Applicazioni degli scenari climatici in Banca d'Italia

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- Micro-simulation approach for assessing transition risk
- Extensions of micro-simulation approach

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- Costal flood and impact on banks' mortgage portfolio
- Methodologies for assessing the exposure of IT NFCs to flood risk

1

Overview of climate risk stress test analysis

Micro-simulation approach for assessing transition risk (1)

- Assess the impact of a one-off carbon tax on HHs' and NFCs' financial vulnerability using a micro-founded approach, i.e. an alternative to standard macro-based climate stress tests
- Account for heterogeneity across households and firms
- Capture their differential exposure and response to climate shocks

Faiella, Lavecchia, Michelangeli and Mistretta (2022)

Multi-step approach

1. Simulate different carbon taxes (based on the NGFS scenarios) and translate them into energy prices

Carbon Tax Scenarios (real €2015 per ton CO_2)

Value	Reference / Justification	Policy Relevance
€50	≈ EU-ETS price; French tax (€56, 2020); higher than German (€25)	Not Paris-consistent (IMF 2019: €66 by 2030; CPLC 2017: €35–70 by 2020)
€100	McKinsey (2020)	Insufficient to make all required investments profitable
€200	Long-term EU target studies; NGFS "Orderly transition" SCC peak	More aligned with EU climate objectives
€800	NGFS (2020, 2021) "Disorderly transition" SCC peak	Extreme case, reflects high-cost transition risks

Micro-simulation approach for assessing transition risk (2)

2. Estimate energy-price elasticities at the micro level (HHs and NFCs)

	Households	Firms
Data	HBS, SHIW	Cerved – CR, INPS, EUROSTAT
Method	Autoregressive distributed lag Quasi panel, Compare subgroups	Log-log specification (Assumption: within each sector energy expenditure is correlated with the firms' size)

$$log Q^z_{s,t} = \lambda_s log Q^z_{s,t-1} + \beta_s log P_t + \gamma_s log E_{s,t} + w + s + t + t^2 + \varepsilon_{s,t}$$

$$log F_{i,t} = \lambda log F_{i,t-1} + \beta log P_{i,t} + t + t^2 + X_{i,t} + \mu_{i,t} + \varepsilon_{i,t}$$

Households' price elasticities.

	Short-run			Long-run
	LS	Stratum-level LS	2SLS	
Electricity	−0.36***	−0.29*	−0.40***	−1.17***
Heating	−0.40***	−0.44**	−0.44***	−1.23***
Transport	−0.17**	−0.45**	−0.66***	−1.46***

Firms' price elasticities.

	Total Economy	Agriculture	Industry	Construction	Services
Total	−0.232***	0.0770	−0.397***	−0.583***	−0.116***
	(0.00)	(0.18)	(0.00)	(0.00)	(0.00)
0–49	−0.231***	0.0746	−0.393***	−0.577**	−0.120***
	(0.00)	(0.32)	(0.00)	(0.01)	(0.01)
>50	−0.208***	0.204*	−0.412***	−0.588***	−0.0141
	(0.00)	(0.06)	(0.00)	(0.00)	(0.75)

Notes: p-values are reported in parenthesis.
* $p<0.05$.
** $p<0.01$.
*** $p<0.001$.

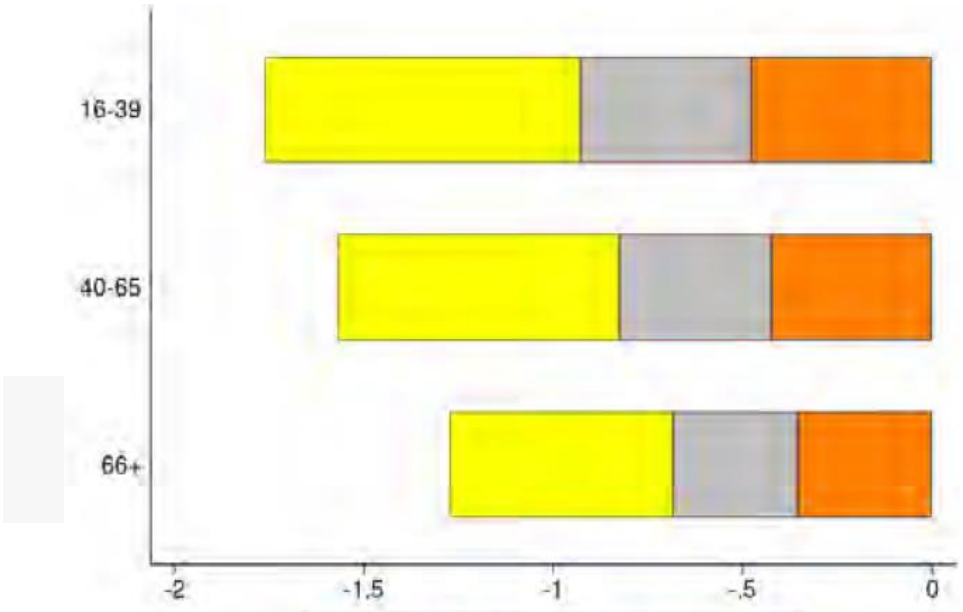
Source: Faiella and Lavecchia (2021)

