Climate Change and Bank Lending: Evidence from Physical and Transition Risks

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Motivation

- Climate risks in the banking sector have been an increasing concern for financial regulators
- Banks are indirectly exposed to two types of climate risks via lending to firms:
  1. **Physical risks**: damages to firms due to increasingly extreme climate events
  2. **Transition risks**: the implementation of climate policies aimed at emission-intensive firms

This Study in a Nutshell

Research question:

- How does firms' exposure to physical and transition risks affect banks' credit allocation?
  1. What happens to lending for non-listed firms, which are typically SMEs?
  2. Do banks provide credit to risky firms engaging in reducing emissions, or "greening" firms?
  3. What are the individual effects of each type of risk, and how do these risks interact?

Data:

- Granular measures for both climate risks and bank-firm matched Danish register data from 2004 to 2019 are utilized

Methodology:

- Saturated fixed effect models in the spirit of Khwaja and Mian (2008), and Jiménez et al. (2012)

Key results:

- Lower credit growth to firms exposed to higher physical and transition risks
- More credit to risky firms with "greening" efforts and to firms with lower interacted risks
- Large heterogeneity on the firm and bank side
- The mechanism indicates that credit supply plays a relatively more important role due to credit risk

Contributions

- Provide evidence based on a more representative sample of firms, including non-listed firms
- Examine the impact of both types of climate risks and interactions based on novel, granular risk measures
- Focus on banks' quantity adjustment and investigate credit allocation to risky and "greening" firms

Danish Administration Data

- **Employer-Employee Matched Data**: firm and worker registers; provides the universe of firm and worker level information
- **Bank-Firm Matched Data**: credit register; account-level data for the universe of corporate bank loan; link with employer-employer matched data
- Final sample: 19,904 firms, 106 banks, and 16 years

Transition Risks Exposure

- Certain firms and industries with higher emission intensity face greater transition risks due to exposure to more stringent climate-related policy

$$\textit{Transition risks indicator}_{ijt} = \textit{Energy intensity}_{ijt} \times \textit{Environmental tax}_{jt}$$

, where

$$\textit{Energy intensity}_{ijt} = \frac{\textit{Energy consumption}_{ijt}}{\textit{Value added}_{ijt}}; \quad \textit{Environmental tax}_{jt} = \frac{\textit{Total environmental tax}_{jt}}{\textit{Value added}_{jt}}$$

for firm i, industry j, year t

Physical Risks Exposure

Construction of physical risks indicator

- Combine exposure to extreme precipitation frequency ($freq_{ct}$) and flood risks (fl_r)
- Allow for incorporating geographic spillover effects

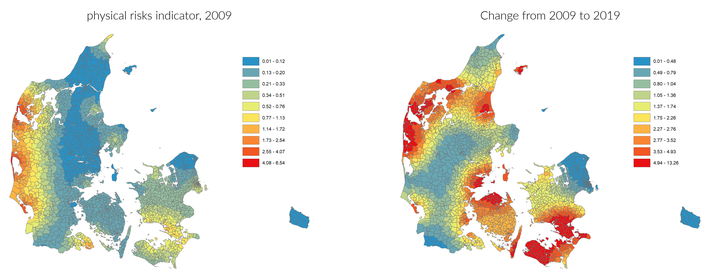
$$\textit{Physical risks indicator}_{p,t} = \sum_{r}^{R} I_{r,t} e^{-\delta x_{p,r}}$$

$$where\ I_{r,t} = fl_r \times freq_{ct}$$

for climate station c, parish p, year t, surrounding parish r

- $\textit{Physical risks indicator}_{p,t}$: physical risks exposure for parish p at year t.
- $I_{r,t}$: interaction between extreme precipitation ($freq_{ct}$) and flood risks (fl_r)
- $e^{-\delta x_{p,r}}$: weighting function that depends on
  - $x_{p,r}$: distance between parish p and r
  - δ: decay parameter (0,1), how far-reach the events can extend

Spatial and Time Variations of Physical Risks Exposure



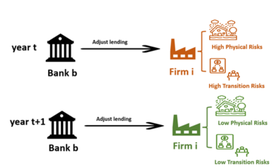
Empirical Specification and Identification

- Start with a simple model, gradually saturate with a complete set of fixed effects including location (parish) $\boldsymbol{\alpha_p}$, industry-year $\boldsymbol{\alpha_{jt}}$, bank-year $\boldsymbol{\alpha_{bt}}$, and firm-bank $\boldsymbol{\alpha_{ib}}$ fixed effects:

