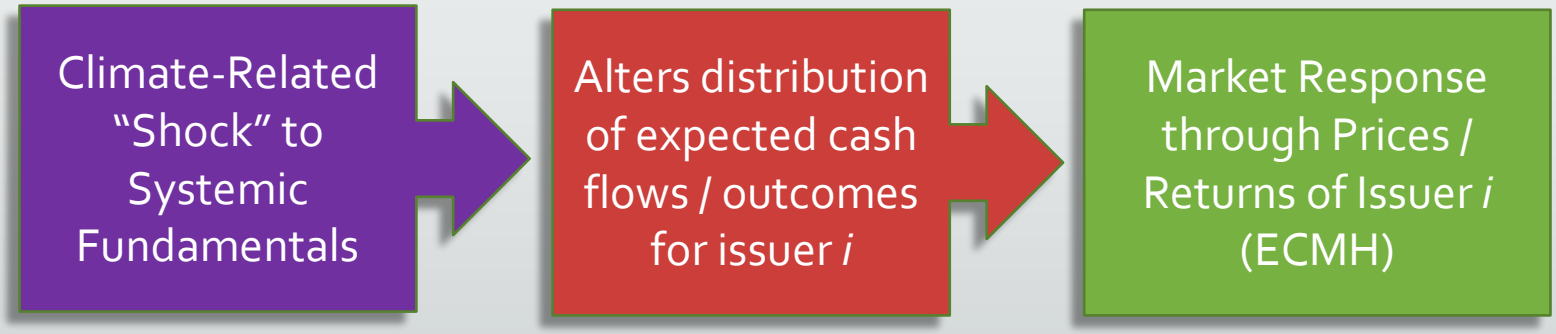
Mapping the Language of Climate Risk Disclosures



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

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

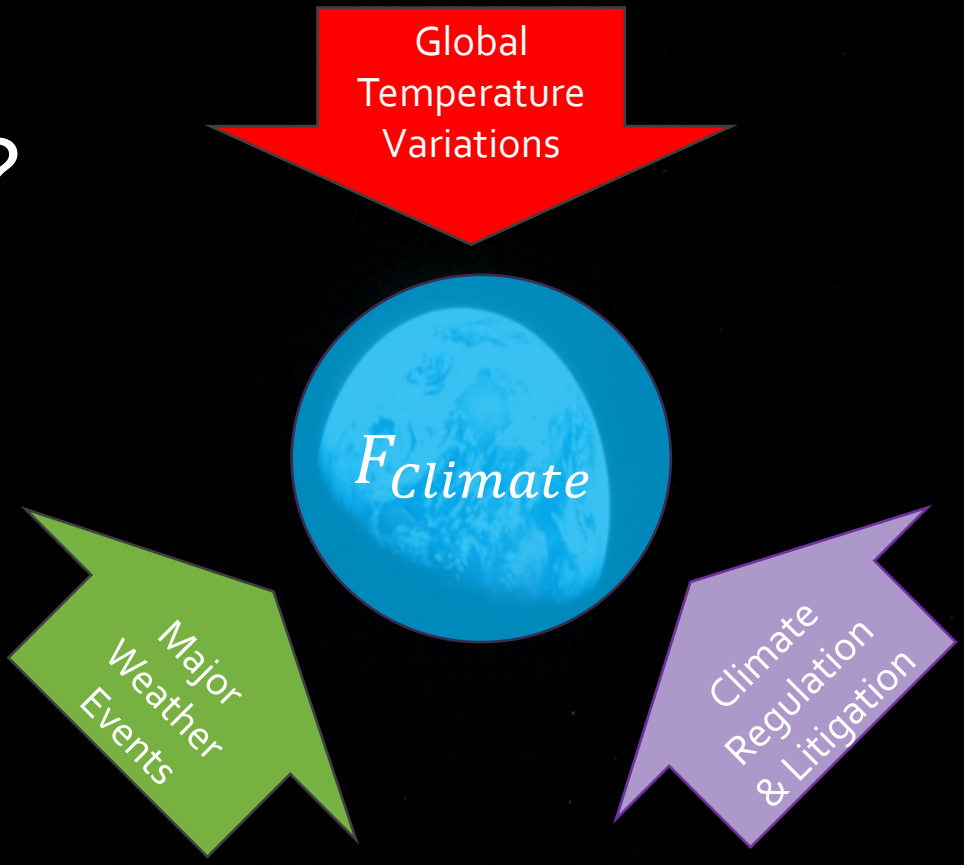
  - Examples:
    - 1-Factor (CAPM): $F_1 = (R_{Mkt} - r_f) \equiv ERP$
    - 3-Factor (Fama-French 1993): $F_1 = ERP$; $F_2 = (R_B - R_S) \equiv BMS$; $F_2 = (R_H - R_L) \equiv HML$

