Climate Change Salience and International Equity Returns

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Shunned, Regulated
Dora Xia & Omar Zulaica


HANNIBAL
WATER WORKS
Physical Risk

Productivity Losses

Ivan Rudik, Gary Lyn, Weiliang Tan, & Ariel Ortiz-Bobea, 2022


CREDIT SUISSE
HANDS OFF
Financial firms carry debtors' exposure
BIS; NGFS; Choi, Gao, Jiang, & Zhang


Infrastructure Reliance (Bohn 2022: commercial downtime)

Demand Effects (ECB)

Deryugina and Hsiang (2014); & Dell, Jones, and Olken (2012)


Transition Winners (e.g.: sequestration)

The Point

The range of potential avenues of exposure is broad.

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This paper:

Explore the pricing of climate change risk–broadly construed–in equity markets.

Specifically,

1. **Construct a broad indicator of climate change salience...**

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1. **Construct a broad indicator of climate change salience, then:**

2. **Are equities exposed to a climate change salience risk?**
3. **Is the risk priced internationally?**
4. **Is the exposure widespread?**

Preview Results

1. **Construct a broad indicator of climate change salience, then:**

2. **Are equities exposed to a climate change salience risk?** (Yes)
3. **Is the risk priced internationally?** (Yes)
4. **Is the exposure widespread?** (Yes)

Literature: Building Blocks

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- **Theory**

  Physical risks and transition risks: Giglio, Kelly, and Stroebel (2020), and Giglio, Maggiori, Rao, Stroebel, and Weber (2021)

- **Carbon Risk**
  - International Equity Carbon Exposure: Bolton and Kacperczyk (2021)
  - Carbon Pricing: Gorgen, Jacob, Nerlinger, Riordan, Rohleder, and Wilkens (2020)
  - Empirical Critique: Aswani, Raghunandan, and Rajgopal (2022)
  - Preference v. Fundamental: Xia and Zulaica (2022)
  - Valuation: Choi, Gao, Jiang, and Zhang (2022)

- **Climate Risk**

  Hedging: Engle, Giglio, Kelly, Lee, and Stroebel (2020)
  - textual analysis of the *Wall Street Journal*
  - sentiment-guided textual analysis with more sources.

  U.S. Bonds: Huynh and Xia (2021)

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1. Construct Climate Change Salience Indicator: κ_t

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- Google Trends' worldwide searches of 'climate change'
  - U.S. investor perspective
  - Monthly observations, scaled relative to searches & sample
  - Construct innovations: $ARIMA(111)(011)_{12}$ à la U.S. Census Bureau (2020) & Dagum and Bianconcini (2016)
- Avoids editorial artifact
- Correlated with 'Negative Sentiment' (Crimson Hexagon)
- Related Search Work
  - Temperature & abnormal returns: Choi, Gao, and Jiang (2020)
  - ESG Flows: Brogger and Kronies (2021)
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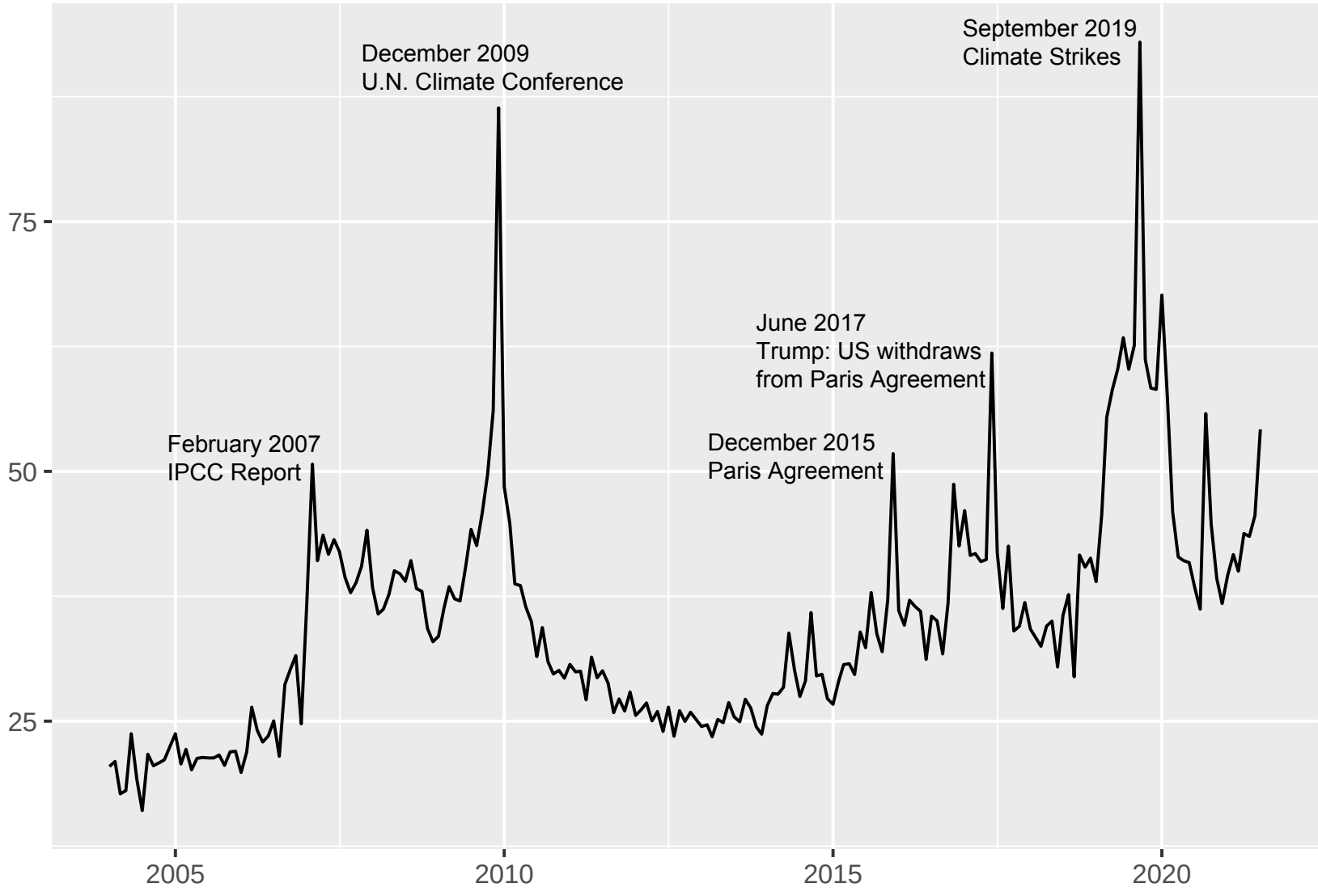
1. Climate Change Salience: κ_t