Micro-simulation approach for assessing transition risk (3)

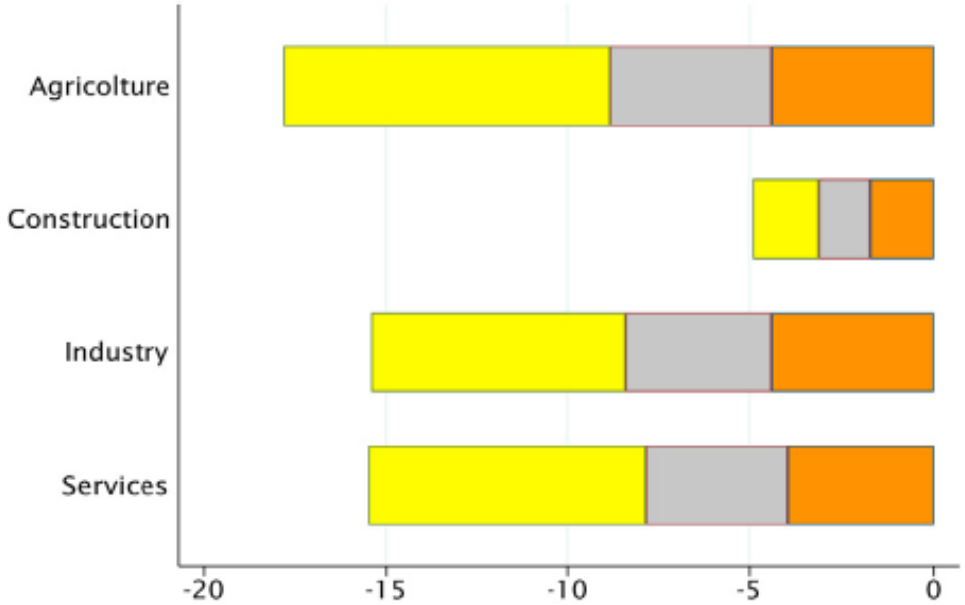
3. Evaluate the effect of the increase in energy price on HH income and NFC EBITDA

⇒ The carbon tax increases energy prices
⇒ The total energy expenditure (Q*P) increases for each HH/NFC according to its elasticity
⇒ Household income and firm EBITDA available for debt-service are reduced in proportion to the increase in the total energy expenditure

Reduction of HH Income (%)



Reduction of Firm EBITDA (%)



Micro-simulation approach for assessing transition risk (4)

4. Assess immediate impact on HH and NFC financial vulnerability

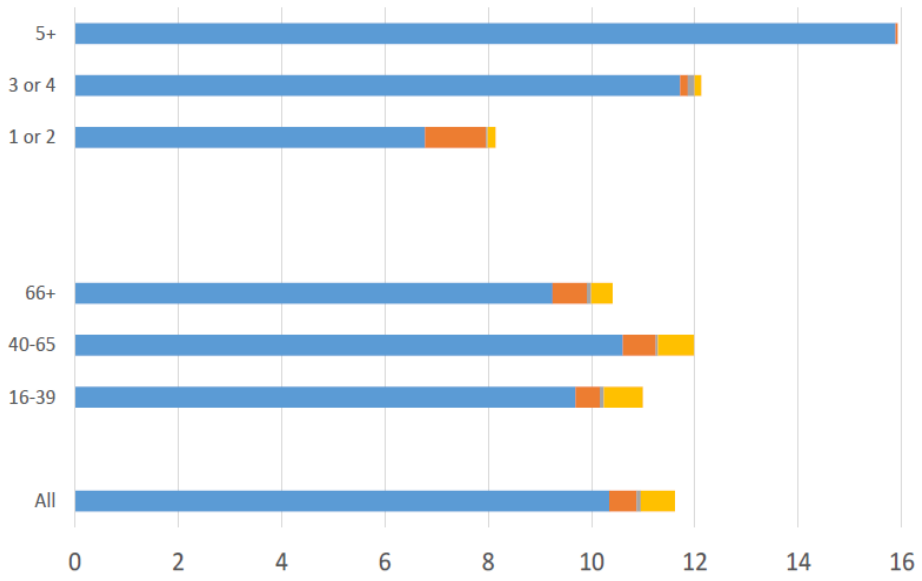
Indicator of HH financial vulnerability:

$$VHH_{i,t} = \begin{cases} 1 & if \ \frac{L_{i,t}}{\tilde{y}_{i,t,\tau}} > 0.3 \text{ and } \tilde{y}_{i,t,\tau} < median(\tilde{y}_{i,t,\tau}) \\ 0 & otherwise \end{cases}$$

