EUROPEAN CENTRAL BANK

EUROSYSTEM

ESRB
European Systemic Risk Board
European System of Financial Supervision

The macroprudential challenge of climate change

SUERF seminar

27 September 2022

Paul Hiebert *(European Central Bank)*

Outline

1. Risk distribution
2. Risk evolution
3. Systemic risk
4. Macroprudential policy
5. Summary

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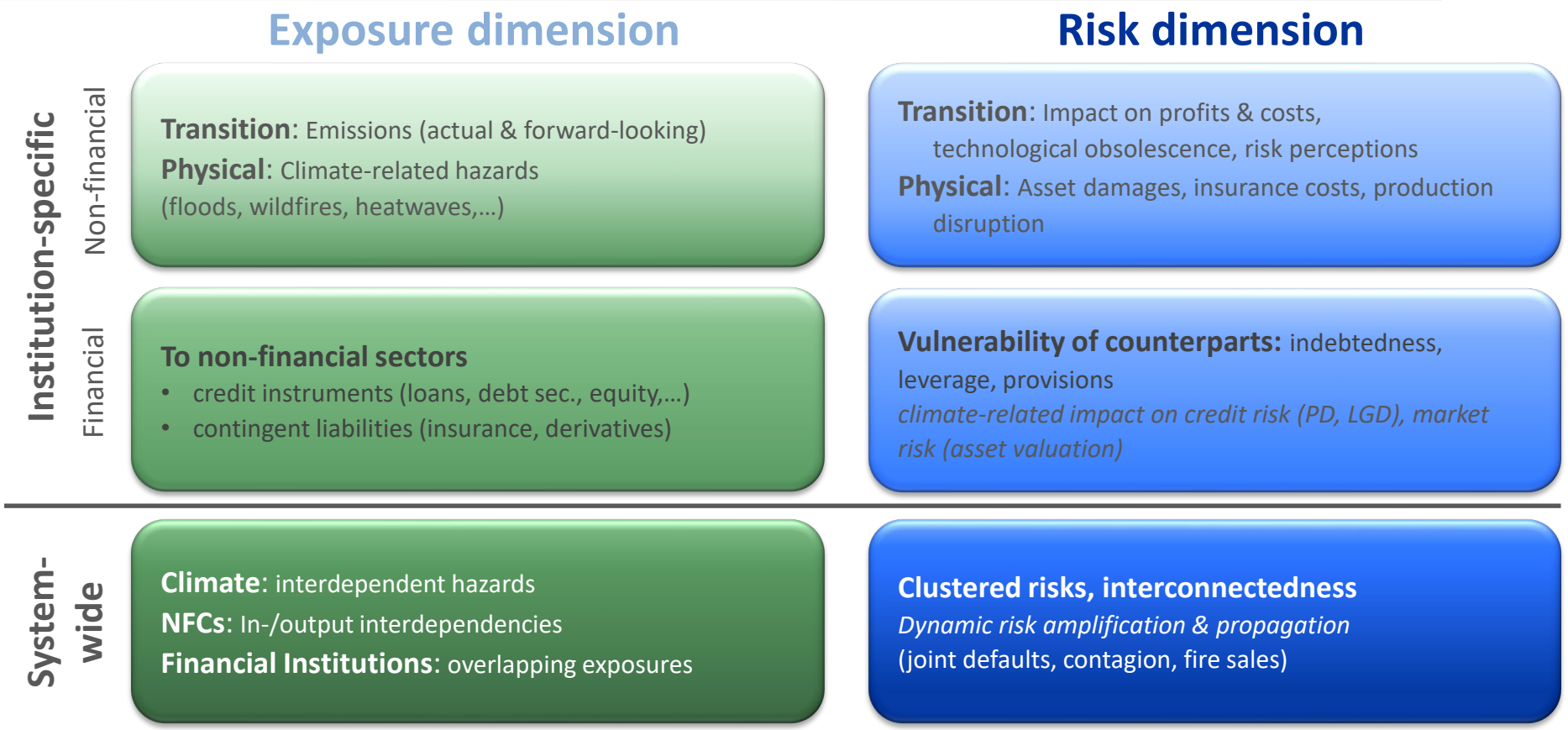
Exposure and risk metric framework