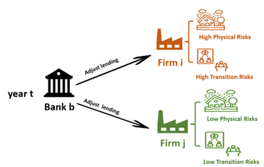
$$\textit{Credit Outcome}_{ibt} = \boldsymbol{\beta_1}\textit{Physical risks}_{pt-1} + \boldsymbol{\beta_2}\textit{Transition risks}_{it-1} + \boldsymbol{X'_{it-1}\gamma_1} + \boldsymbol{\alpha_p} + \boldsymbol{\alpha_{jt}} + \boldsymbol{\alpha_{bt}} + \boldsymbol{\alpha_{ib}} + \boldsymbol{\epsilon_{ibt}}$$

for firm i, bank b, year t, industry j, and parish p

- Identification including firm-bank fixed effects relies on exploiting credit evolution within the same firm-bank pair, in response to the change in climate risks over time



With firm-bank fixed effects



Without firm-bank fixed effects

Do Banks Adjust Credit Allocation? Baseline Results on Loan Growth

	Loan Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Physical Risks	-1.368***	-1.483***	-1.274***	-1.276***	-1.283***	-1.143**
	(0.489)	(0.490)	(0.491)	(0.491)	(0.489)	(0.540)
Transition Risks	-2.208***	-2.203***	-2.100***	-2.146***	-1.783***	-1.632***
	(0.598)	(0.574)	(0.547)	(0.562)	(0.441)	(0.427)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	
Year Fixed Effects	Yes	Yes	Yes	Yes		
Bank Fixed Effects	Yes	Yes	Yes	Yes		
Parish Fixed Effects			Yes	Yes	Yes	Yes
2-digit Industry Fixed Effects				Yes		
2-digit Industry-Year Fixed Effects					Yes	Yes
Bank-Year Fixed Effects					Yes	Yes
Bank-Firm Fixed Effects						Yes
Firm Variables		Yes	Yes	Yes	Yes	Yes
Bank Variables		Yes	Yes	Yes		
R-sq	0.086	0.087	0.097	0.097	0.123	0.190
N	189,200	189,142	187,764	187,760	187,700	179,374

- Credit outcome (intensive margin): $Loan\ Growth_{ibt} = \frac{(loan_{ibt} - loan_{ibt-1})}{(0.5 \times loan_{ibt} + 0.5 \times loan_{ibt-1})} \times 100\%$
- 1 sd ↑ in physical risks → 1.1%-1.4% ↓ in loan growth (8%-10% deviation from the mean)
- 1 sd ↑ in transition risks → 1.6%-2.2% ↓ in loan growth (11%-16% deviation from the mean)

Further Results: The Role of "Greening" Firms and the Interactions of Risks

Do banks allocate more credit to risky and "greening" firms?

- Includes an interaction of climate risks variables with proxies for "greening" firms, i.e., reduction in energy intensity, apply for a green patent
- Positive coefficients in the interaction terms suggest banks also consider firms' engagement in risk adaptation or mitigation as a positive signal

What is the role of interactions of physical and transition risks?

$$\textit{Credit Outcome}_{ibt} = \boldsymbol{\beta_1}\ \textit{Low PR}_{it-1} \times \textit{Low TR}_{it-1} + \boldsymbol{\beta_2}\ \textit{High PR}_{it-1} \times \textit{Low TR}_{it-1} + \boldsymbol{\beta_3}\ \textit{Low PR}_{it-1} \times \textit{High TR}_{it-1} + \boldsymbol{\beta_4}\ \textit{High PR}_{it-1} \times \textit{High TR}_{it-1} + \boldsymbol{X'_{it-1}\gamma_1} + \boldsymbol{Z'_{bt-1}\gamma_2} + FEs + \boldsymbol{\epsilon_{ibt}}$$

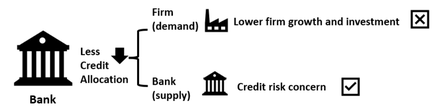
for firm i, bank b, year t

- Positive coefficient for $\boldsymbol{\beta_1}$ suggests more credit reallocation to firms with low interacted (compounded) risks, relative to medium risks groups

Heterogeneity analysis:

- At the firm level, the effects are more pronounced for constrained firms (small, highly leveraged)
- At the bank level, the effects are concentrated within highly exposed banks with repeat lending relationships

Mechanism: Supply vs Demand, Which Side is More Important?



- No evidence that climate risks are linked to lower firm growth (investment growth, employment growth fixed asset growth, and sales growth)
- Evidence suggests that higher climate risks are associated with increased credit risk, as measured by various firm-level financial stress (low EBIT, high ICR) and survival proxies (exit)