

**Climate
and Energy
Finance Group**
(CEFGGroup)



BUSINESS SCHOOL
Te Kura Pakihi

Accountancy & Finance
Te Tari Matauraka Kaute Putea

In search of climate distress risk

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Presentation Outline

1. Introduction

2. Literature review

3. Research design

4. Main result

5. Conclusion

1. Introduction

Research Question

Has climate risk been realized in default (distress) risk at the corporate-level?

If so, are there different results for backward (i.e. carbon footprint) & forward-looking measures (i.e. climate risk disclosure) ?

Motivation

- Rising popularity of climate change topics especially on the ‘market risk’ component (i.e. tradeable securities), but less is known if the same effect exists on the ‘credit risk’ component
- Prior researches limit their analysis to debt instruments (loans/ bonds) with indicative price and distinctive features (embedded options, maturity, covenants)
- Proxies of climate risk in past studies are either too generic [ESG score] or too narrow [Scope 1 direct emissions]

Anecdotal signals that climate change, especially transition risk, is not just a long-term risk but is a contemporary phenomenon

Photographer: Lu

Deals

U.S. Coal Giant That Pressed Trump for Bailout Faces Default

By [Will Wade](#) and [Rick Green](#)

October 3, 2019, 9:50 AM GMT+13 Updated on October 4, 2019, 2:05 AM GMT+13

0.02 0.50% ▲ S&P 500 3059.75 0.50% ▲ Nasdaq 9592.05 0.60% ▲ U.S. 10 Yr 0.52% flat 0.00% ▼ Crude Oil 55.50 0.20% ▲

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BUSINESS

PG&E: The First Climate-Change Bankruptcy, Probably Not the Last

The fast fall of PG&E after California's wildfires is a jolt for companies considering the uncertain risks of a warming planet

By [Russell Gold](#)

REUTERS World Business Markets Breakingviews Video More

COMMODITIES NEWS FEBRUARY 13, 2021 / 7:33 AM / UPDATED 5 MONTHS AGO

S&P downgrades Exxon and Chevron on climate risk, dour earnings

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Business Economics Banking Money Markets Project Syndicate B2B

\$ **The polluters** Top investment banks provide billions to expand fossil fuel industry

The New York Times

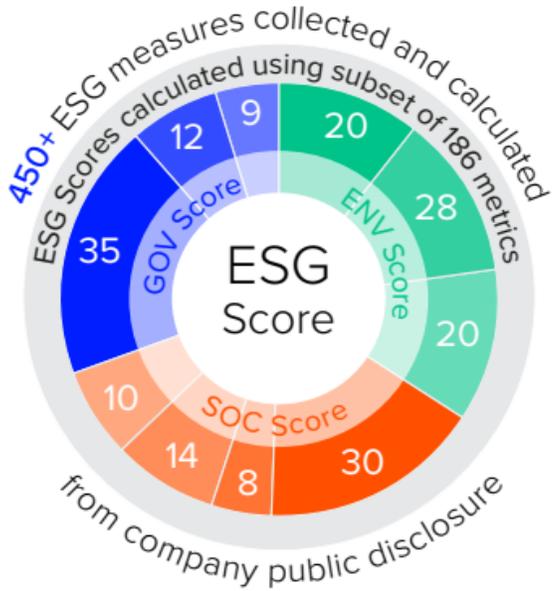
Moody's Buys Climate Data Firm, Signaling New Scrutiny of Climate Risks

Firms ignoring climate crisis will go bankrupt, says Mark Carney

Bank of England governor warns of financial collapse linked to climate emergency

Past proxies of climate risk are either too generic or too narrow ...

