Financial Vulnerability from Climate Shocks: Peruvian Evidence

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Motivation

- Climate shocks are a growing source of financial risk:
  - direct: output/asset losses; indirect: propagation through credit and deposits.
- In emerging economies, thinner insurance and tighter credit make financial intermediation a key amplifier.
- **This paper.** Using Peruvian micro-data (weather $\times$ bank-branch), we ask how anomalous weather reshapes *credit and deposit markets*, and how these micro effects *aggregate*.

  Three questions:
  1. How do temperature/precipitation anomalies dynamically affect credit and deposits? Do banks and non-banks differ?
  2. Through which physical-damage channels are the shocks transmitted?
  3. What is the aggregate effect of weather-related financial risk on the credit market and macro variables?

Main Results

Roadmap: Data $\rightarrow$ Identifying variation $\rightarrow$ Micro LP (Q1) $\rightarrow$ Aggregation & VAR (Q3)

Main Results

- Financial institutions cannot fully absorb weather shocks $\rightarrow$ credit and deposits decline persistently.
- Damages (collateral) are the transmission channel.
- In aggregate, a credit tightening with short-lived macro effects.

Literature Review: Financial Vulnerability from Climate Shocks

Climate Shocks and Macroeconomic Outcomes

- Temperature rise has mixed effects: positive in cold countries, negative in warm ones [Acevedo et al. (2020); Bandt et al. (2021)]. Negative effects are stronger in developing economies [Bandt et al. (2021)].
- Higher temperatures depress growth, agriculture, industry, and political stability in developing economies [Dell et al. (2012)].
- Rising temperatures raise inflation via food prices; effects are stronger in emerging economies [Faccia et al. (2021)].

Natural Disasters, Banks, and Credit Spreads

- Natural disasters raise deposit rates in U.S. banks; spatial spillovers dominate direct effects [Barth et al. (2024)].
- Tropical storms reduce deposits and credit in Caribbean banks [Brei et al. (2019)].
- After disasters, deposits fall; foreign banking claims mitigate funding needs (East Asia). No contemporaneous default-risk effect [Nguyen et al. (2024)].
- Climate change has an inverted U-shaped effect on rural credit risk [Wang et al. (2024)].
- Higher climate risk increases corporate credit spreads [Ho et al. (2024)].

Data

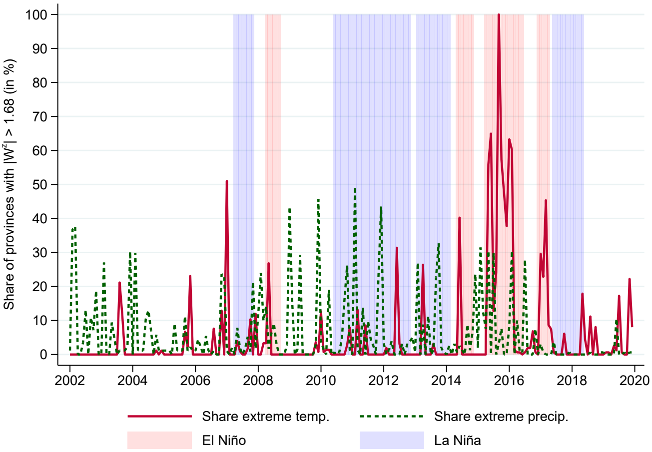
- **Climate** — CRU TS v4.03 (0.5° grid) (Harris et al., 2020)
  - Data: temperature and precipitation data area-weighted to 189 provinces, 1901m1–2023m12.
  - Shocks = month-of-year province z-scores over a rolling 30-yr window, for weather variable W in province i in month t :

$$W^{z}_{i,t} = \frac{W_{i,t} - W^{\text{avg}}_{i,m(t)}}{\sigma^{W}_{i,m(t)}}, \qquad W \in \{\mathcal{T}, \mathcal{P}\}.$$

  CRU is station-based: estimates most reliable for **coastal and Andean** provinces.

- **Financial** — SBS bank/non-bank branch-level credit & deposits, aggregated to financial institution–province, 2002m1–2019m12.
- **Damages** — INDECI emergencies by type (roads, housing, education, hectares, water, drainage, irrigation).
- **Macro** — ToT, GDP, CPI, credit, interbank rate, M1, lending rate, exchange rate; controls incl. ENSO.
- **Sample ends 2019m12** — deliberately, to avoid COVID-era liquidity programs that distort credit/deposit dynamics.

Identifying variation: weather anomalies are pervasive



Share of provinces with $|W^z_{i,t}| > 1.68$. Red/blue bands: El Niño / La Niña (ENFEN, moderate+).

- Peaks around ENSO (2016–17 Coastal El Niño), but sizeable variation outside ENSO windows.
- $\Rightarrow$ identification does not rely only on major climatic events.