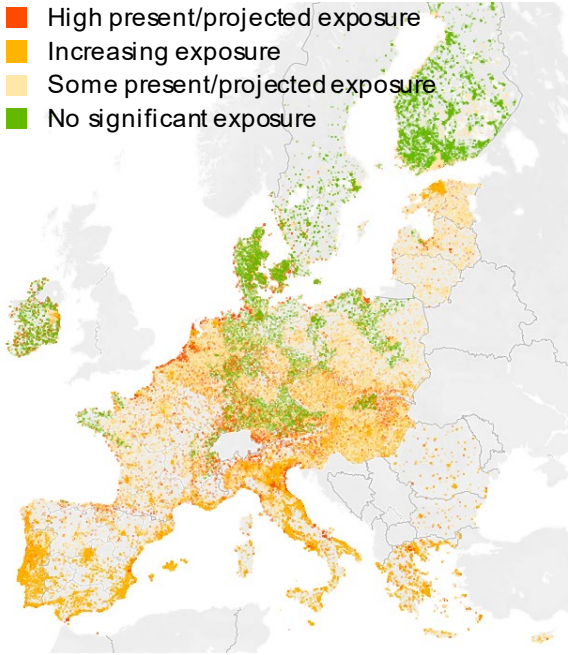


ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

Physical risk exposures

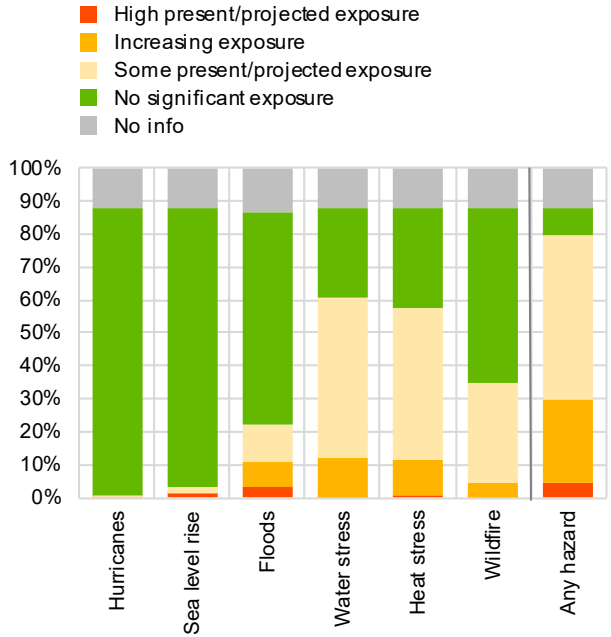
Mapping firm exposures to physical hazards

(Index, Maximum firm exposure to physical hazards)



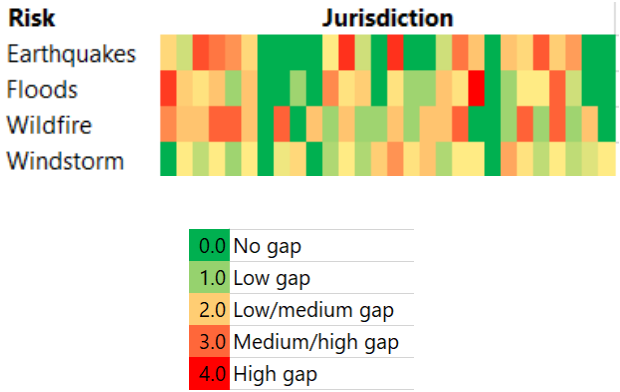
Share of euro area bank credit exposures to firms, by hazard level

(percentages of total bank exposures to NFCs)



Protection gap for European countries by hazard

(Index; A protection gap > 3 is expected to present material risk to the real economy)



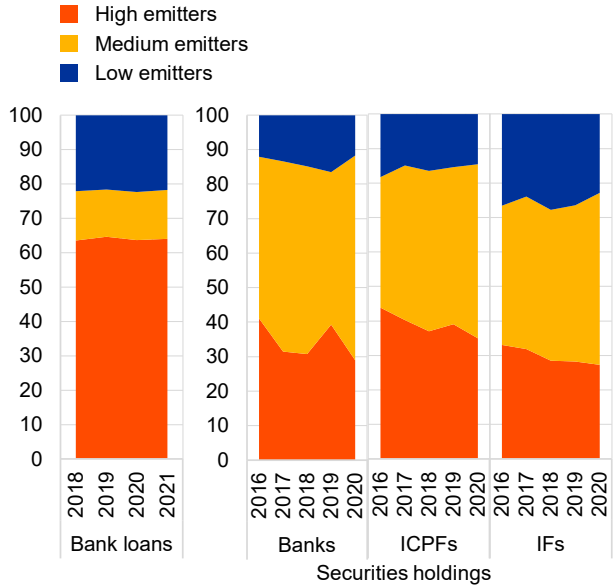
Sources ECB/ESRB (2021), Climate-related risk and financial stability based on AnaCredit, 427. Notes: Physical risk hazard scopes over a 20-year horizon. information refers to firm HQ location. Scores for different risk categories may translate differently into risk levels and economic damages, depending on the risk category.