- Thought Experiment: A Climate Factor?
  - Design statistical factor tailored to Climate Risk: $\boldsymbol{F_{Climate}}$
  - Nest within accepted asset pricing models (e.g., CAPM / F-F)
  - Estimate "Climate Betas" for public companies

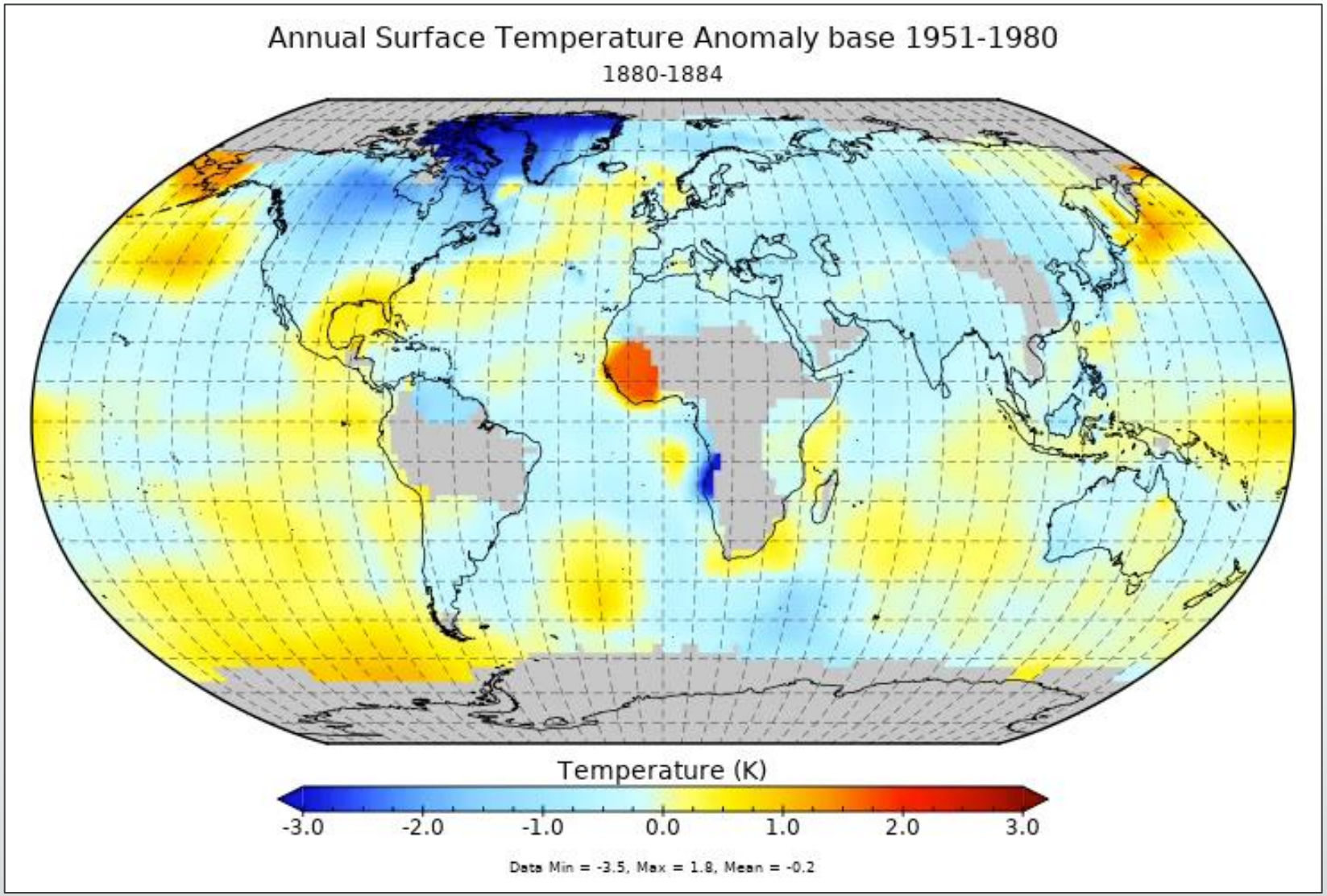
➢ "Significant" Estimated Climate β ⇔ Climate risk material ⇔ Should Disclose (if APT model correctly specified)

