



EUROPEAN CENTRAL BANK

EUROSYSTEM



**ESRB**  
European Systemic Risk Board  
European System of Financial Supervision

# Financial stability challenges of climate- related financial risk



*Round table: How can research help?*

Session 2 of Sustainable Finance Research Forum

27 October 2022

**Paul Hiebert** *(European Central Bank)*

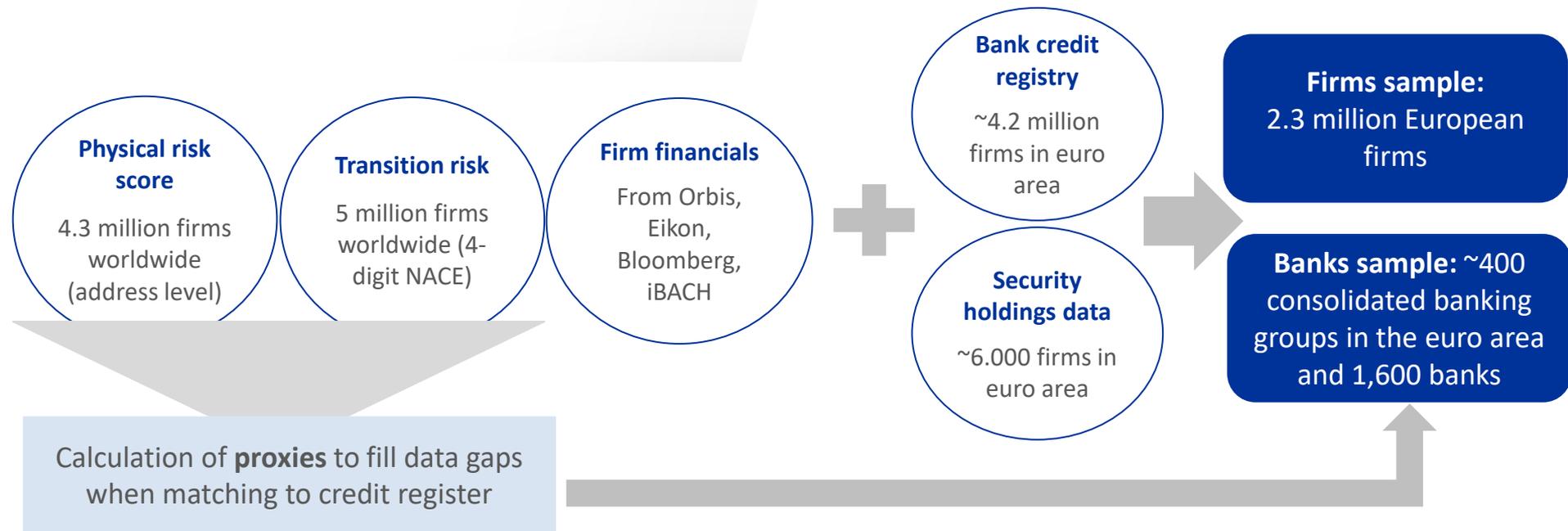
## Outline

Distribution of financial risk

Evolution of financial risk

Summary

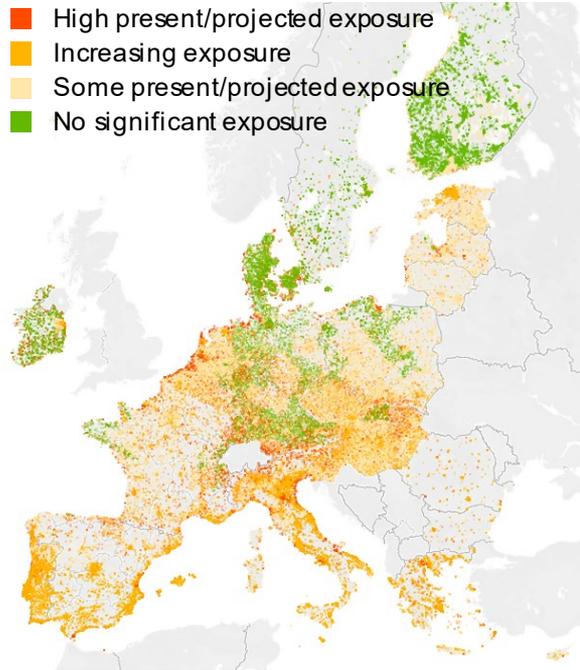
# Mapping financial exposures



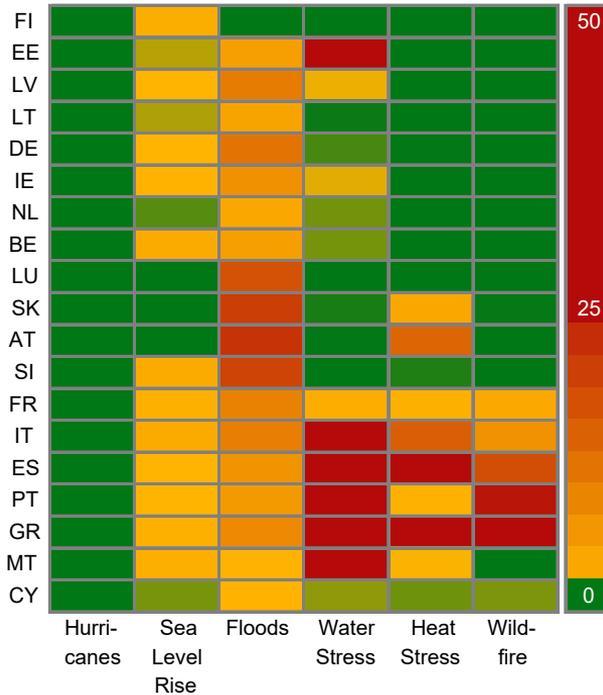
Source: [Alogoskoufis et al \(2021\)](#)