Source: ECB/ESRB (2021), Climate-related risk and financial stability, based on EIOPA pilot dashboard.

Transition risk exposures

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

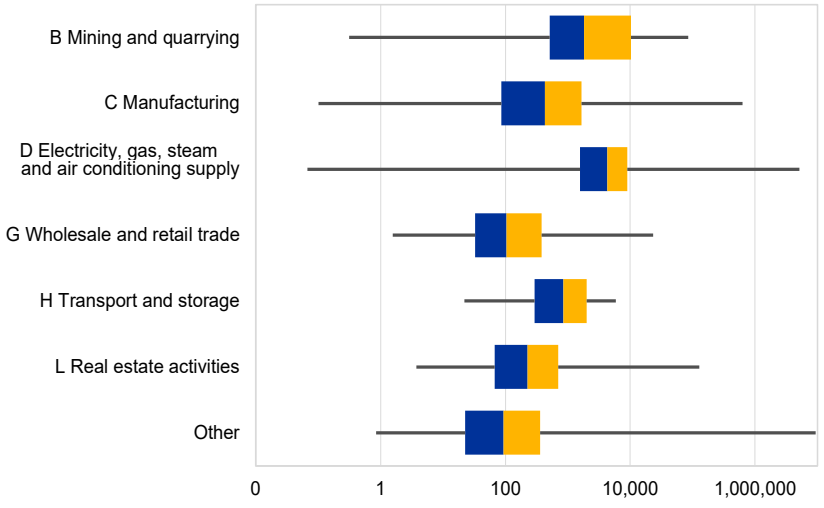
(2018-21, 2016-20, percentages of total exposures and securities holdings)



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

Firm-level emission intensities across and within euro area sectors

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

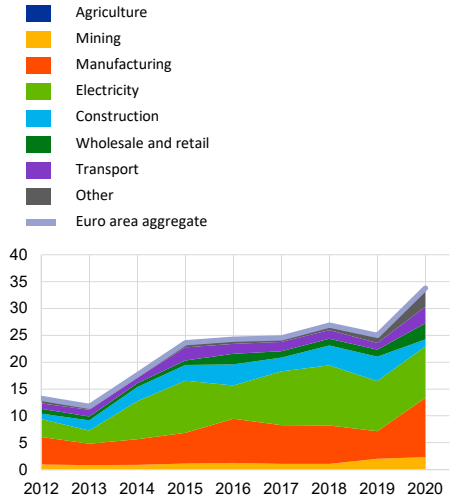


Source: ECB/ESRB (2021), Climate-related risk and financial stability, based on Urgentem data Note: Only firms directly reporting emissions are considered (approximately 3,000 European firms)

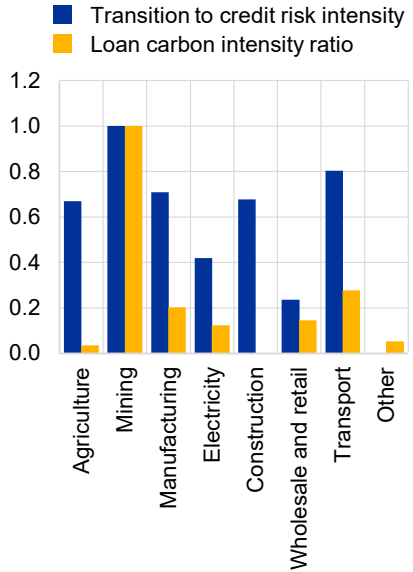
From climate exposures to financial risk

- Combining climate risk factors (carbon emissions or physical risk scores) with firm-level probabilities of default (pre-existing vulnerabilities) reveals also an increasing credit risk intensity of *transition risk*, driven strongly by electricity sector

Euro area transition induced financial risk increasing
(sectoral contribution to the EA aggregate TCI)



Credit intensity of transition risk versus emissions for sectors
(TCI & emission intensity)



Sources: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change. Based on data of Urgentem, Anacredit (2019), Register of Institutions and Affiliates Data (RIAD) and ECB calculations.
Notes: The transition-to-credit risk-intensity (TCI) combines banks' loan exposures with firm's emissions and probabilities of default to capture banks' exposures to transition risk (normalisation by institution with highest TCI / carbon intensity). A physical-to-credit risk-intensity (PCI) accounts for the physical dimension of climate risk, computed by replacing (firm-level) emissions with (firm-level) vulnerability towards natural hazards using physical risk scores/