ESG Score



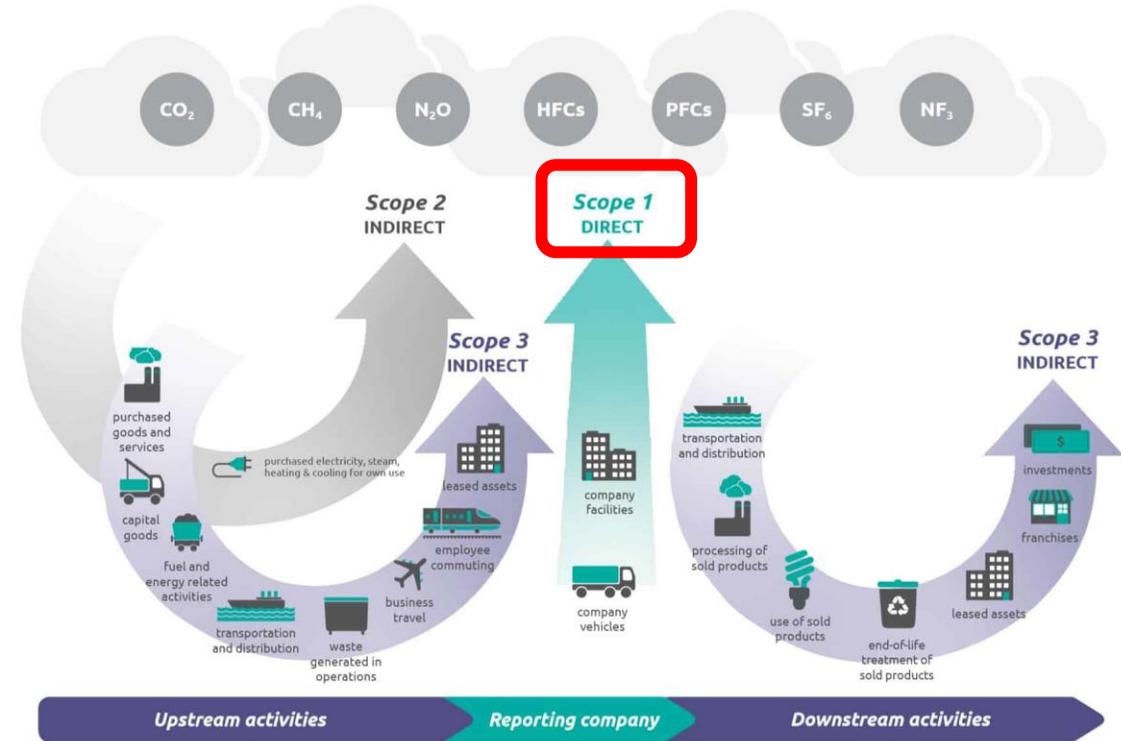
Category definitions are available in [Appendix F](#).

- Environmental
 - Resource use
 - Emissions
 - Innovation
- Social
 - Workforce
 - Human rights
 - Community
 - Product responsibility
- Governance
 - Management
 - Shareholders
 - CSR strategy

Refinitiv | ESG Scores 6

Refinitiv (2020)

Corporate Carbon Footprint



GHG Protocol (2013)

... where climate change risk disclosure in annual filings have clear advantages

- The SEC Commission Guidance Regarding Disclosure Related to Climate Change (2010) mandates disclosure of material climate risk in annual filings for U.S. public firms on *impact of climate change legislation and regulation, international accords on climate change, indirect consequences of regulations or business trends, and physical impacts of climate changes.*

- ⇒ Cover both current and potential impacts
- ⇒ Cover the whole spectrum of climate change

CERES/CookESG SEC Sustainability Disclosure Search Tool

INTEL CORP Climate Risk Disclosure Report. Fiscal Year Ending Dec 30, 2017

In collaboration with:



ENVIRONMENTAL SUSTAINABILITY

Driving to the lowest environmental footprint possible helps us achieve efficiency, lower costs, and respond to the needs of our customers and community stakeholders. We invest in conservation projects and set company-wide environmental targets, seeking to drive **reductions in greenhouse gas emissions**, energy use, water use, and waste generation. Since 2012, we have invested more than \$185 million in approximately 2,000 **energy conservation** projects, resulting in annual cost savings of approximately \$120 million and cumulative energy savings of more than 3 billion kilowatt hours. We are also working with others to apply Internet of Things technologies to environmental challenges such as **climate change** and water conservation.