# Physical risk exposures: Concentrated across geographic regions

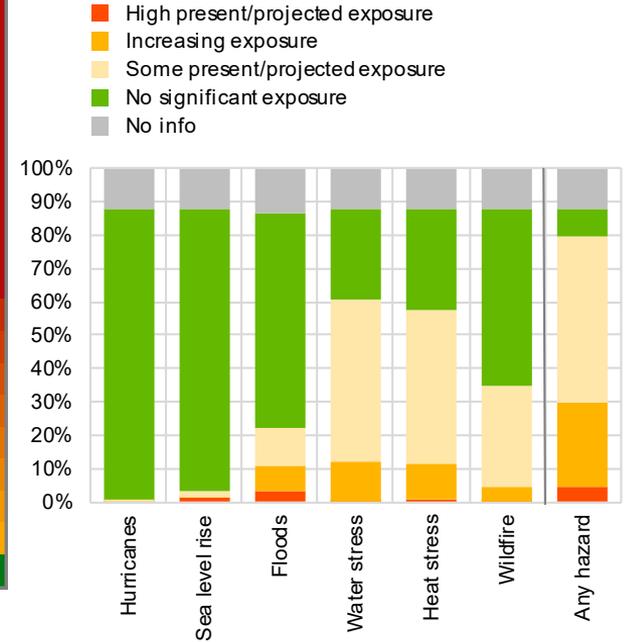
## Mapping firm exposures to physical hazards



## Share of firms to high or increasing exposure to a physical hazard



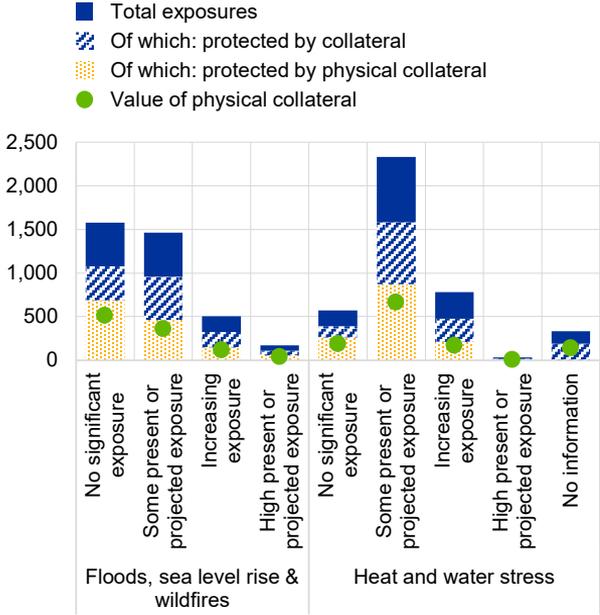
## Share of euro area bank credit exposures to firms, by firm physical risk level



Sources ECB/ESRB (2021), [Climate-related risk and financial stability](#) based on AnaCredit, 427, ECB calculations. Notes: Physical risk hazard scopes reflect a 20-year horizon.

# What role for mitigants?

## Banks' credit exposures secured by collateral (EUR billion)



Sources: ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on AnaCredit, 427 data and ECB calculations. Notes: December 2020. Maximum risk level considered across floods, sea level rise and wildfires; EUR 4.2 tn of exposures considered; NFC location used to assign risk levels refers to the HQ.

## Estimated insurance protection gap in EU countries (Protection gap > 3 expected to present material risk to real economy)

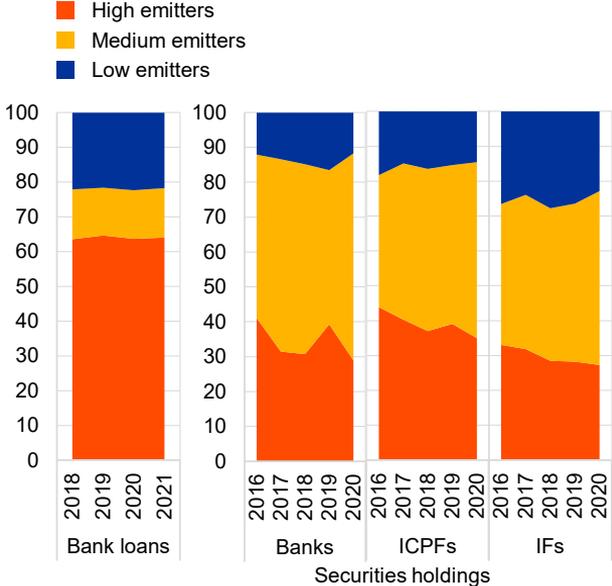


Source: ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on EIOPA calculations