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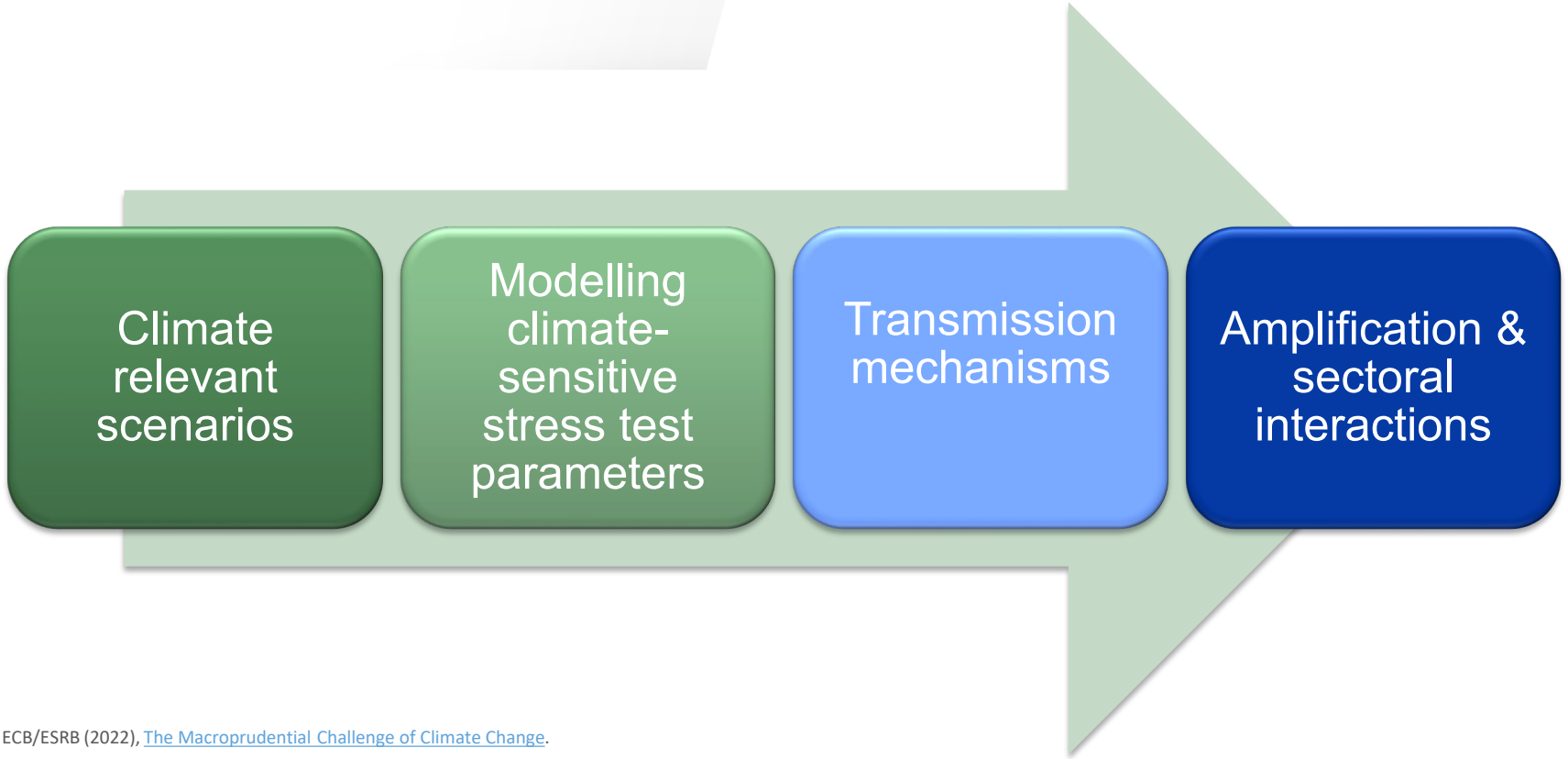
Scenario analysis & stress testing



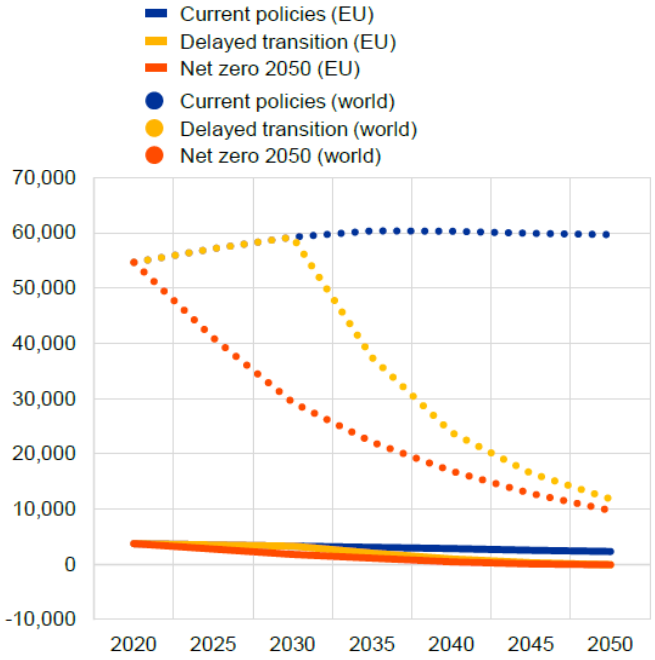
Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