SUPPLY CHAIN RESPONSIBILITY

Actively managing our supply chain creates business value for Intel and our customers by helping us reduce risks, improve product quality, achieve environmental and social goals, and raise the overall performance of our suppliers. Over the past five years, we have completed more than 450 supplier audits using the Responsible Business Alliance Code of Conduct standard and have expanded training and capacity building programs with our suppliers. We actively collaborate with others and lead industry initiatives on key issues such as advancing responsible minerals sourcing, addressing risks of forced and bonded labor, and improving transparency around **climate and water impacts** in the global electronics supply chain.

These restrictions could harm our business and results of operations by increasing our expenses or requiring us to alter manufacturing and assembly and test processes. **Climate change may also pose regulatory and environmental** risks that could harm our results of operations and affect the way we conduct business. For example, **climate change regulation** could result in increased manufacturing costs associated with air pollution control requirements, and increased or new monitoring, recordkeeping, and **reporting of greenhouse gas emissions**. We also see the potential for higher **energy costs** driven by **climate change regulations** if, for example, utility companies pass on their costs to their customers. Furthermore, many of our operations are located in semi-arid regions such as Arizona, New Mexico, and Israel that may become increasingly vulnerable to **rising average temperatures** or prolonged **droughts** due to **climate change**. Our fabrication facilities require significant water use and, while we recycle and reuse a portion of the water used, we may have difficulties obtaining sufficient water to fulfill our operational needs. In addition, **climate change may pose physical and regulatory risks** to our suppliers, including increased **extreme weather events** that could result in supply delays or disruptions. WE ARE SUBJECT TO CYBERSECURITY AND PRIVACY RISKS.

2. Literature Review

ESG Score

- Environmental concerns are associated with a higher cost of debt and lower credit ratings. Proactive environmental practices are associated with a lower cost of debt (Bauer & Han, 2010)
- Higher ESG Score (upgrade) leads to lower CDS spread (Drago et al., 2019; Barth et al., 2020)
- High-emitter industry or low Sustainability E score worsen credit ratings & yield spreads of corporate bonds (Seltzer et al., 2020)
- Firms with 'climate concerns' in MSCI KLD has a higher cost of debt (Chava, 2014).

Carbon Footprint

- Banks have more favorable lending conditions for firms that disclose emissions or have lower emissions (Kleimeier & Viehs, 2016), while penalizing firms with bigger fossil-fuel reserves (Delis et al., 2019).
- Higher Scope 1 emissions are associated with a lower Merton distance to default on a sample of global investment-grade firms (Capasso et al., 2020)
- Carbon emissions (Scope 1) have a negative impact on credit ratings of U.S. firms (Md Safiullah et al., 2021)

Climate Risk Disclosure

- Climate risk disclosures have a significant effect on future return on assets, earning persistence and forward earning responses (Wang, 2017); firm value, cost of capital and beta (Berkman et al., 2019).
- Stock market reacts positively to shareholder proposals to induce climate change-related disclosure on the proxy filing day (Diaz-Rainey et al., 2020), and has higher valuations for disclosing firms after such proposals (Flammer et al., 2020)
- Disclosing transition risks increases CDS spreads (the risk-perception effect), while disclosing physical climate risks leads to a decrease in CDS spreads (the uncertainty reduction effect) (Kölbel et al., 2021)

3. Research Design

Sample US S&P500 non-financial firms in 2010-2018

Model

$$DD_{it} = \sum \beta_{0,q} DD_{it-q} + \beta_1 \mathbf{Climate}_{it} + \sum \beta_{2,k} \mathbf{FirmControl}_{it}^k + \theta_i + \mu_t + \epsilon_{it}$$

- DD_{it} is the distance-to-default DD of firm in the end of year t.
- DD_{it-q} is the past DD of lag length q
- $\mathbf{Climate}_{it}$ is the climate risk profile of the firm i in year t
- $\mathbf{FirmControl}_{it}^k$ is the vector of k firm- and environment-specific control variables
- θ_i is the firm fixed effect
- μ_t is the year fixed effect
- ϵ_{it} is the random error term

Estimation Method

Dynamic system generalized method of moments estimator [GMM] (Arellano & Bover, 1995; Blundell & Bond, 1998)

