

A Market-based Approach to Climate Stress Testing

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Climate Stress Testing Challenges

1. Analyses based on past climate events may not effectively capture the change in the perception of risk.
 - ▶ Our methodology is [market-based](#), allowing us to fully incorporate changes in the market's expectations.
2. Climate risk itself changes over time, and how firms, banks, and markets respond to the perceived risk also changes over time.
 - ▶ We estimate a [dynamic model](#), allowing variations over time.
3. Data gaps and timeliness
 - ▶ Our methodology only requires [publicly available information](#).
 - ▶ We estimate our model on a [daily basis](#), allowing for a timely response to rapidly changing climate risk.

- ▶ Jung, Engle, and Berner (2021) provides a [market-based approach](#) to assess the resilience of financial institutions to climate risk.
- ▶ The methodology involves three steps:
 1. Measure the climate risk factor.
 2. Estimate time-varying climate beta of banks.
 - ▶ Dynamic Conditional Beta (DCB) model
 3. Compute systemic climate risk (CRISK).
 - ▶ CRISK: Expected capital shortfall of banks in a climate stress scenario
- ▶ Use the CRISK measure to study the climate-related risk exposure of large global banks

Step 1: Climate Transition Risk Factor

We use transition risk factors designed to decrease in value as transition risk escalates.

- ▶ Stranded Asset Factor (Litterman):
 - ▶ $0.3 \cdot \text{Energy ETF} + 0.7 \cdot \text{Coal ETF} - \text{S\&P 500 ETF}$
 - ▶ *“A large proportion of existing fossil fuel reserves should remain unused to meet global temperature targets under the Paris Agreement.”*
(McGlade and Ekins, Nature 2015)
- ▶ Emission Factor: Emission-weighted average industry return
- ▶ Brown minus Green Factor: Emission Factor - Clean Energy ETF
- ▶ Climate efficient factor mimicking portfolio

Transition Risk Factor Responses around Events

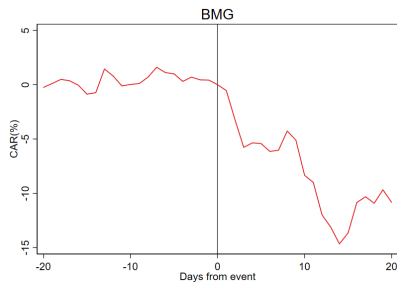


Figure: Paris Agreement

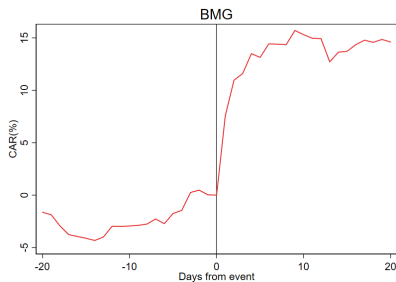


Figure: Trump Election

Step 2: Time-varying climate beta

Estimate each bank i 's $\beta_{it}^{Climate}$

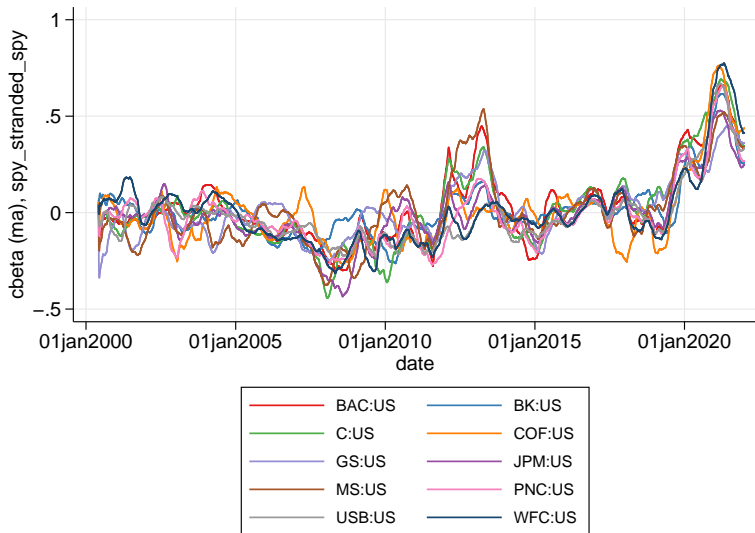
- ▶ Bank's stock return sensitivity to the climate factor
- ▶ Dynamic Conditional Beta Model²

$$r_{it} = \beta_{it}^{Mkt} MKT_t + \beta_{it}^{Climate} CF_t + \varepsilon_{it}$$

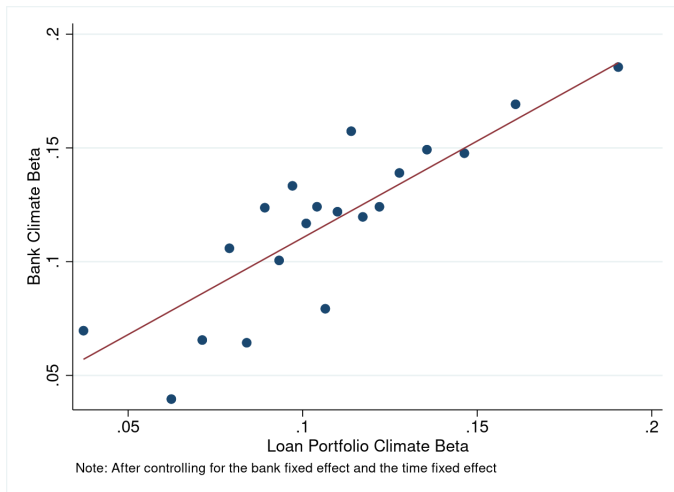
- ▶ Allows volatility and correlation to be time-varying.
- ▶ Expect:
 - ▶ $\beta^{Climate} > 0$ for banks with large exposure to brown loans