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

$WTF_{Climate}?$

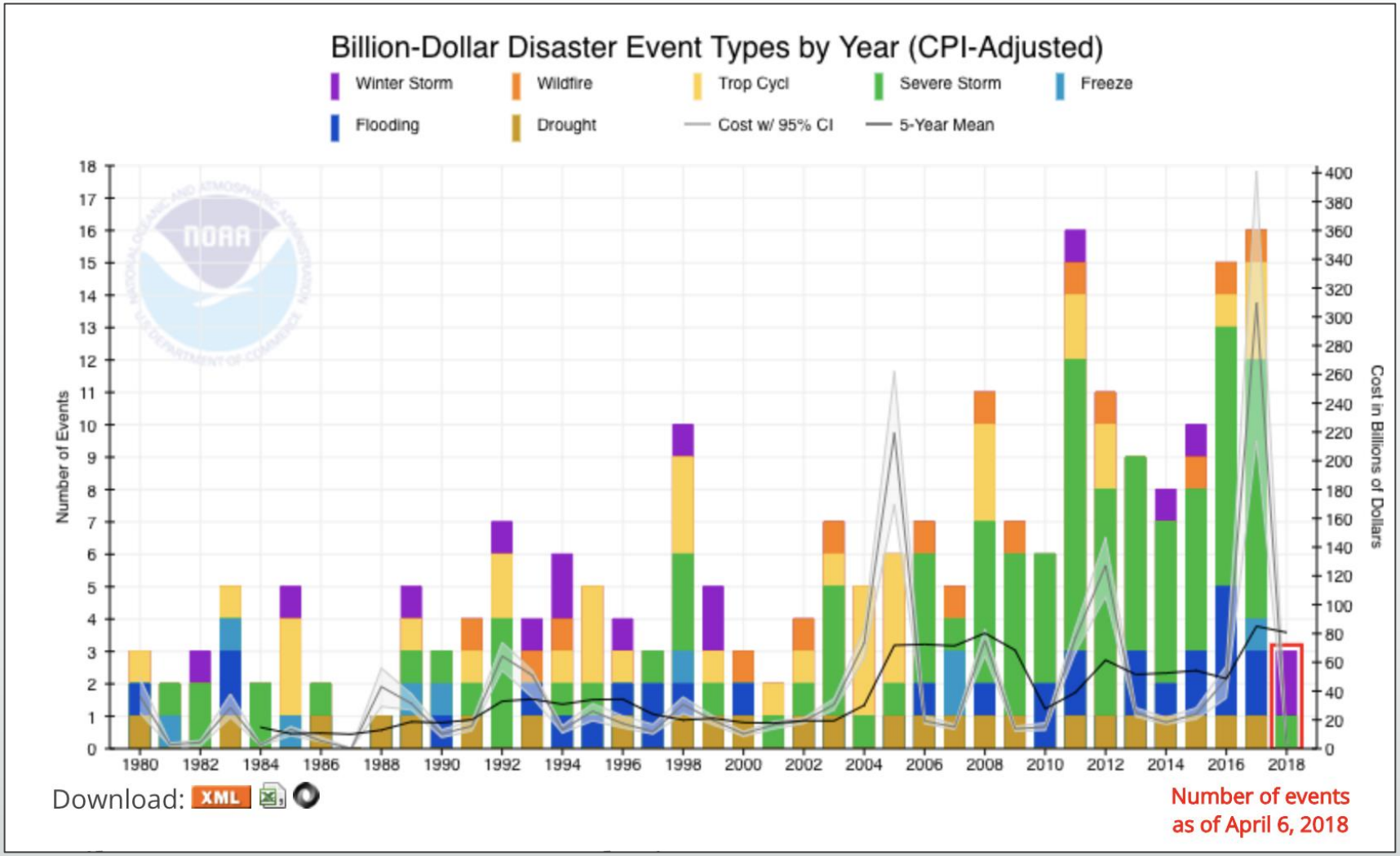

Global Temperature Variations
$F_{Climate}$
Major Weather Events
Climate Regulation & Litigation