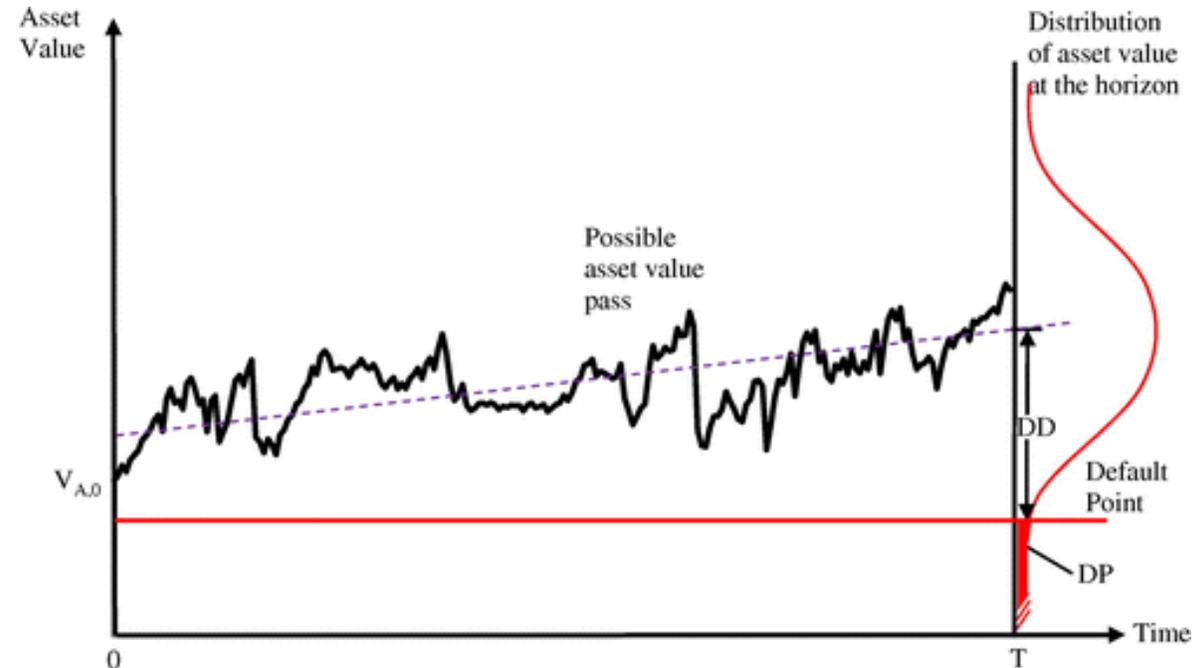
3. Research Design

Distance to Default

$$DD_{itT} = \frac{\ln\left(\frac{V_{it}}{F_{it}}\right) + (\mu_{it} - 0.5 * \sigma_{V_{it}}^2) * T}{\sigma_{V_{it}} * \sqrt{T}}$$

- DD_{it} is the distance-to-default DD of firm in the end of year t.
- V_{it} : estimated asset value
- F_{it} : the level of debt or default point
- μ_{it} : the annual expected return of the firm's asset
- $\sigma_{V_{it}}$ is the asset volatility

Of which, V_{it} and $\sigma_{V_{it}}$ are unobservable and are estimated using an iteration process following (Crosbie & Bohn, 2003; Vassalou & Xing, 2004) using SAS codes by Bharath and Shumway (2008)