2. Estimate Firm Exposure to Climate Change Salience, κ

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60-month rolling regressions

Allows each firm's exposure to change slowly over time

$$r_{i,t} = \alpha_i + \beta_i^{\kappa} \kappa_t + \mathbf{f}_t' \beta_i^{f} + \eta_{i,t}$$

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60-month rolling regressions

$$r_{i,t} = \alpha_i + \beta_i^{\kappa} \kappa_t + \mathbf{f}_t' \beta_i^{f} + \eta_{i,t}$$

$$\rightarrow$$

144 rolling estimates of β_i^{κ} for each firm

Now: 3. Does the exposure matter to investors?

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Out-of-Sample Estimate of:

$$r_{i,t} = \alpha + \gamma^{\beta^{\kappa}} \hat{\beta}^{\kappa}_{i,t-1} + ... + \varepsilon_{i,t},$$

Now: 3. Does the exposure matter to investors?

Out-of-Sample Estimate of:

$$r_{i,t} = \alpha + \gamma^{\beta^{\kappa}} \hat{\beta}^{\kappa}_{i,t-1} + ... + \varepsilon_{i,t},$$

$$\gamma^{\beta^{\kappa}} < 0?$$

Now: 3. Does the exposure, β_i^{κ}, matter to investors?

Specifically, out-of-sample estimate of:

$$r_{i,t} = \alpha + \gamma^{\beta^{\kappa}} \hat{\beta}_{i,t-1}^{\kappa} + g_{i,t-1}'\gamma^{g} + h_{i,t-1}'\gamma^{h} + \hat{\beta}_{i,t-1}^{\kappa} h_{i,t-1}'\gamma^{h\beta} + \varepsilon_{i,t},$$

$\hat{\beta}_{i,t-1}^{\kappa}$, prior 5-year exposure
$g_{i,t-1}$, past variables a là Fama-French
$h_{i,t-1}$, variables to interact with $\beta_{i,t-1}^{\kappa}$

Now: 3. Does the exposure matter to investors?

Out-of-Sample Panel Estimate:

$$r_{i,t} = \alpha + \gamma^{\beta^{\kappa}} \hat{\beta}^{\kappa}_{i,t-1} + g'_{i,t-1}\gamma^{g} + h'_{i,t-1}\gamma^{h} + \hat{\beta}^{\kappa}_{i,t-1} h'_{i,t-1}\gamma^{h\beta} + \varepsilon_{i,t},$$

Panel follows Petersen (2009) to account for correlated errors.