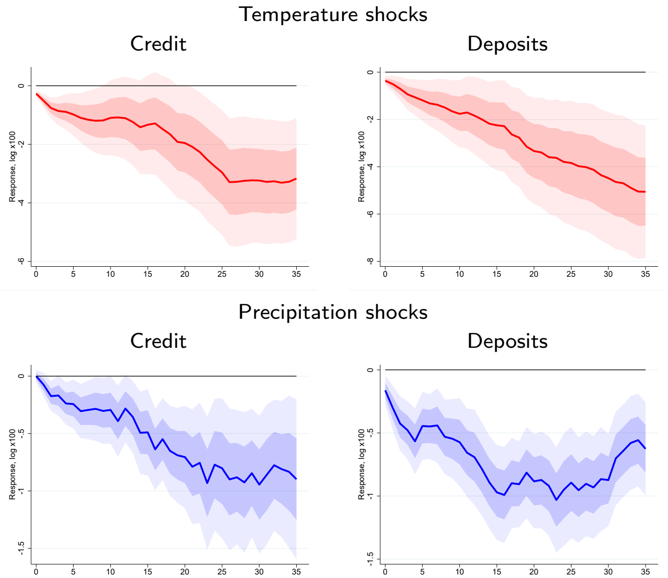
Empirical strategy: micro local projections

Local projection for $h = 0, 1, \ldots, H$:

$$y_{bp,t+h} - y_{bp,t-1} = \alpha_{bp,h} + \beta_h^{\mathcal{T}}\, \mathcal{T}_{p,t} + \beta_h^{\mathcal{P}}\, \mathcal{P}_{p,t} + \sum_{k=1}^{K} \gamma_k^h X_{j,t-k} + u_{bp,t}^h.$$

- $y_{bp,t+h}$: log credit or deposits of bank b, province p.
- $\mathcal{T}_{p,t}$ and $\mathcal{P}_{p,t}$: the temperature and precipitation anomalies.
- Objects of interest: $\beta_h^{\mathcal{T}}$, $\beta_h^{\mathcal{P}}$ — sensitivity of finance to weather anomalies.
- X: exchange rate, interest rate, liquidity, inflation, activity, ENSO.

Q1: Credit and deposits decline persistently, but $\mathcal{T}$ shocks more pervasive

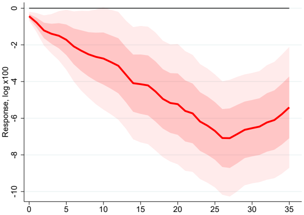


Micro IRF to a 1 SD shock.

Q1: Banks vs non-banks — $\mathcal{T}$ shocks

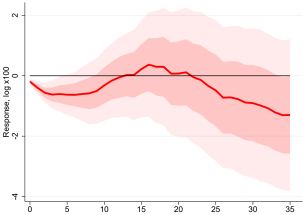
Banks

Credit

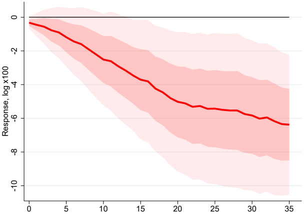


Non Banks

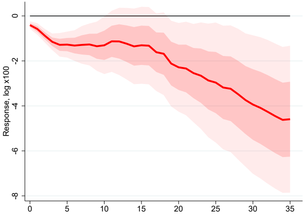
Credit



Deposits

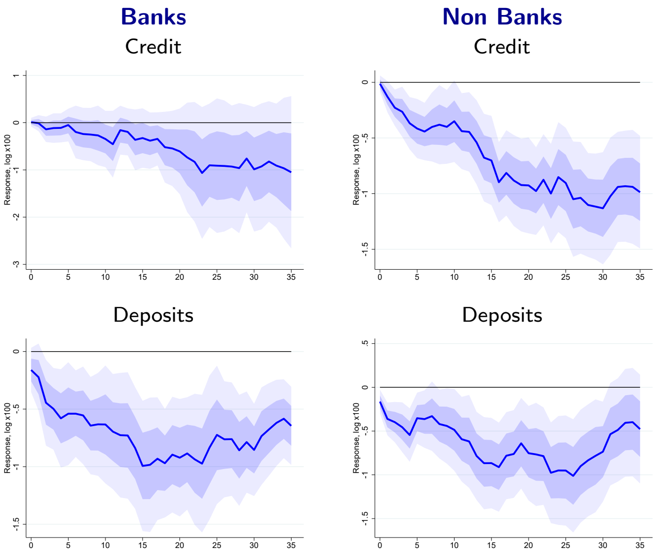


Deposits



Temperature shocks (credit top, deposits bottom). Banks more exposed than Non-banks

Q1: Banks vs non-banks — $\mathcal{P}$ shocks



Temperature shocks (credit top, deposits bottom). Non-banks — geographically concentrated, microcredit-focused — transmit shocks more strongly.