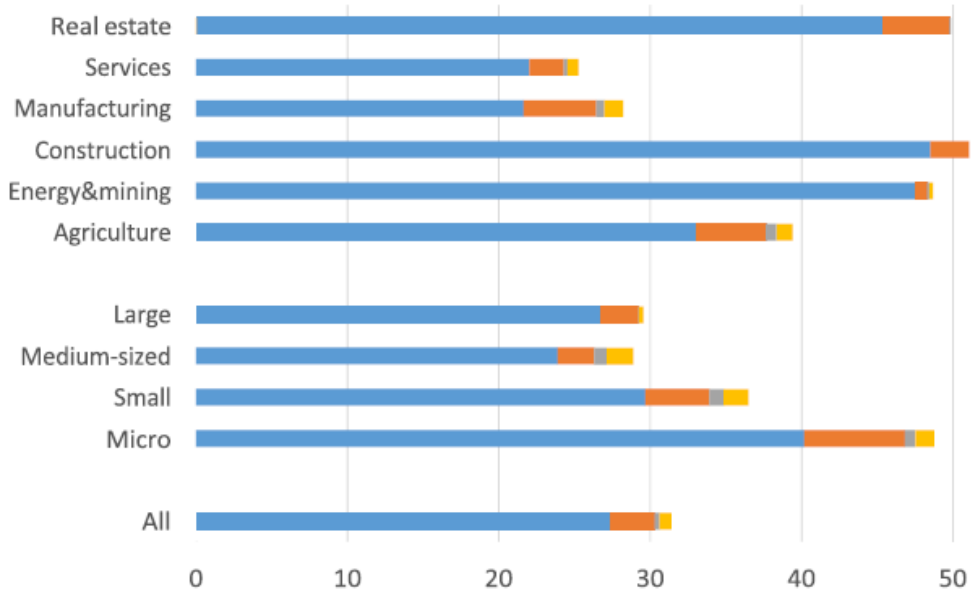
Indicator of firm financial vulnerability:

$$VNFC_{i,t} = \begin{cases} 1 & if \ EBITDA_{i,t}\left(1 - x_{i,t,\tau}\right) < 0 \text{ or } \frac{IE_{i,t}}{EBITDA_{i,t}\left(1 - x_{i,t,\tau}\right)} > 0.5 \\ 0 & otherwise \end{cases}$$

HH Debt at risk in 2016 (%)



Firm Debt at risk in 2018 (%)



Extensions of micro-simulation approach for assessing transition risk

Extension 1 – Effect on sector-level firms' probability of default

Credit risks stemming from the introduction of a carbon tax – during periods of low default rates – are modest for banks: on average, over a one-year horizon, the default rates of firms increase but remain below their historical averages.

Aiello and Angelico (2022)

Extension 2 – Effects on individual firms' default rates

The introduction of carbon taxation would have a limited impact on credit risk: a carbon tax of EUR 40 (*Below 2°C*), EUR 90 (*Net Zero 2050*) and EUR 140 (*Delayed Transition*) per tonne of CO2 would raise the average PD by 0.6, 2.3 and 4.1 basis points, respectively. The effect is slightly larger for the Agriculture and Services sectors, while there is no clear pattern relating to firm size

Di Virgilio, Faiella, Mistretta & Narizzano (2023)

Extension 3 – Effects of the surge in energy prices on HH vulnerability

If energy price elasticity is not duly accounted for, financial vulnerability rises excessively following an energy price upsurge. However, when consumption rebalancing is taken into account, financial vulnerability remains rather low and in line with the supervisory data.

Colabella, Lavecchia, Michelangeli and Pico (2023)

2

Overview of scenario analysis on flood risk

Impact of flood-risk on Italian real wealth

Expected economic loss = E x P x V

E = Exposure → Value of housing assets
- 2011 Censimento: 400,000+ micro-sections with floor-level housing data (Istat)
- 2020 OMI Price: 28,000 market areas