²Engle(2002), Engle(2009), Engle(2016)

Time-varying climate beta of U.S. Banks



Loan Portfolio Climate Beta: U.S. Banks



- Based on Y-14 data, 21 listed U.S. banks, 2012:Q2 - 2021:Q4
- Bank climate beta reflects bank's loan portfolio exposure to climate risk.

Step 3: CRISK

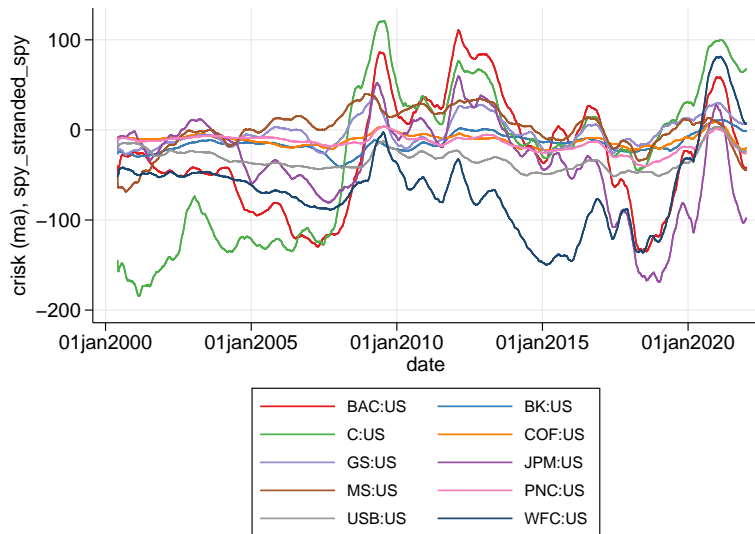
Follow the SRISK methodology³

$$\begin{aligned} CRISK_{it} &= E_t[\text{Capital Shortfall}_i \mid \text{Climate Stress}] \\ &= E_t[k(D_{it} + W_{it}) - W_{it} \mid \text{Climate Stress}] \\ &= kD_{it} - (1 - k) \underbrace{(1 - LRMES_{it})}_{=\exp(\beta_{it}^{Climate} \log(1-\theta))} W_{it} \end{aligned}$$

- ▶ D : Book value of debt
- ▶ W : Market capitalization
- ▶ LRMES: Expected equity loss conditional on the climate stress
- ▶ Prudential level of equity relative to assets $k = 0.08$ ($k = 0.055$ for Europe)
- ▶ Climate stress level $\theta = 0.5$
 - ▶ 1% quantile of 6 month return on the stranded asset portfolio

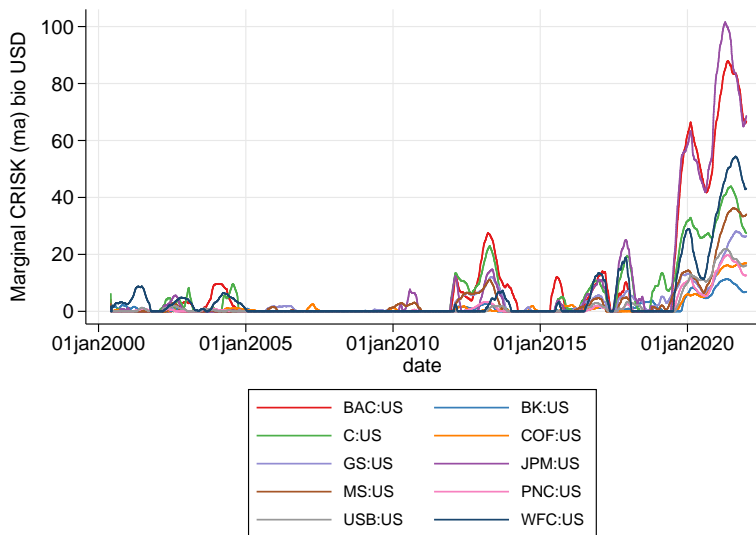
³Acharya et al (2011, 2012), Brownlees and Engle (2017)

CRISK of U.S. Banks



Marginal CRISK: U.S. Banks

$$(1 - k) \cdot EQUITY \cdot LRMES$$



Conclusion

- ▶ We introduce a measure called CRISK, systemic climate risk, which is the expected capital shortfall of a financial institution in a climate stress scenario.
- ▶ The climate beta and CRISK substantially increased during 2020.
- ▶ The increase in CRISK during 2020 was mainly due to decrease in equity values of banks and increase in climate betas.
- ▶ CRISK is considerably higher than expected capital shortfall of banks under *zero* climate stress scenario.
- ▶ Bank climate beta reflects bank's loan portfolio exposure to climate risk.

Thank you!

You might also be interested in:

- ▶ Measuring the Climate Risk Exposure of Insurers
- ▶ U.S. Banks' Exposures to Climate Transition Risks
- ▶ Review Article: Climate Stress Testing