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)

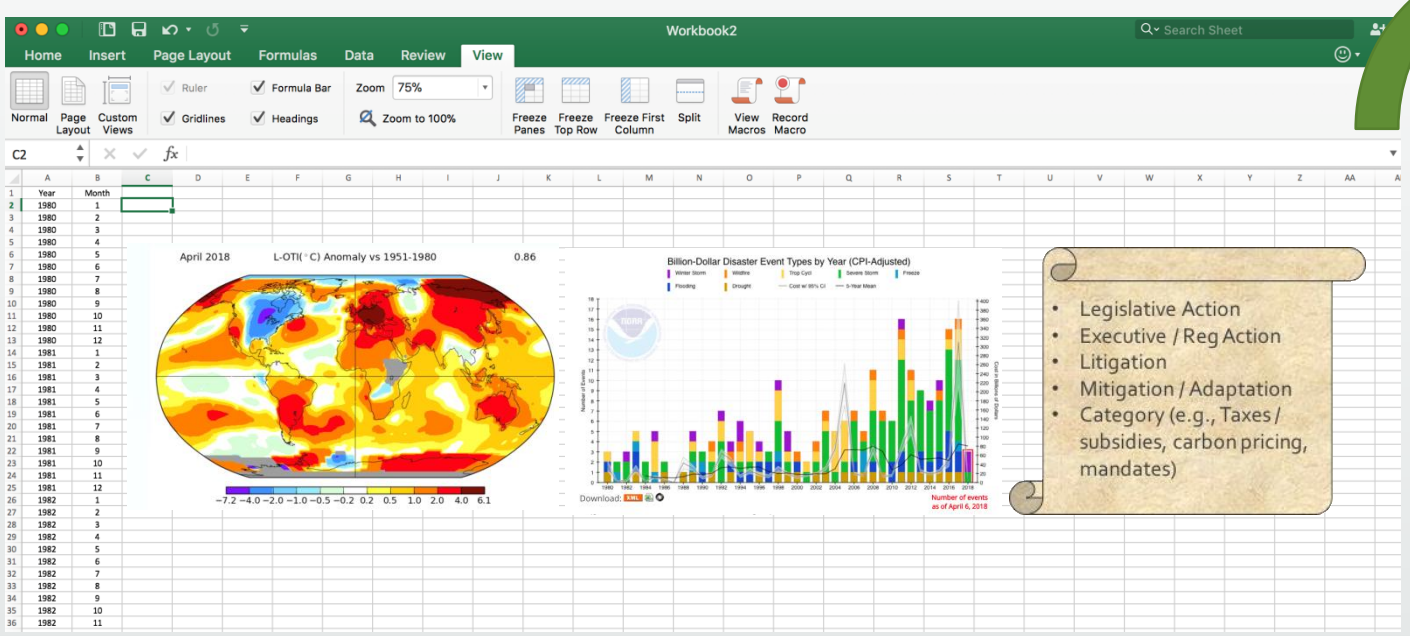
Climate-Related Legal Events (1980-2017)

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



- Legislative Action
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- Category (e.g., Taxes / subsidies, carbon pricing, mandates)

Singular Value Decomposition

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

BA
EigenVector1
-104.0156
251.9595
-198.1679
-116.4723
72.7842
-34.1128
142.9144
-251.3753
-193.7817
262.6201
-260.9474
-153.7278
-272.7258
-186.7715
-254.2821
-266.7950
285.8658
163.1131
-191.5432
-107.3813
190.3905
157.0056
176.6178
145.3530
-28.1411
-242.6383
-148.4693
-276.4915
-59.3854
83.3777
-107.4327