Medium-term scenarios

Impacts of the NGFS net zero 2050 and delayed transition scenarios

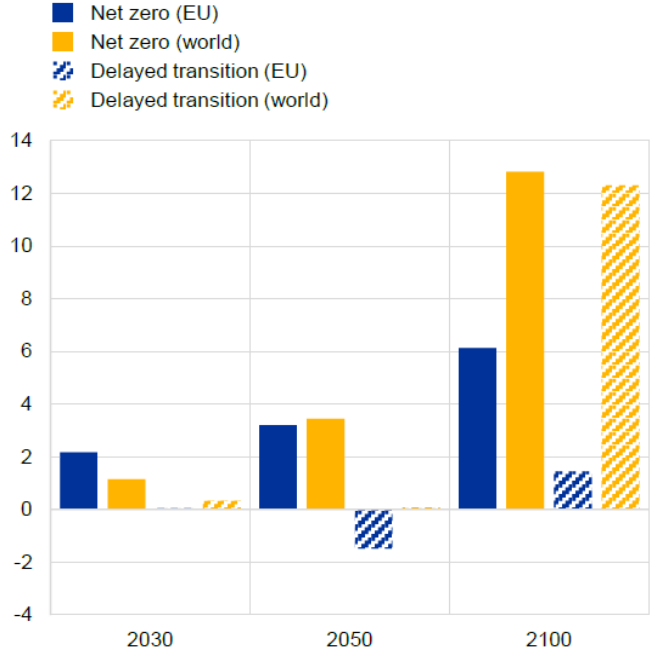
a. GHG emissions

Gt CO2 / year



a. GDP

% deviation from the current policy scenario



Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change, NGFS.

Near-term scenarios

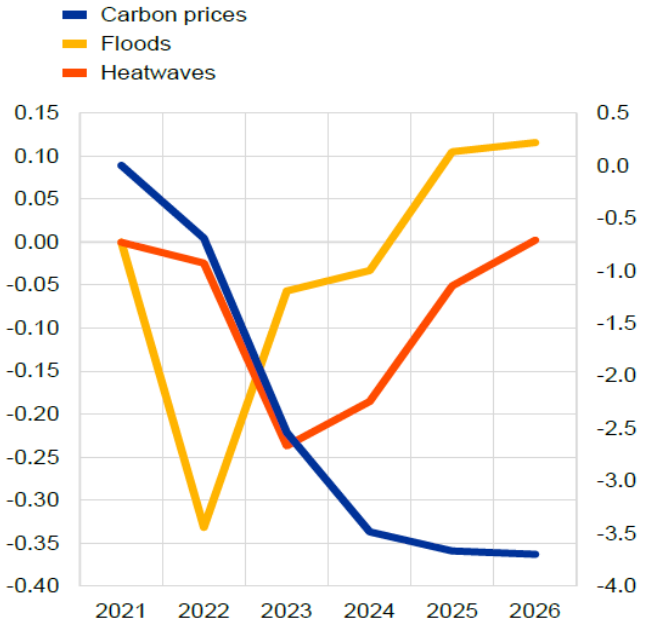
Climate relevant scenarios

	Carbon prices	Flood risk	Heatwave risk
Risk type	Transition	Physical	Physical
Trigger	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
Design	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
Additional information on calibration		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)