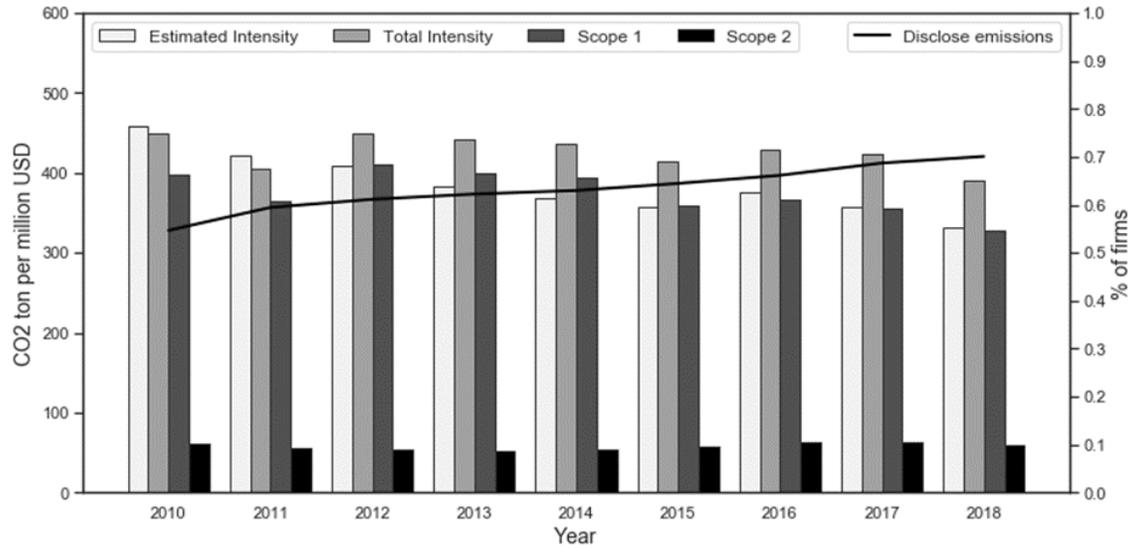
Note: DD: Distance to default, DP: Default probability

4. Main result

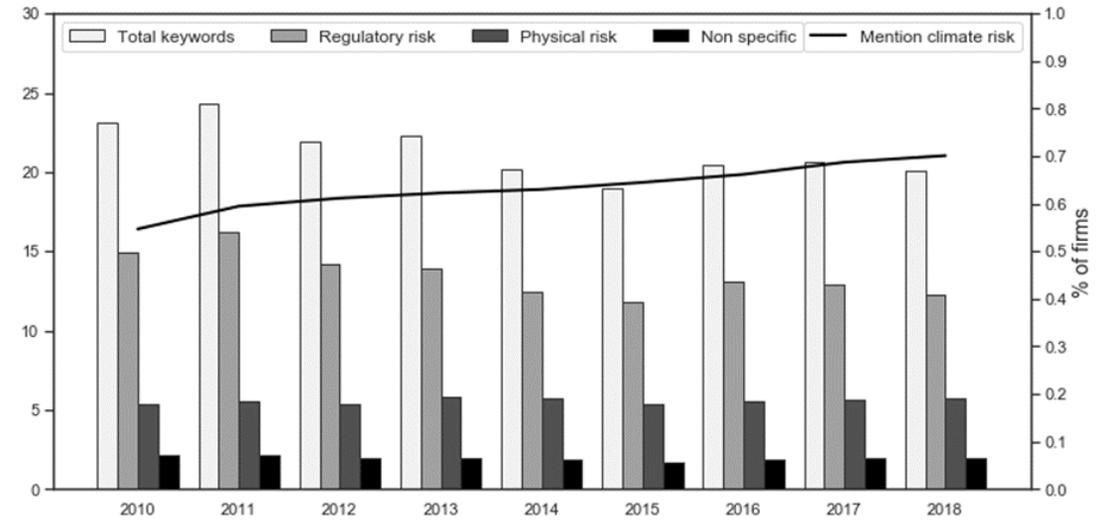
Variables	Label	SP500 firms					
		Obs	Mean	Median	STD	Min	Max
Distress risk							
Distance to Default	DD	3,296	11.41	10.67	5.61	1.34	36.30
Naïve Distance to Default	naïve_DD	3,296	10.87	10.05	5.63	-0.32	36.20
Carbon intensities							
Estimated intensity (CO2e-ton /mil USD)	ln_cie	3,296	383	45	1,030	1	6,035
Total intensity (CO2e-ton /mil USD)	ln_ci12	2,096	426	53	1,066	1	6,052
Scope 1 intensity (CO2e-ton /mil USD)	ln_ci1	2,096	373	15	1,061	0	6,853
Scope 2 intensity (CO2e-ton /mil USD)	ln_ci2	2,108	58	26	114	0	972
Climate risk disclosure in 10K filings							
Total climate keywords	climate	3,296	34	6	74	0	429
Physical risk keywords	physical	3,296	6	1	10	0	57
Regulatory risk keywords	regulatory	3,296	13	1	29	0	159
Nonspecific risk word counts	non_specific	3,296	2	0	4	0	19
Firm control							
Size - total asset (mil USD)	ln_assets	3,296	30,057	13,925	53,665	442	747,793
Size- market cap (mil USD)	ln_market_cap	3,296	35,465	15,190	63,622	1,478	868,880
Firm age (year)	ln_age	3,296	37.13	26.00	30.93	1.00	137.00
Market to book (time)	mtb	3,296	4.21	3.06	9.09	-44.12	53.42
ROA (%)	roa	3,296	6.6%	5.9%	6%	-14%	25%
Leverage (%)	debt_ratio	3,296	30.8%	29.6%	16.8%	0.0%	83.9%
Cash ratio (%)	cash_ratio	3,296	11.8%	7.0%	13.3%	0.1%	62.1%
Retained earnings /Assets (%)	retained_ratio	3,296	29.8%	28.7%	36.4%	-110.2%	130.0%
Capital expenditure ratio (%)	capex_ratio	3,296	4.6%	3.3%	4.3%	0.2%	23.4%
Asset volatility (%)	assetvol	3,296	23.3%	21.6%	9.3%	9.6%	62.7%
Beta (slope)	beta	3,152	1.02	1.01	0.50	0.09	2.57
Idiosyncratic risk (%)	idio_risk	3,152	6.4%	5.7%	2.7%	2.8%	16.8%
ESG score (1-100)	esg_score	3,296	55.00	57.40	19.59	0.49	95.12