3. Out of Sample Estimates – Baseline Regression

Variable	(1)	(2)
$\gamma^{\beta^{\kappa}}$	-0.0186	-0.0218
	(0.0008)	(0.0009)
$\gamma^{\beta^{R_m}}$	0.4834	0.6341
	(0.0414)	(0.0465)
$\gamma^{\beta^{smb}}$	0.0004	0.0133
	(0.0291)	(0.0346)
$\gamma^{\beta^{hml}}$	0.1371	0.2155
	(0.0279)	(0.0326)
Firm Effects	no	yes
Country Effects	yes	yes

A firm with a median value of β_κ has an annual return that is two percent greater than one at the 75^{th} percentile.

3. Out of Sample Estimates – Nonlinearity

Variable	(3)	(4)	(5)
$\gamma^{\beta^{\kappa}}$	0.0149	0.0181	0.0277
	(0.0034)	(0.0036)	(0.0062)
$\gamma^{\kappa:\beta^{\kappa}}$	-0.0967	-0.1161	-0.0993
	(0.0095)	(0.0100)	(0.0096)
γ^{κ}	-1.5382	-0.15434	-1.5828
	(0.0817)	(0.0845)	(0.0823
$\gamma^{\beta^{Rm}}$	0.3684	0.5056	0.3543
	(0.0426)	(0.0482)	(0.0425)
$\gamma^{\beta^{smb}}$	0.0552	0.0833	0.0559
	(0.0296)	(0.0355)	(0.0298)
$\gamma^{\beta^{hml}}$	0.0598	0.1270	0.0700
	(0.0290)	(0.0340)	(0.0289)

At the median κ, a firm with a median β^{κ} earns an annual return again about 1.9 percent greater than a firm with a β^{κ} at the 75^{th} percentile.

4. Accounting for β^{κ}

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$$\hat{\beta}^{\kappa}_{i,t} = \gamma_0 + m'_{i,t}\gamma^m + \gamma_{fin} d_{fin} + c'_{i,t}\gamma^c + \epsilon_{i,t},$$

$m'_{i,t}$, vector of reported emissions
d_{fin}, financial firm indicator
$c'_{i,t}$, firm-specific characteristics

Variable	(1)	(2)	(3)	(4)
ln scope 1	-0.2514	0.1298	0.0819	.
	(0.1971)	(0.1807)	(0.1792)	.
ln scope 2	0.0015	0.1734	0.1909	.
	(0.2250)	(0.2337)	(0.2382)	.
ln scope 3	0.0498	0.1829	0.1798	.
	(0.1084)	(0.1047)	(0.1051)	.
$ln\frac{scope1}{sales}$	.	.	.	0.1229
	.	.	.	(0.1780)
$ln\frac{scope2}{sales}$	.	.	.	0.3313
	.	.	.	(0.2377)
$ln\frac{scope3}{sales}$	.	.	.	0.1901
	.	.	.	(0.1053)
ln ppe	0.3424	-0.0080	-0.0376	-0.4479
	(0.2519)	(0.2604)	(0.2651)	(0.2699)
d_{fin}	-2.1879	0.4352	-0.0520	-0.4247
	(0.9504)	(0.8912)	(0.8809)	(0.8636)
ln size	3.1429	2.6844	2.7888	1.9627
	(0.4874)	(0.4817)	(0.4924)	(0.4430)
ln $\frac{b}{m}$	2.3874	1.7250	1.6922	1.4391
	(0.4090)	(0.3737)	(0.3763)	(0.3736)
ln sales	-0.7039	-2.6843	-2.6482	.
	(0.4867)	(0.4662)	(0.4688)	.

- Climate change salience risk is unrelated to emissions.
- Small firms and growth firms exhibit more climate change salience risk.
- Additional sales conditionally indicate greater risk.

4. Accounting for β^{κ}

- Emission result is consistent with: Aswani, Raghunandan, and Rajgopal (2022)
- Overall, suggests the ubiquity of climate change risk

4. More accounting for β^{κ}

Variable	(5)
ln scope 1	0.1829
	(0.2059)
ln scope 2	0.1453
	(0.2484)
ln scope 3	0.2140
	(0.1178)
.	.
.	.
.	.
Country Characteristics	
emissions per capita	-0.4402
	(0.4082)
climate risk index	1.0277
	(0.3998)
GDP per capita	-1.7630
	(0.7195)
climate change policy score	-0.4717
	(0.3584)
political stability index	-0.3010
	(0.6888)
non-renewable energy use	0.1765
	(0.6473)
oil producer	1.7250
	(1.2092)
emerging market	0.4179
	(1.0491)

Conclusions

Investors accept a lower return in order to hedge against a broad indicator of climate-change related risk.

- A discount for low climate salience risk exists.
- The discount is magnified when climate change salience is high.

Climate change salience risk is widespread: it extends beyond narrowly defined stranded assets or high-emitting firms.

- Exposure arises among among firms with all levels of emissions.
- Small firms, growth firms, and firms in countries with (so far) low weather related losses remain relatively unhedged against climate change salience risk.

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