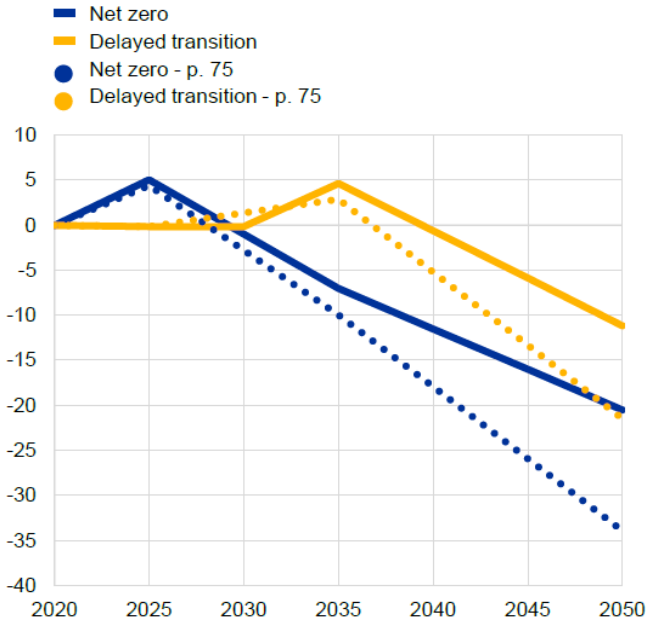


Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

Corporate risk

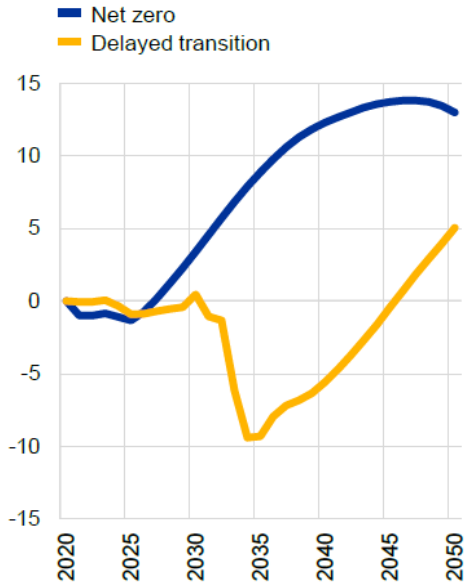
Corporate PD projections in NGFS scenarios

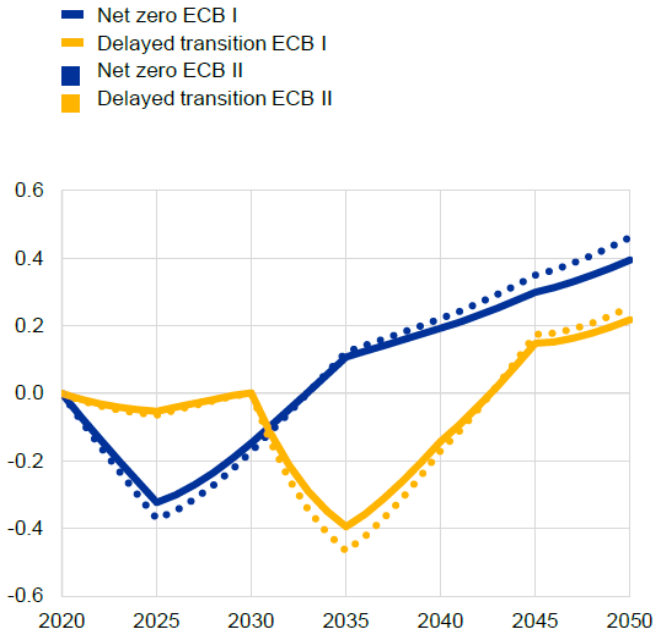
% deviation from the current policy scenario



Climate-sensitive corporate equity prices over time (LHS) and bond prices (RHS)

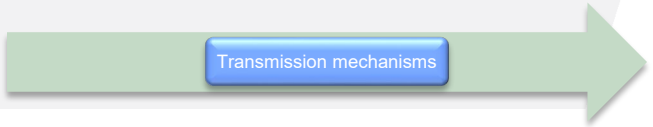
% relative to Current Policies





Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

Aligning financial system scenario analyses



Overview of scenario analysis

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

Sources: Own exposition.

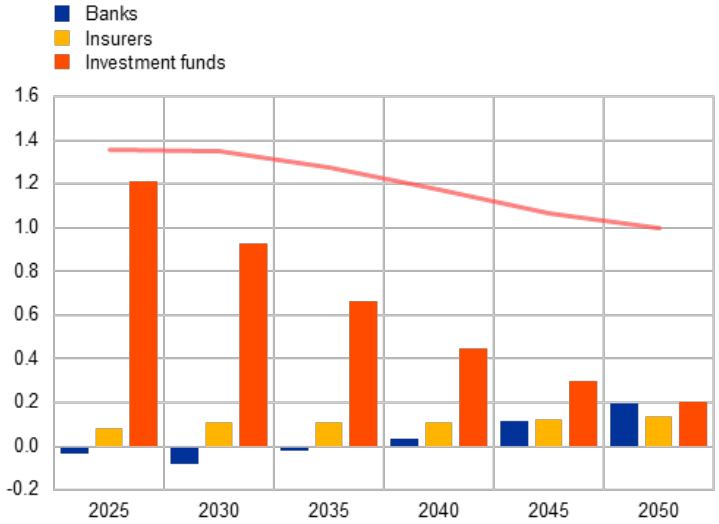
Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