4. Main result

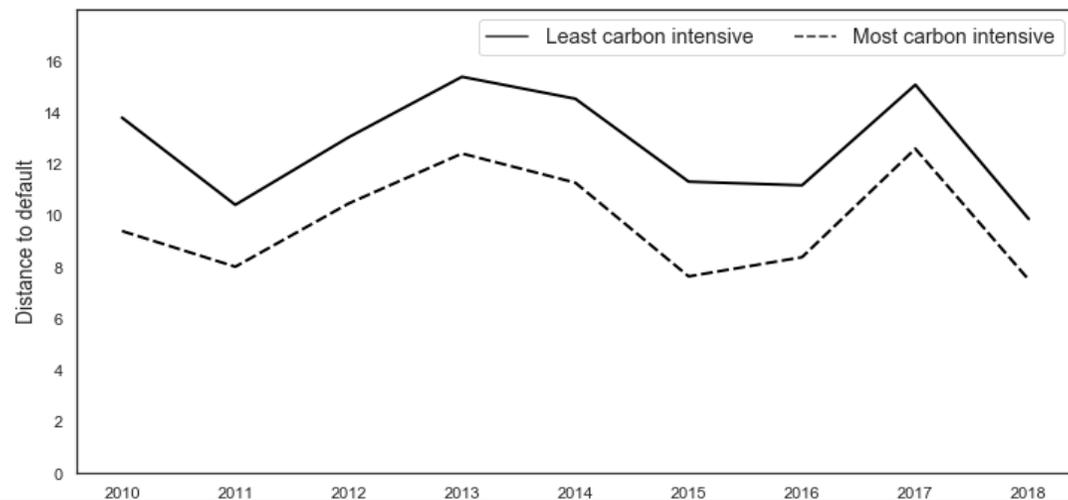
Panel (a): The average carbon intensities over time