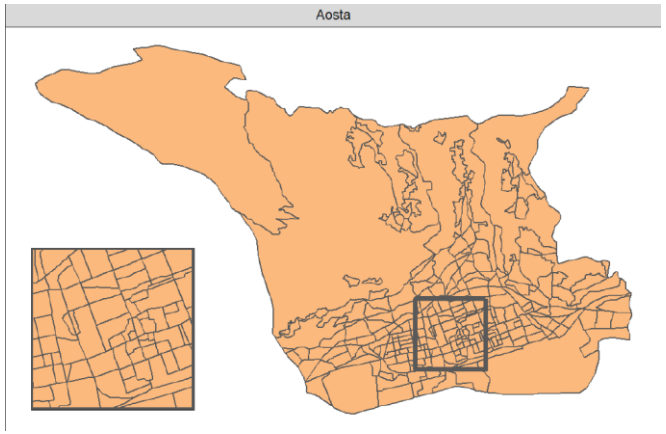
P = Probability of flooding → 2020 ISPRA maps [& JRC maps]
- Geographical identification of floodable areas
- 3 probability scenarios: high, medium, low

V = Vulnerability → damage functions (Huizinga et al., 2017)
- Loss of dwellings value (% of the total value) as a function of the floor level

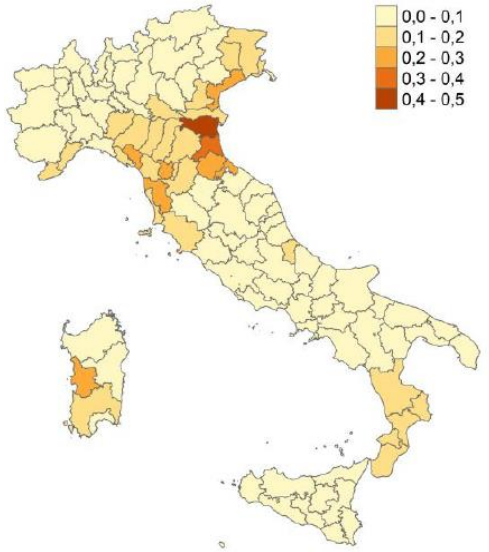
Exposure ISPRA Low prob (>200 years)	Annual expected loss
991,8 billion (23,3% housing stock)	10,8 billion (0.25% housing stock)

Loberto e Spuri (2023)

Geolocalization



Average loss (% of housing stock)



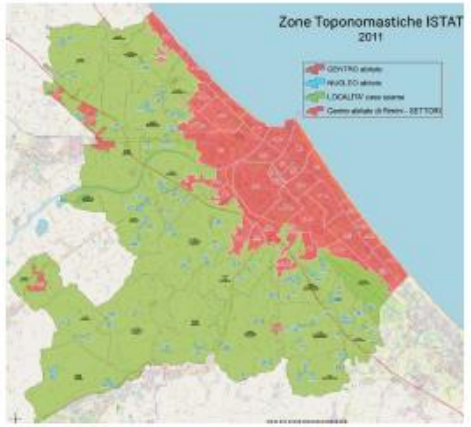
Costal flood and impact on banks' mortgage portfolio

- **Case study:** The choice of Rimini is linked to the implementation of coastal defense intervention in the southern area of the city, the Sea Park, with a height of 2.8 meters above sea level, for a total cost of 33.3 million euros

- **Methodology:** **Expected risk = E x P x V**
  E = mortgage portfolio provided by 3 banks
  P, V = Amadio (2022)

- **Main Result and Takeaway:**
  - ✓ The coastal barrier significantly reduces the losses in the mortgage portfolio
  - ✓ Some critical points regarding data collection:

  (1) **Imprecise geolocalization**: Incorrect or incomplete address (e.g. missing street number) invalidate risk assessments in about 1/5 of cases.
  (2) **Missing dwelling plan details**: No floor-level data, limiting flood risk analysis (ground floors more exposed).
  (3) **No insurance data**: Catastrophe policy info unavailable, though useful for assessing vulnerability—even on existing loans.



Source: Municipality of Rimini (link)

Faiella e Lavecchia (2025)

Methodologies for assessing NFC exposure to hydrogeological risks

Borrower exposure to hydrogeological risk through integration of data from:

- ✓ Hazard maps (ISPRA) on floods and landslides at municipality level
- ✓ Number of employees by municipality for each company to estimate the presence of a business unit (InfoCamere)
- ✓ AnaCredit data on loans and collateral

- Key results:
  - ✓ 8% of loans in high landslide-risk areas, 3% of loans in high flood-risk areas
  - ✓ Collateral and borrower locations typically coincide => Collateral offers limited risk mitigation in high-risk areas.

Meucci e Rinaldi (2022)

Further improvement:

- ✓ Exploit the exact location of all establishments (geolocation via Open Street Map)
- ✓ Exploit Hazard maps (ISPRA) on floods at granular level
- ✓ **Case study**: Application to manufacturing companies

- Key findings:
  - ✓ ~35% of manufacturing firms are exposed to floods or landslides; these firms represent ~50% of sector employment.
  - ✓ Floods main risk: 29.4% of firms have at least 1 establishment exposed to flood risk; 8.3% face landslide exposure.

Loberto e Russo (2024)

Thank you!

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