Q2: Unveiling the Transmission Mechanism with Damage Data

To assess the impact of the damages, due to the natural disaster, on credit activity and non-performing loan ratio, we propose the following linear model:

$$Y_{rt} \quad = \quad \alpha_r + \beta_0 Y_{rt-1} + \beta_1 X_{rt} + \epsilon_{rt},$$

X_{rt}	(1) Individual	(2) Housing	(3) Education	(4) Road	(5) Hectare	(6) Water	(7) Drainage	(8) Irrigation
X = Natural Event: Heavy Rain; Y = Credit Growth								
$CREG_{rt-1}$	0.124***	0.124***	0.126***	0.123***	0.124***	0.125***	0.126***	0.125***
D^X_{rt}	-0.221***	-0.198***	-0.112	-0.258***	-0.251***	-0.221**	-0.161*	-0.208***
Observations	4,513	4,513	4,513	4,513	4,513	4,513	4,513	4,513
X=Natural Event: Heavy Rain; Y = Deposit Growth								
$DEPG_{rt-1}$	-0.107***	-0.107***	-0.108***	-0.106***	-0.108***	-0.108***	-0.108***	-0.109***
D^X_{rt}	-0.301***	-0.307***	-0.699***	-0.392**	-0.554***	-0.722***	-0.734***	-0.837***
Observations	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538
X= Natural Event: Heavy Rain - Y = Non-performing loan ratio								
NPL_{rt-1}	0.967***	0.967***	0.966***	0.967***	0.966***	0.966***	0.966***	0.966***
D^X_{rt}	0.0475***	0.0470***	0.0644***	0.0614***	0.0435***	0.0513***	0.0477***	0.0615***
Observations	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. All regressions include region fixed effects and month fixed effects. Clustered (at region level) standard error.

Table: Regression Results - Non-performing loan ratio

	(1) Individual	(2) Housing	(3) Education	(4) Road	(5) Hectare	(6) Water	(7) Drainage	(8) Irrigation
A. Natural Event: Low Temperature								
NPL_{rt-1}	0.954***	0.958***	0.907***	0.949***	0.944***	0.927***	0.991***	0.952***
X_{rt}	-0.00321	0.00902	0.00901	0.00131	0.00605	0.00530	0.0118	-0.000233
Observations	959	434	118	182	351	66	33	112
NPL_{rt-1}	0.966***	0.966***	0.966***	0.966***	0.966***	0.966***	0.966***	0.966***
D^X_{rt}	0.0276**	0.0134	0.0138	0.0418**	0.00136	0.0584**	0.0843***	0.0352*
Observations	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450
B. Natural Event: Heavy Rain								
NPL_{rt-1}	0.967***	0.967***	0.977***	0.969***	0.945***	0.945***	0.920***	0.951***
X_{rt}	0.0112***	0.00963***	0.00558	-0.00206	-0.00204	0.00331	0.0118*	-0.000243
Observations	1,446	1,384	418	700	354	311	224	414
NPL_{rt-1}	0.967***	0.967***	0.966***	0.967***	0.966***	0.966***	0.966***	0.966***
D^X_{rt}	0.0475***	0.0470***	0.0644***	0.0614***	0.0435***	0.0513***	0.0477***	0.0615***
Observations	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%.
They includes region fixed effects. Clustered (at region level) standard error.

Aggregation: Weather-financial Losses Shock

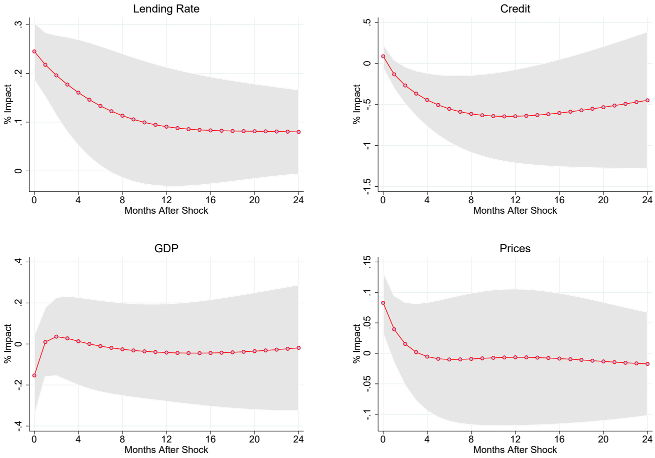
- We define an aggregate **Weather-Financial Losses**, WFL_t at time t :

$$WFL_t = \sum_h \sum_p \left(\beta_h^{\mathcal{T}}\, \mathcal{T}_{p,t-h} + \beta_h^{\mathcal{P}}\, \mathcal{P}_{p,t-h}\right) \times \omega_{p,t}$$

- $\omega_{p,t}$: province weight; keep only significant weather$\rightarrow$credit contributions.

- Then feed WFL_t into a recursive VAR $\rightarrow$ financial and macro responses.

Q3: A WFL shock tightens credit; macro effects short-lived



Lending rate $+\approx$10 bps (persistent); credit -0.5% at 24m; GDP/CPI short-lived. 2003m5–2019m12.

Takeaways

- Financial institutions struggle to absorb temperature and precipitation shocks: credit and deposits fall persistently; non-banks more exposed.
- Physical damages (roads, housing, crops, sanitation, irrigation) are a measurable transmission channel, raising NPLs.
- In aggregate, weather-financial risk delivers a credit tightening (higher rates, lower credit) with limited, short-lived macro effects.

Thank you!

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