# Transition risk exposures: Concentrated across (and also *within*) economic sectors

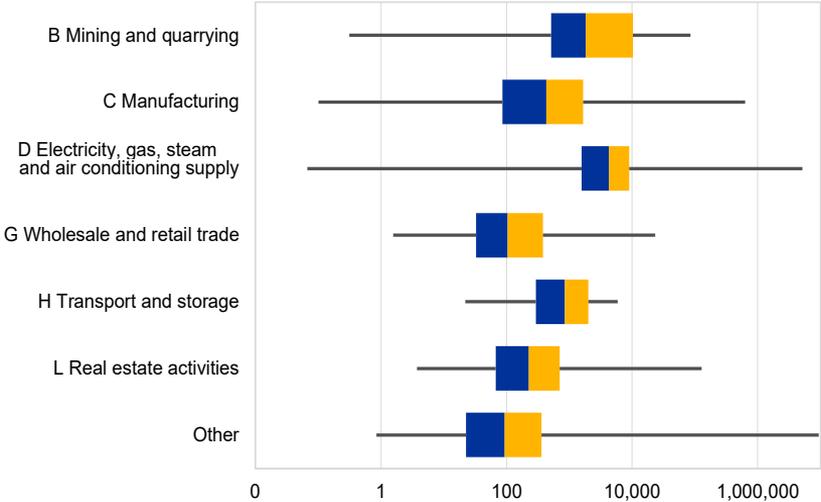
## Euro area credit exposures to, and securities holdings of high and low emitters

(2018-21, 2016-20, percentages of total exposures and securities holdings)



## Firm-level emission intensities across and within euro area sectors

(Emissions in tonnes of CO2 equivalents per USD million revenue)



Sources: Urgentem, ECB (AnaCredit), Bureau van Dijk – Orbis database and ECB calculations. – see [ECB Financial Stability Review](#), May 2022.

Source: ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on Urgentem data Note: Only firms directly reporting emissions are considered (approximately 3,000 European firms)

## Exposure dimension

## Risk dimension

Institution-specific

Non-financial

**Transition:** Emissions (actual & forward-looking)

**Physical:** Climate-related hazards  
(floods, wildfires, heatwaves,...)

**Transition:** Impact on profits & costs,  
technological obsolescence, risk perceptions

**Physical:** Asset damages, insurance costs, production  
disruption

Financial

**To non-financial sectors**

- credit instruments (loans, debt sec., equity,...)
- contingent liabilities (insurance, derivatives)

**Vulnerability of counterparts:** indebtedness,  
leverage, provisions  
*climate-related impact on credit risk (PD, LGD), market  
risk (asset valuation)*

System-wide

**Climate:** interdependent hazards

**NFCs:** In-/output interdependencies

**Financial Institutions:** overlapping exposures

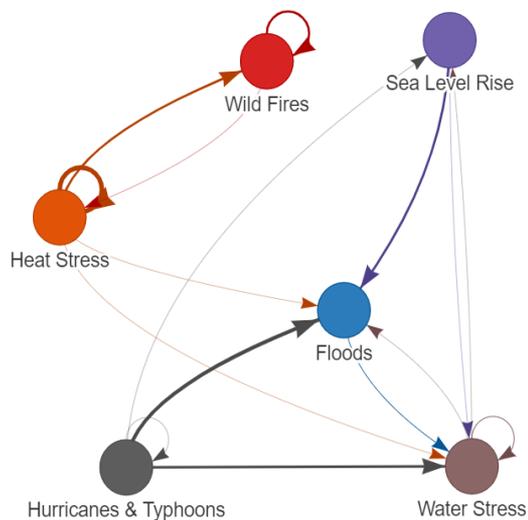
**Clustered risks, interconnectedness**  
*Dynamic risk amplification & propagation  
(joint defaults, contagion, fire sales)*

## Potential systemic amplifiers (*physical risk*)

- Financial stability risks may be exacerbated by exposures to multiple interdependent hazards and self-reinforcing loops
- Overlapping portfolios with exposures to transition or physical risks may imply loss amplification via fire sales among investors

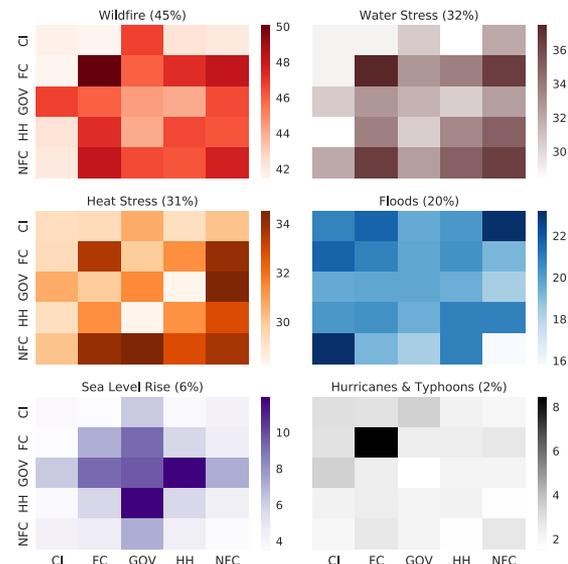
### Interdependencies of natural hazards

(Arrows based on hazards' correlations and causal relations)



### Physical-risk-weighted overlapping portfolios

Share of common asset holdings [%] (mean in parenthesis)