$F_{Climate}$

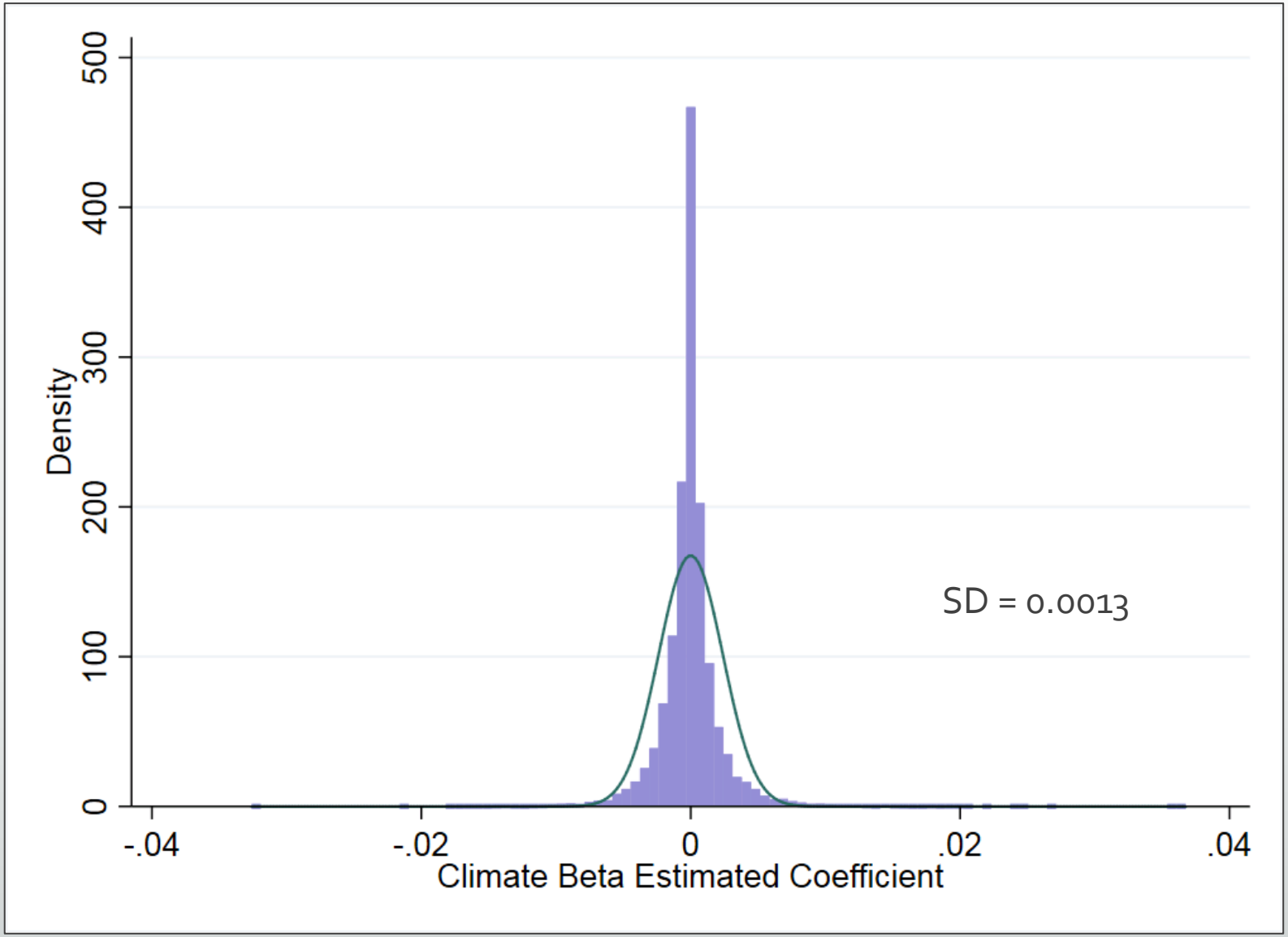
Empirical Strategy

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

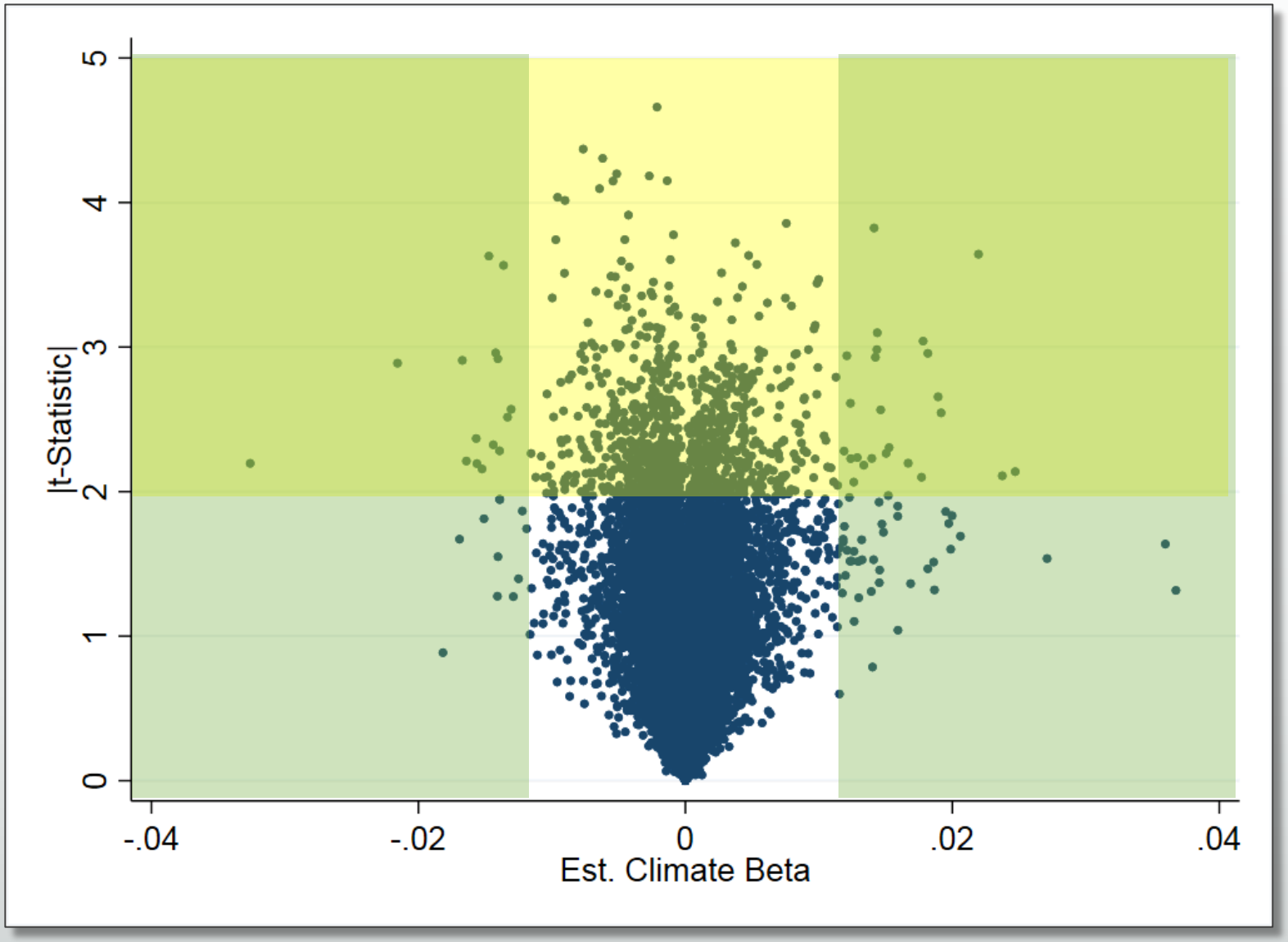
$$(R_i - r_f) = \alpha_i + \beta_{1i} \cdot ERP + \beta_{2i} \cdot BMS + \beta_{3i} \cdot HML + \beta_{4i} \cdot F_{Climate} + \varepsilon_i$$

- Max estimation period: 1995-2017; must include ≥4 full years of data
- Results in estimated climate βs for ~12,500 issuers