Aligned scenario analyses across the financial sector

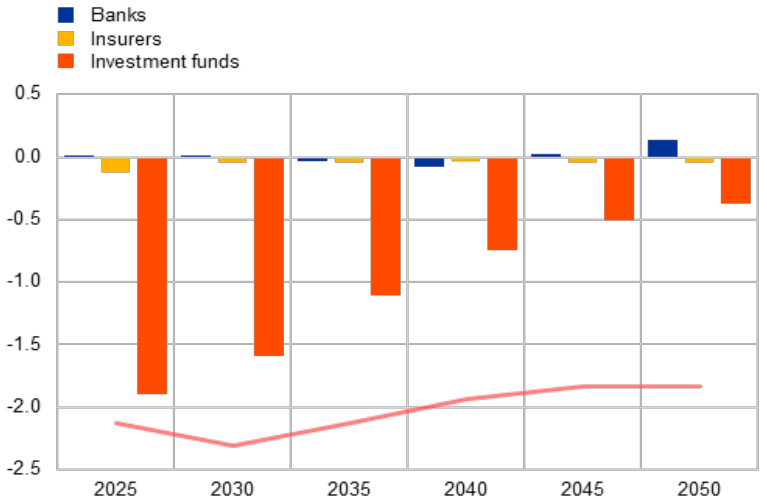
Evolution of expected losses under reference scenario relative to status quo - *evolution*

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



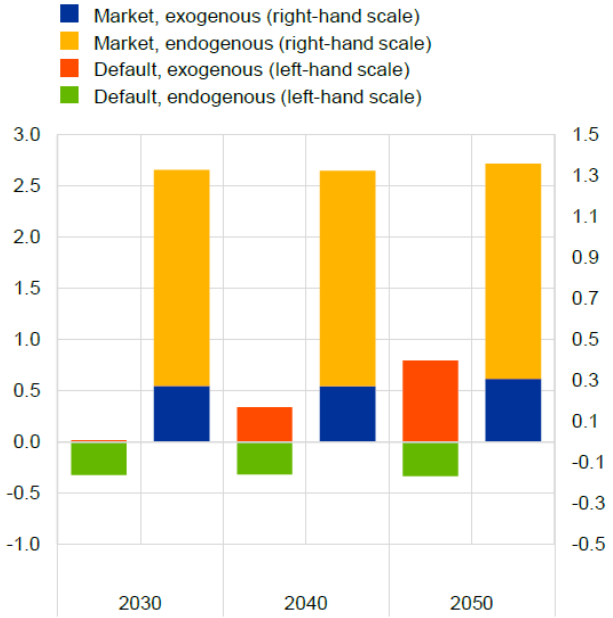
Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change based on data and models of ECB, EIOPA, ESMA.
Notes: For the banking sector bars reflect expected annual losses in percentage of initial loan values. Positive figures are relative gains; negative are relative losses. For insurers 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.

Financial system interactions

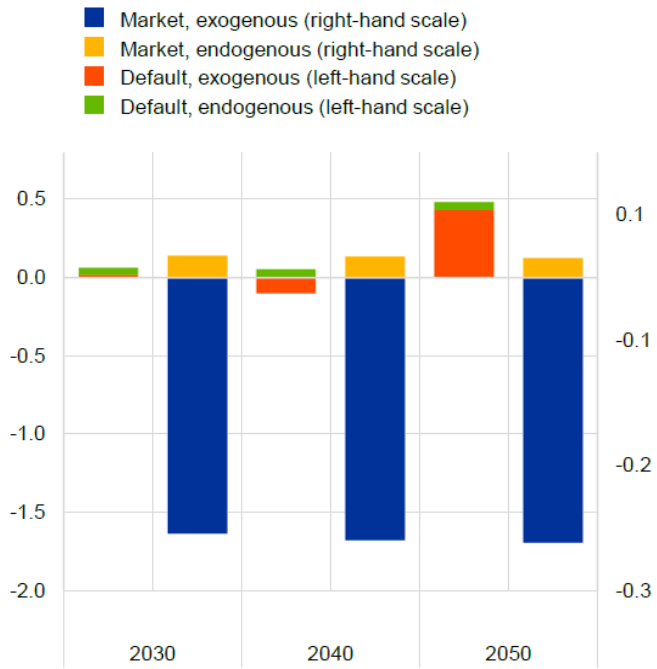
System-wide interactions

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.