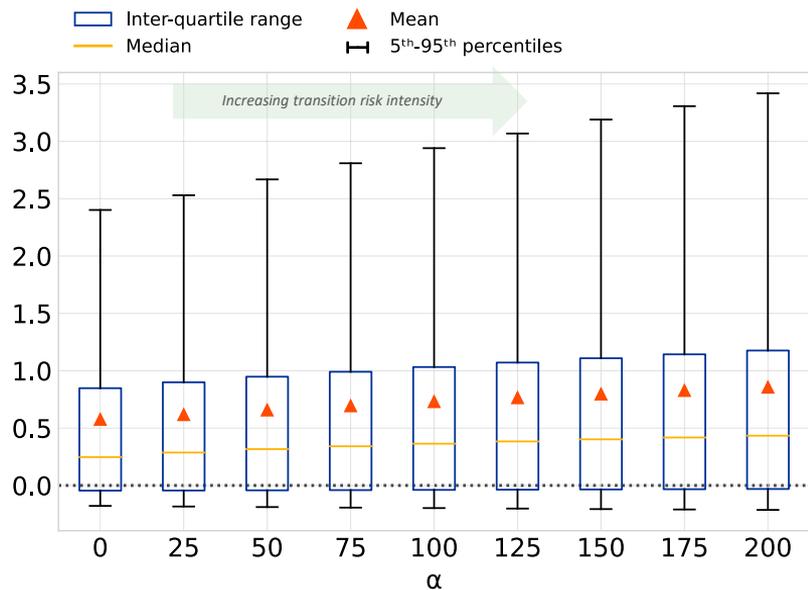
Sources: ECB/ESRB (2022), [The Macroprudential Challenge of Climate Change](#); Left – Data from Gill and Malamud, “Reviewing and visualizing the interactions of natural hazards”, 2014, and ECB calculations. Right – Security Holding Statistics, 427, and ECB.

Notes: Left – Links refer to both correlations as well as causal links. Arrows' thickness is proportional to a score capturing either increased probability or causal trigger of hazards, in terms of both spatial overlaps as well as temporal likelihood. Right – Overlapping portfolios weighted by physical hazards scores as share of common asset holdings by aggregate sectors.

# Potential systemic amplifiers (*transition risk*)

## Pairwise default correlations

(for increasing transition risk intensity ( $\alpha$ ), %)



Source: ECB/ESRB (2022), [The Macroeprudential Challenge of Climate Change](#).

Note: Based on a multi-firm Merton model (A. Grassi and L. Mingarelli) and 500k bootstrapped Monte Carlo simulations on the full EA Moody's Credit Edge sample. The *transition risk intensity* parameter  $\alpha = (1 - \beta)T$  incorporates both the transition risk shock  $T$  as well as a pass-through factor  $\beta$  capturing the degree to which firms can pass the cost of a transition risk shock to consumers.