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



Defining "Significance"
Scatterplot of Est. Climate Betas and | t-Stats |



Most "Significant" Climate Ri

SIC	COMNAM	coef	tstat
6211	WADDELL & REED FINANCIAL INC	-0.0021575	-4.9751058
3341	HORSEHEAD HOLDING CORP	-0.0061038	-4.258219
1311	ULTRA PETROLEUM CORP	-0.0049656	-4.2
1311	LINN ENERGY LLC	-0.004485	
6722	FRANKLIN RESOURCES INC	-0.0	
4412	FREESEAS INC		
5641	AEROPOSTALE INC		
1221	PEABODY ENERGY CORP	-0.0051974	-3.6020846
8249	CORINTHIAN COLLEGES INC	-0.0054769	-3.4324
7372	ORACLE CORP	-0.0012848	-3.4255011
7370	T I B C O SOFTWARE INC	-0.0052531	-3.41396
1389	GULFMARK OFFSHORE INC	-0.0030655	-3.3847301
3559	RENNOVA HEALTH INC	-0.004537	-3.384444
5700	BED BATH & BEYOND INC	-0.0012086	-3.3490913
3674	CISCO SYSTEMS INC	-0.0010908	-3.3409853
2834	VALEANT PHARMACEUTICALS INTL INC	-0.0022931	-3.3205156
3572	BROCADE COMMUNICATIONS SYS INC	-0.0030954	-3.2943904
3546	BLACK & DECKER CORP	0.00080713	3.2921166
3672	CELESTICA INC	-0.0023894	-3.2647707
3570	STEEL EXCEL INC	-0.001938	-3.2307706
4412	DRYSHIPS INC	-0.0076583	-3.2147985
3533	NATIONAL OILWELL VARCO INC	-0.0021125	-3.2092524
2082	CRAFT BREW ALLIANCE INC	0.00232024	3.1854217
8711	C G G	-0.002845	-3.1647012
6211	DOMINION RESOURCES BL WARRIOR TR	-0.0020106	-3.1297262
6726	POWERSHARES E T F TRUST	0.00069183	3.0643024
1311	VANGUARD NATURAL RESOURCES LLC	-0.003671	-3.0418375
1389	HORNBECK OFFSHORE SVCS INC NEW	-0.0033961	-3.0161481
8200	APOLLO EDUCATION GROUP INC	-0.0020981	-3.0084391
7370	CHECK POINT SOFTWARE TECHS LTD	-0.001947	-2.9750836

SIC			
672			
287			
672			
209			
603			
873			
581			
366			
628			
367			
731			
122			
367			
274			
737			
357			
631			
287			
131			
131			
6726	SPDR INDEX SHARES FUNDS	-0.0005282	-2.6613092
3572	U S GOLD CORP	-0.0012183	-2.6319399
6021	FIDELITY SOUTHERN CORP NEW	0.00148403	2.6180117
5621	L BRANDS INC	-0.0006513	-2.6146445

Attorney General
Barbara D. Underwood

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A.G. Schneiderman Secures Unprecedented Agreement with Peabody Energy to End Misleading Statements and Disclose Risks Arising From Climate Change

Attorney General's Investigation Found That Coal Giant's Public Statements On Risks Posed To The Company By Climate Change Violated State Laws Prohibiting False And Misleading Conduct In Connection With Securities Transactions

Peabody Energy Corporation Is The Largest Publically Traded Coal Company In The World

Schneiderman: Peabody Energy Has A Responsibility To Be Honest With Its Investors And The Public About The Risks Posed By Climate Change, Now And In The Future

NEW YORK – Attorney General Eric T. Schneiderman today announced that a first-of-its-kind investigation by his office found that Peabody Energy Corporation (Peabody) – the largest publically traded coal company in the world – violated New York laws prohibiting false and misleading conduct in the company's statements to the public and investors regarding financial risks associated with climate change and potential regulatory responses.

What issuers should be disclosing (but are not*)? (Criterion: Estimated Climate β statistically ≠ 0)

Disclosure	Significant Climate Beta: 0	Significant Climate Beta: 1
0	3,720	138
1	1,646	90
	31%	40%

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 reliable ML platform to detect and classify Climate Risk Disclosures
  - Promising (if still speculative) 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)

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_2 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.