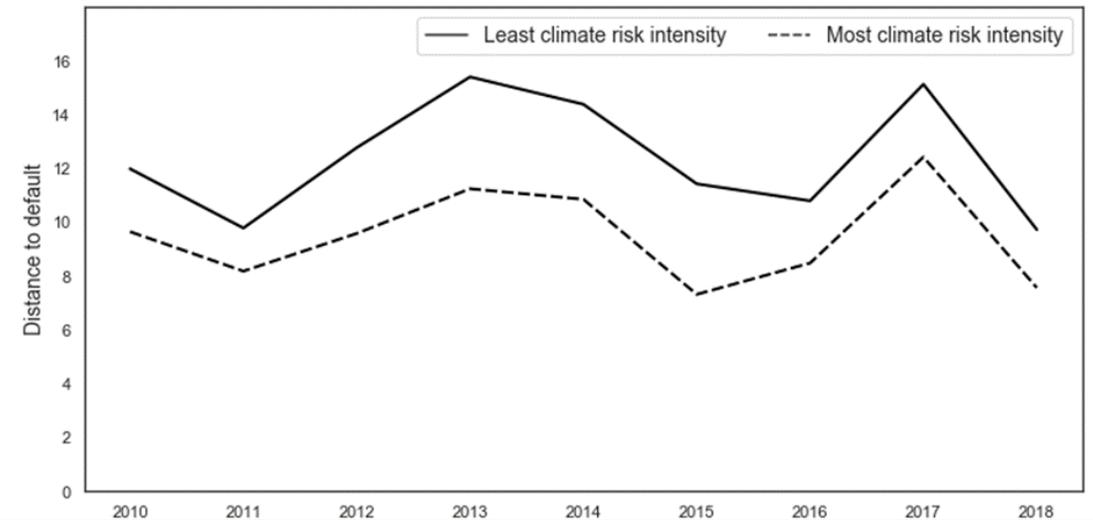
Panel (b): The average climate risk keywords over time



Panel (c): Distance to default by total carbon intensities



Panel (d): Distance to default by climate risk disclosure intensity



4. Main result

Climate transition risk has a negative impact of US firm-level distance to default. The impact is only significant for discussion of climate transition risk in annual filings.

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Model	GMM	GMM	GMM	GMM						
Lagged DD	0.210*** (0.044)	0.189*** (0.056)	0.199*** (0.053)	0.163*** (0.052)	0.213*** (0.042)	0.205*** (0.041)	0.216*** (0.042)	0.215*** (0.044)	0.188*** (0.054)	0.213*** (0.043)
Carbon emissions										
Estimated carbon intensity	-0.179 (0.261)									-0.049 (0.274)
Total carbon intensity		-0.225 (0.363)							-0.018 (0.377)	
Scope 1 intensity			-0.436 (0.344)							
Scope 2 intensity				-0.083 (0.408)						
Climate risk disclosure										
Total climate keywords					-0.025** (0.010)				-0.037** (0.015)	-0.022** (0.010)
Physical risk keywords						-0.026 (0.033)				
Regulatory risk keywords							-0.043*** (0.016)			
Non-specific risk keywords								-0.145 (0.104)		
<i>Number of firm-years</i>	2902	1886	1954	1885	2902	2902	2902	2902	1886	2902
<i>Number of firms</i>	408	282	289	283	408	408	408	408	282	408
<i>Number of instruments</i>	32	32	32	32	32	32	32	32	34	34
<i>Arellano-Bond test for AR(1)</i>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<i>Arellano-Bond test for AR(2)</i>	0.762	0.705	0.686	0.851	0.788	0.741	0.812	0.798	0.714	0.782
<i>Hansen test of over id. restrictions</i>	0.254	0.300	0.412	0.357	0.380	0.285	0.417	0.153	0.561	0.424
<i>Hansen test excluding group for</i>	0.498	0.888	0.930	0.409	0.621	0.570	0.629	0.609	0.988	0.485
<i>Difference in Hansen test for levels</i>	0.216	0.234	0.333	0.329	0.320	0.237	0.354	0.118	0.479	0.382

4. Main result

The impact is strengthened by the Paris Agreement in 2015 but is short-lived and disappears in later years.