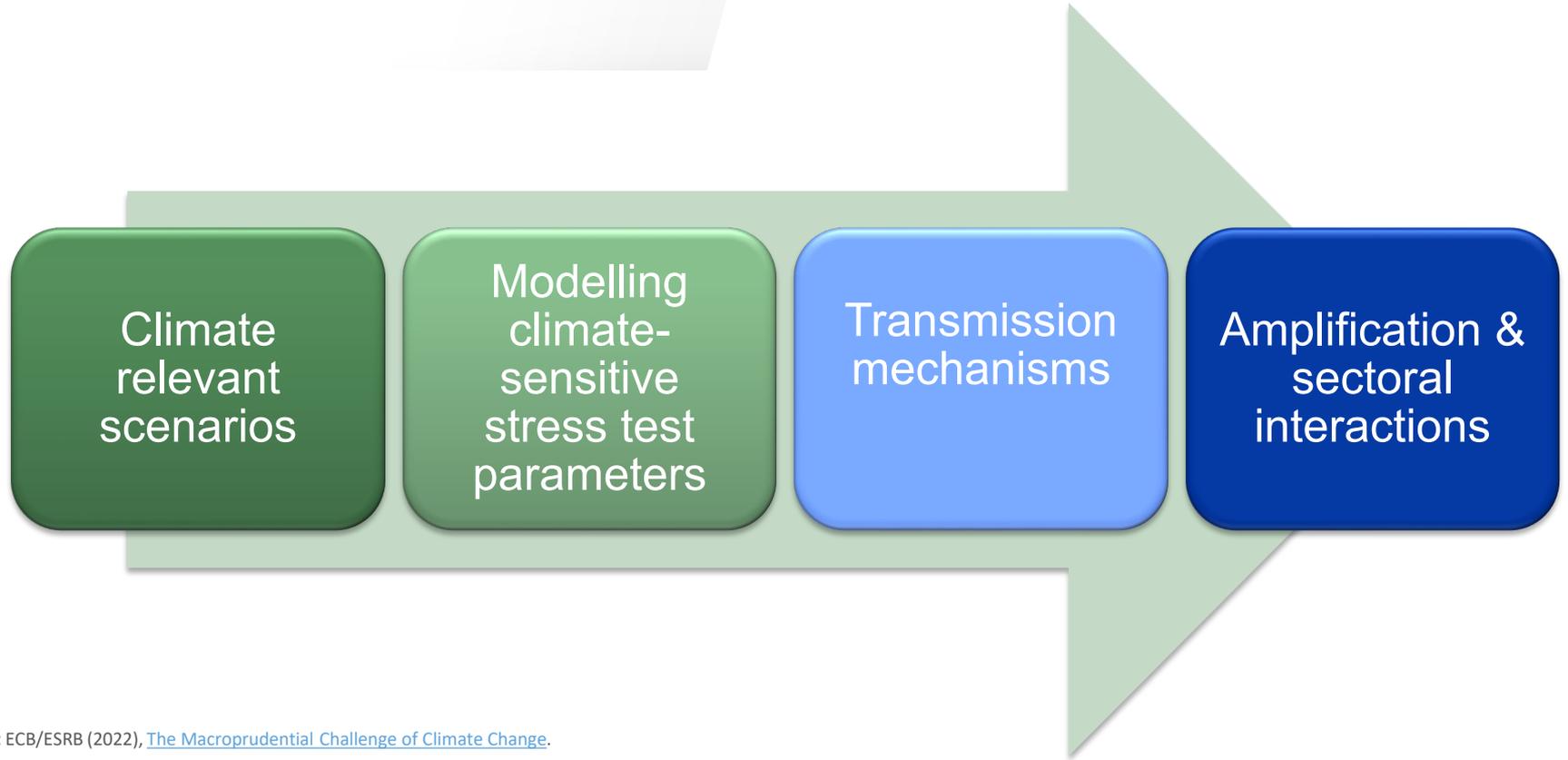
## Outline

Distribution of financial risk

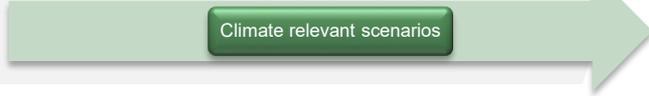
Evolution of financial risk

Summary

## Scenario analysis & stress testing



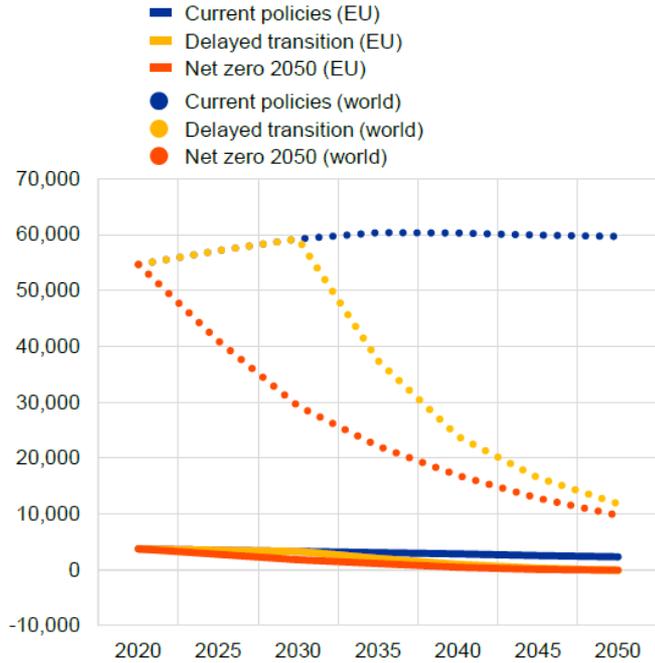
Source: ECB/ESRB (2022), [The Macprudential Challenge of Climate Change](#).