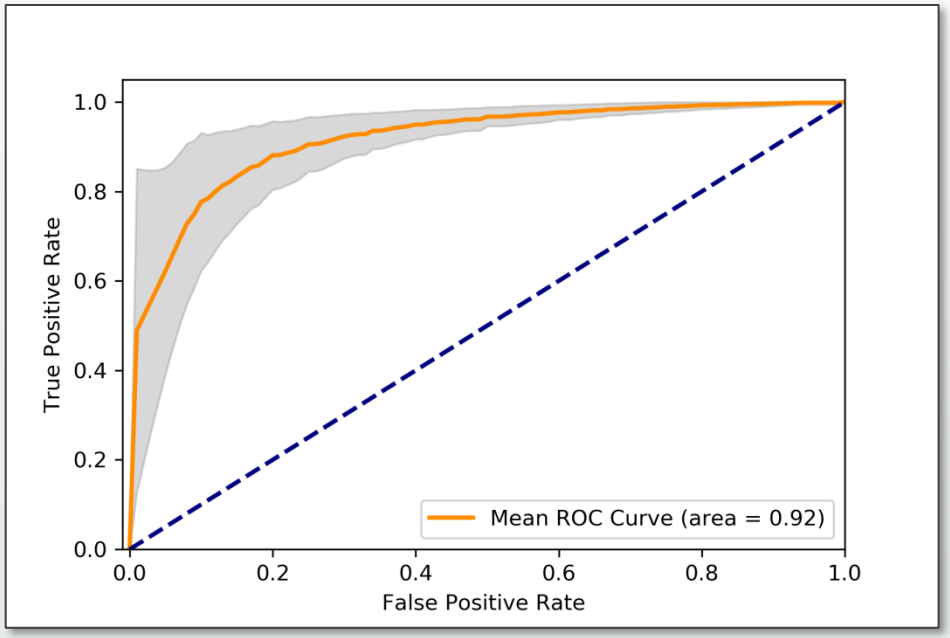
COLUMBIA LAW SCHOOL

Estimate	Mean	SD
CCR	93.82	1.62
Precision	0.95	0.02
Recall	0.98	0.01
F_1 Score	0.97	0.01
AUROC	0.92	0.04

$$Precision = \left(\frac{\#TruePos}{\#TruePos + \#FalsePos}\right)$$

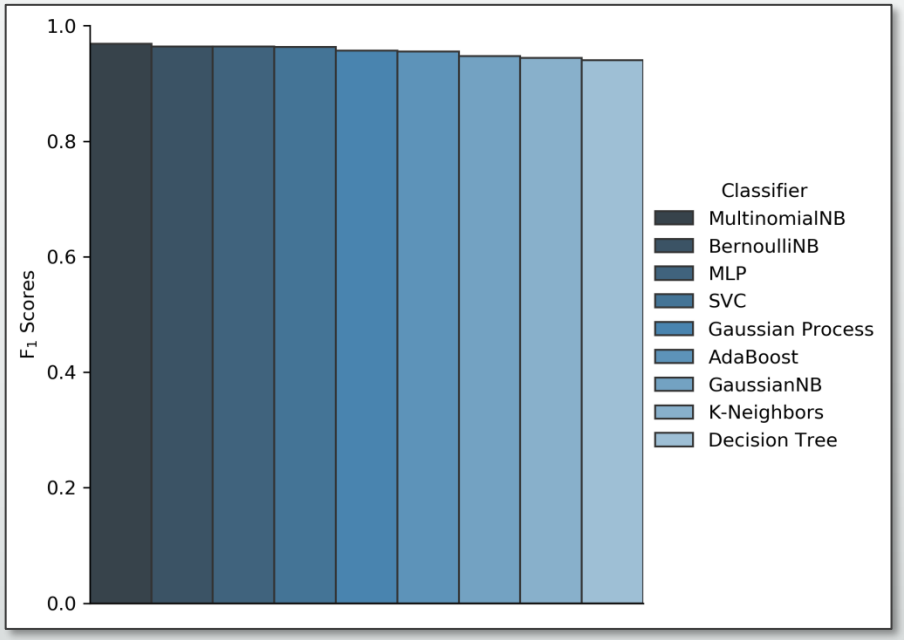
$$Recall = \left(\frac{\#TruePos}{\#TruePos + \#FalseNeg}\right)$$

More Metrics on Classifier Performance



Receiver Operator Characteristic (ROC)

Comparison of F1 Scores (Ensemble)



$$F_1 = \frac{2 \times Precision \times Recall}{Precision + Recall}$$