Effect	Temporal effect				Post 2015 effect			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Column	GMM	GMM	GMM	GMM	GMM	GMM	GMM	GMM
Model	GMM	GMM	GMM	GMM	GMM	GMM	GMM	GMM
Climate risk disclosure								
Climate-related keywords	-0.012** (0.005)				-0.012** (0.006)			
Physical risk keywords		-0.018 (0.020)				-0.024 (0.021)		
Regulatory risk keywords			-0.018** (0.008)				-0.019** (0.008)	
Non-specific risk keywords				-0.066 (0.061)				-0.098 (0.066)
Interaction terms with 2015 / post 2015								
Climate-related keywords x Dummy 2015	-0.008*** (0.002)				0.004* (0.002)			
Physical risk keywords x Dummy 2015		-0.027*** (0.010)				0.007 (0.012)		
Regulatory risk keywords x Dummy 2015			-0.011*** (0.003)				0.007** (0.003)	
Non-specific risk keywords x Dummy 2015				-0.060 (0.038)				0.079** (0.032)
<i>Number of firm-years</i>	2902	2902	2902	2902	2902	2902	2902	2902
<i>Number of firms</i>	408	408	408	408	408	408	408	408
<i>Number of instruments</i>	34	34	34	34	34	34	34	34
<i>Arellano-Bond test for AR(1)</i>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<i>Arellano-Bond test for AR(2)</i>	0.649	0.688	0.646	0.721	0.765	0.749	0.771	0.768
<i>Hansen test of overid. Restrictions</i>	0.227	0.286	0.212	0.127	0.271	0.278	0.332	0.140
<i>Hansen test excluding group for levels</i>	0.605	0.513	0.476	0.367	0.501	0.651	0.428	0.316
<i>Difference in Hansen test for levels</i>	0.183	0.243	0.180	0.113	0.232	0.224	0.300	0.132

4. Main result

Firms with highest climate risk (above 75%) [regulatory disclosure] have a significant lower distance to default as compared to firms with lowest climate risk (bottom 25%).

Quantile Dummy Indicators on Climate Risk Factors (Baseline = bottom 25%)	25% - 50%	50% - 75%	Above 75%
Carbon emissions			
Estimated carbon intensity	-1.016 (0.768)	-1.146 (1.064)	-2.952* (1.565)
Total carbon intensity	-1.000 (0.892)	-1.121 (1.158)	-2.522** (1.223)
Scope 1 intensity	-1.237 (1.069)	-0.901 (1.268)	-2.262 (1.569)
Scope 2 intensity	0.144 (0.841)	-0.326 (1.093)	-1.170 (1.278)
Climate risk disclosure			
Climate-related keywords	-0.916 (0.809)	-1.232 (1.024)	-3.189** (1.378)
Physical risk keywords	-1.697** (0.840)	-0.406 (0.870)	-1.457 (1.056)
Regulatory risk keywords	-1.350 (0.869)	-2.653* (1.365)	-4.289*** (1.505)
Non-specific risk keywords	-1.438 (0.919)	-2.822** (1.252)	-2.357* (1.386)

4. Main result

The climate distress risk effect is stronger in states with carbon pricing initiatives.

Model	GMM	GMM	GMM	GMM
RGGI states dummy	1.300*** (0.467)	1.195** (0.462)	1.264*** (0.458)	1.193** (0.473)
Climate risk disclosure				
Climate-related keywords	-0.009* (0.005)			
Physical risk keywords		-0.013 (0.019)		
Regulatory risk keywords			-0.014* (0.007)	
Non-specific risk keywords				-0.050 (0.057)
Climate risk disclosure				
Climate-related keywords x RGGI states dummy	-0.010 (0.006)			
Physical risk keywords x RGGI states dummy		-0.029 (0.027)		
Regulatory risk keywords x RGGI states dummy			-0.016** (0.008)	
Non-specific risk keywords x RGGI states dummy				-0.061 (0.081)

5. Conclusion & Implications

Conclusions

- Climate risk has a negative impact on S&P500 firms' distance to default.
 - This impact is limited to transition risk and the disclosures of this risk in annual filings (i.e forward looking measures).
 - Meanwhile, carbon footprint or disclosure of physical risk do not have a similar effect in the U.S. context
- The Paris Agreement temporarily strengthens the negative relationship between climate risk and distance to default in the year 2015.
 - However, the effect is short-lived and disappears in later years
- The climate distress risk effect is stronger:
 - Among firms with highest climate risk (top 25%)
 - Among firms with headquarter in states with stricter carbon price regulations

Implications

- Climate distress risks should be reflected in credit risk models
- The reflection of climate distress risk should move beyond traditional/backward carbon footprint proxies