## Impacts of the NGFS net zero 2050 and delayed transition scenarios

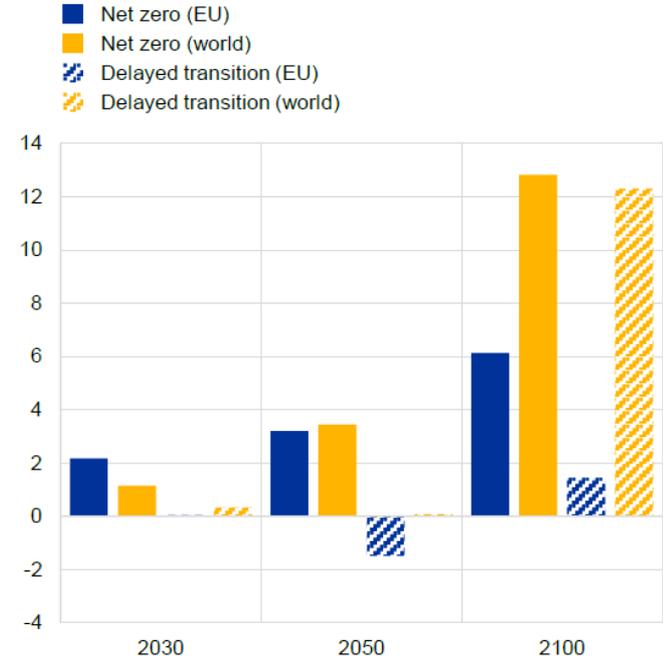
### a. GHG emissions

Gt CO<sub>2</sub> / year



### a. GDP

% deviation from the current policy scenario

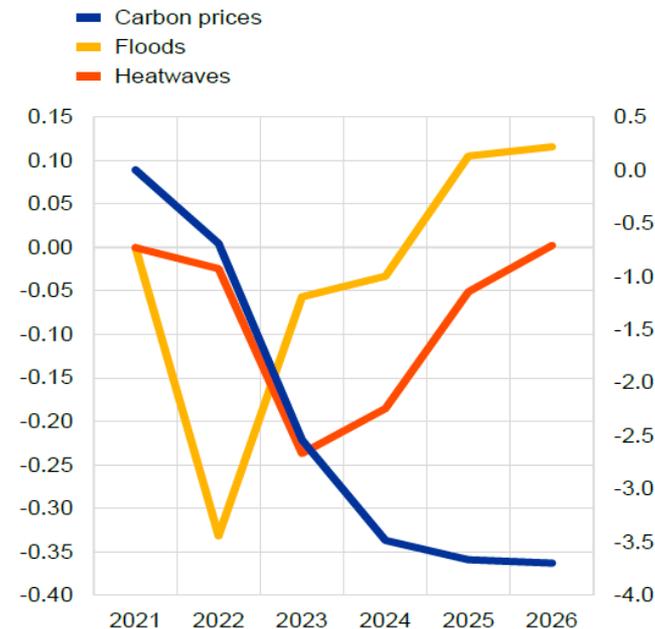


	Carbon prices	Flood risk	Heatwave risk
<b>Risk type</b>	Transition	Physical	Physical
<b>Trigger</b>	Immediate and substantial increase in carbon prices	Extreme flood in the EU in the first quarter of 2022	A long heatwave in the EU in the summer of 2022
<b>Design</b>	An increase in carbon prices corresponds to the front-loaded change in carbon prices in five most adverse years of the NGFS delayed transition scenario*	Total losses due to the impact of flooding on asset and properties in 2022 of €100 billion. The JRC Flood Risk Index differentiates losses across regions and countries.	Adverse country-level productivity shocks for EU countries
<b>Additional information on calibration</b>		Estimated direct and indirect costs of 2021 losses due to floods exceed €40 billion, with some estimates nearing €50 billion.	Country-level productivity shocks due to heatwaves from the NGFS Climate Impact Explorer, based on ISIMIP data. Selecting the higher end of the impact distribution in 2020.

Note: \* The adverse impact of carbon price increases is partially mitigated by higher revenues raised through the carbon tax, with half of these being then recycled in the economy in the form of an income tax cut.

## EU GDP in near-term scenarios

(differences in percentage points of GDP compared with the baseline, right-hand scale, carbon price scenario, left-hand scale, floods and heatwaves scenarios)



# Channels of bank risk

Modelling climate-sensitive stress test parameters

## Risk drivers

### Transition risk

- Carbon costs
- Technological change and energy efficiency
- Demand for goods

### Physical risk

- Damages to physical capital
- Production disruption

*Revenues, costs, debt, profits,  
leverage, Probability of Default*

**Corporates**  
(banks' counterparts)

*Credit risk  
Market risk*

## Banks

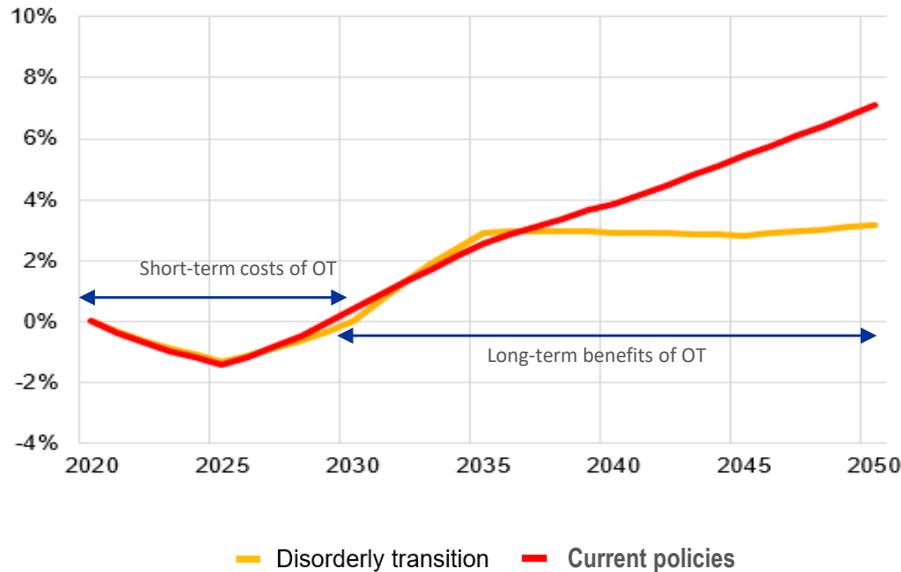
- Aggregate **default probability** of credit portfolio
- **Losses** from corporate bond repricing

**Mitigants:** Insurance coverage protects capital from damages

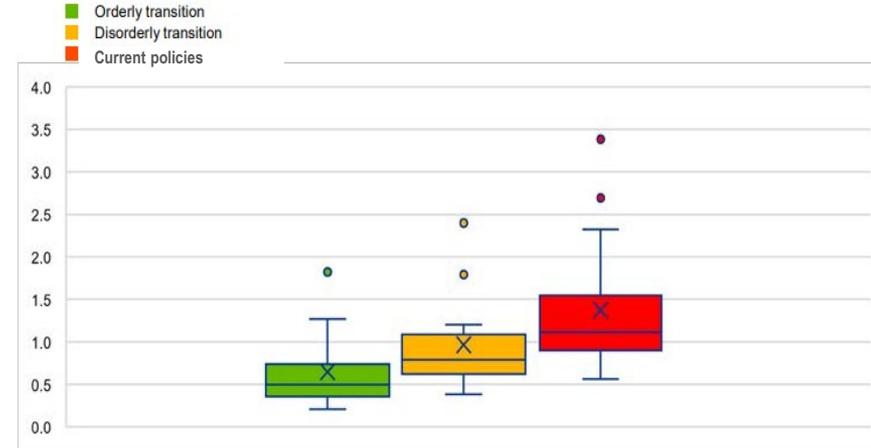
**Amplifiers:** Insurance costs increase in some vulnerable areas

## Median portfolio PD: Time evolution

*% differences in adverse scenarios compared to orderly transition scenarios*



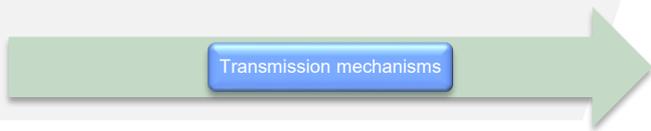
## Distribution of the increase in portfolio LGDs



## Overview of scenario analysis

	Banking sector	Insurance sector	Investment funds
<b>Long-term scenarios</b>	Current policies (baseline), Net Zero, Delayed transition		
<b>Near-term scenarios</b>	Carbon Tax, Flood, Heat Wave		
<b>Sample</b>	~2,300 banks (monetary financial institutions residing in the euro area with credit exposures above 25k EUR), 19 geographies	1821 EU/EEA insurers	10,806 funds
<b>Items under stress</b>	Loans to corporate sector (notional outstanding amounts in 2020)	Equities and corporate bonds	Equities (EUR 9tn of assets, as of March 2022)
<b>Value of items under stress over time</b>	Constant	Constant	Compounding (the value of an exposure changes over time along with compounded rate of return)
<b>Risk channels</b>	Credit risk	Market risk	Market risk
<b>Coverage of overall exposures</b>	27% of assets to non-financial companies	78% of equities and corporate bonds	68% of fund assets
<b>Coverage of the overall sector</b>	20% of total banking sector assets	27% of insurers' assets	~50% of EU investment fund net assets
<b>Source of information on balance sheets</b>	Anacredit, SUBA	Solvency II QRTs, EIOPA	Morningstar
<b>Other data</b>	Orbis, Eikon, Bloomberg, iBach, Urgentem, 427, NGFS	Solvency II QRTs, EIOPA	Refinitiv

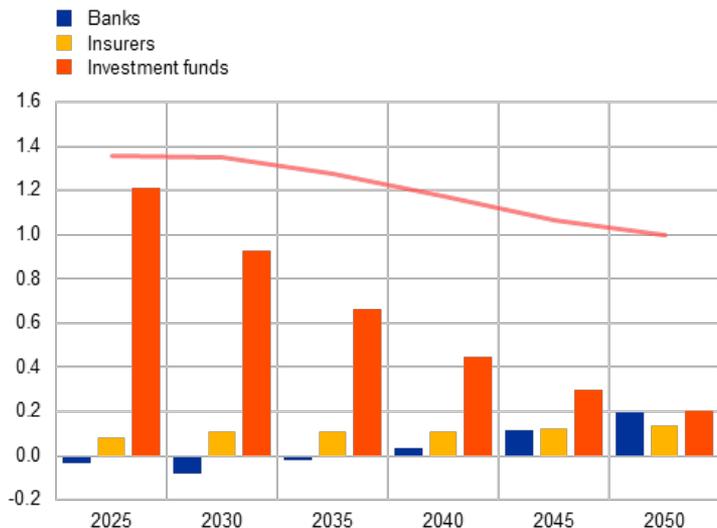
Sources: Own exposition.



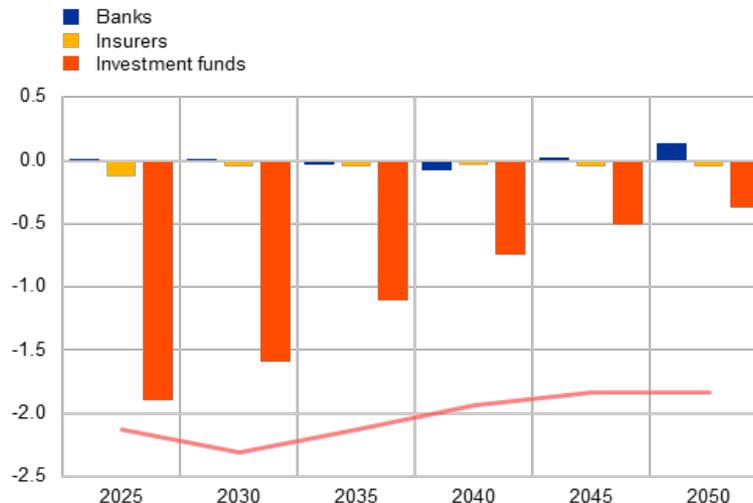
## Evolution of expected losses under reference scenario relative to status quo - *evolution*

y-axis: difference in % of stress tested assets compared to the current policies scenario of the same year

### a. Net Zero 2050 (orderly transition)



### b. Disorderly transition



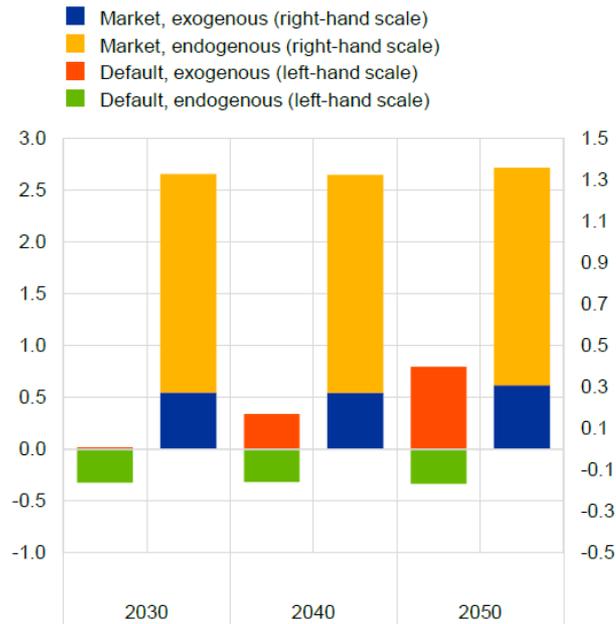
Source: ECB/ESRB (2022), [The Macroprudential Challenge of Climate Change](#) based on data and models of ECB, EIOPA, ESMA.

Notes: For the banking sector bars reflect expected annual losses in percentage of initial loan values. Positive figures are relative gains; negative are relative losses. For insurers and investment funds bars represent losses in percentage of initial asset values (equities and bonds for insurers, and equities for investment funds). The red line represents cumulative losses of investment funds accounting for dynamic changes in equity values over time in percentage of equities measured in the reference period.

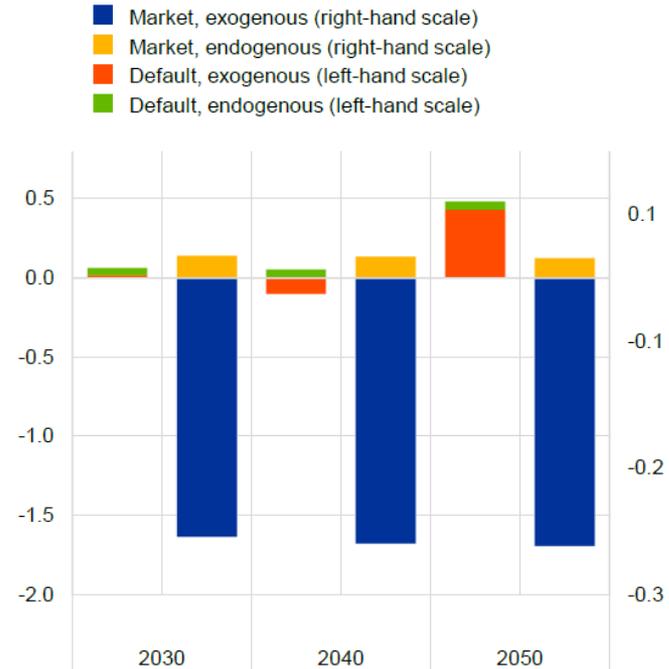
## System-wide interactions

Orderly transition relative to status quo. Primary axis: losses expressed in terms of total assets in the system, per cent mille (left-hand scale). Secondary axis: percentage

### a. Net Zero 2050 (orderly transition)



### b. Disorderly transition



Source: ECB/ESRB (2022), [The Macroprudential Challenge of Climate Change](#).  
 Note: "Default, first-round" refers to firm defaults. "Market, first-round" refers to exogenous market losses both due to the market scenario and due to the price drop of exogenously defaulting firms issuing securities. "Second-round" losses are model-driven.

## Outline

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# Key analytical findings of ECB/ESRB work to date

*Cross sectional  
dimension of  
systemic risk*

## Concentrated financial exposures to climate change at regional, sectoral, and firm level

- Physical risk at regional level: Concentration to hazards for regions, amid insurance protection gaps
- Transition risk at sectoral level: Concentration to high emission intensity across and within sectors, with limited abatement

## Systemic amplification could exacerbate climate risk concentrations

- Potential clustering of hazards amid portfolio overlaps in climate-sensitive portfolios across the financial sector
- A sharp carbon adjustment could double average firm default correlation through counterparty linkages, more for high emitters

*Time series  
dimension of  
systemic risk*

## Scenario analysis suggests path dependence, with losses from an insufficient or ineffective transition

- *Firms*: Physical risks become dominant with time, with disproportionate losses for vulnerable firms
- *Banks*: Losses of up to 1.75% of risk-weighted exposures to firms by mid-century, concentrated in electricity and real estate
- *Non-banks*: Small average revaluation losses, but up to 14% for investment funds invested in fossil fuel dependent industries

## Climate-related financial losses initially market risk (with amplification), presaging eventual credit risk

- Climate shocks initially impact market risk (nonbanks), followed by credit risk (banks), with financial system risk propagation potentially amplifying revaluation losses up to four times
- The path to reduced climate risk may be bumpy, with near term tradeoffs inherent to climate risk benefits from action which only accrue with time, and strong distributional forces at play

# Climate change and financial stability: **Four challenges**



**Systemic, global nature** of climate change, amplified by non-linearities and tipping points



**Foreseeable materialization, but high uncertainty** about exact evolution and impact of climate policies due to complex interactions between economic agents, policies and nature



**Irreversibility** of climate change if not mitigated in a timely way



**Long time horizons**, as impact mostly expected in the long run

# Climate change and financial stability: How can research help?



Interactions climate-economy-  
financial system (all of it!)

**Systemic, global nature** of climate change, amplified by non-linearities and tipping points



**Foreseeable materialization, but high uncertainty** about exact evolution and impact of climate policies due to complex interactions between economic agents, policies and nature



**Irreversibility** of climate change if not mitigated in a timely way

Scenario analysis to bring uncertainty into realm of probabilistic risk



**Long time horizons**, as impact mostly expected in the long run

Transitions, not just steady states  
"Life is what happens when you're busy making other plans"  
- John Lennon