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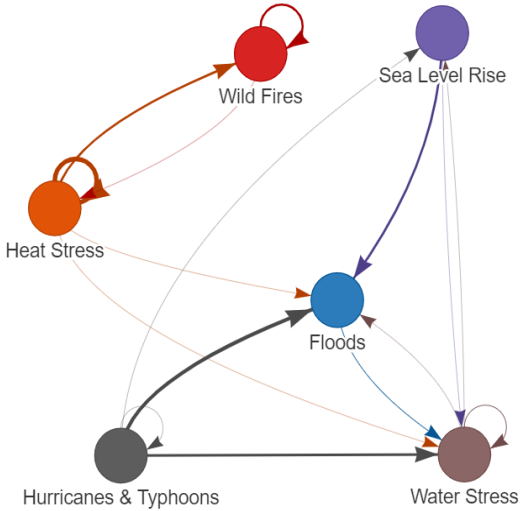
5. Summary

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

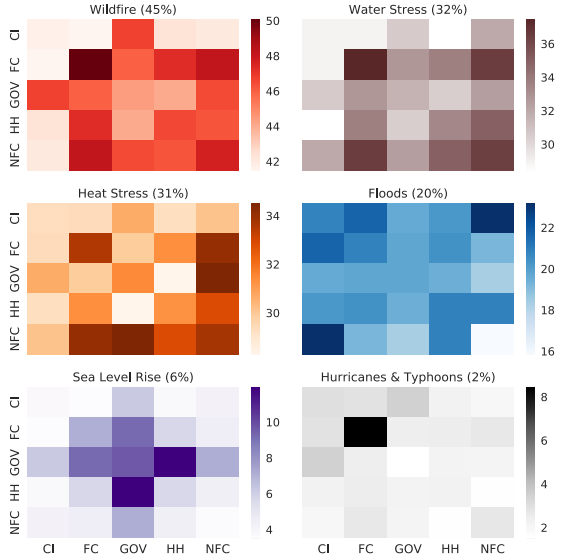
Interdependencies of natural hazards

(Arrows based on hazards' correlations and causal relations)



Physical-risk-weighted overlapping portfolios

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

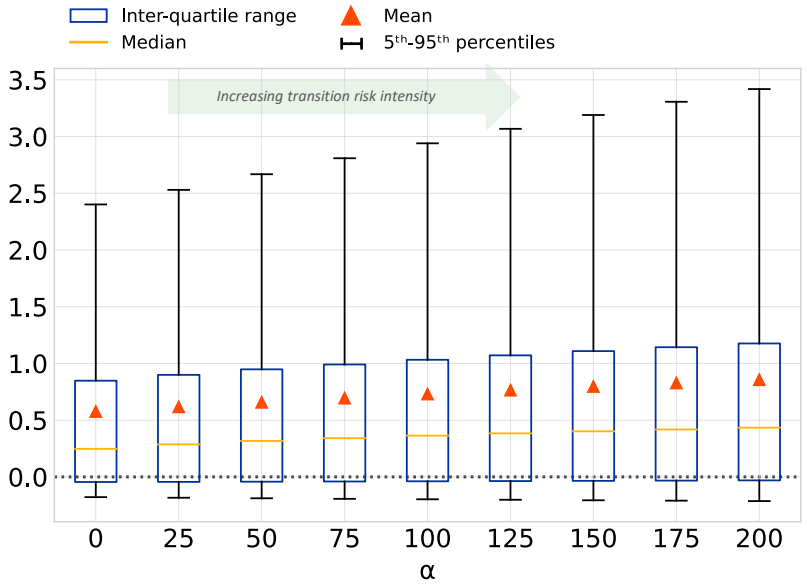


Sources: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change; Left – Data from Gill and Malamud, "*Reviewing and visualizing the interactions of natural hazards*", 2014, and ECB calculations. Right – Security Holding Statistics, 427, and ECB.
Notes: Left – Links refer to both correlations 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 (α) , %)

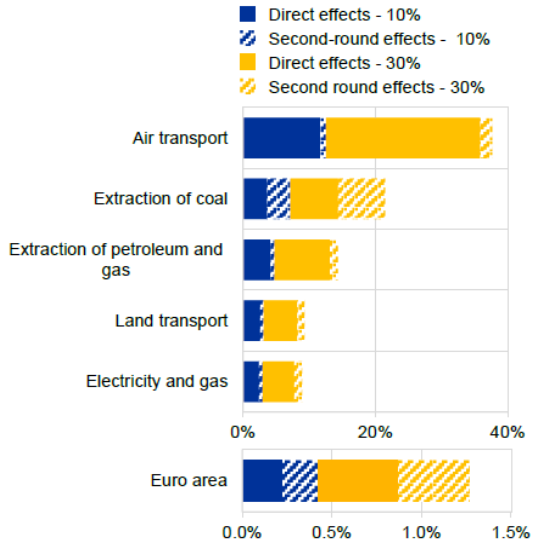


Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

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 β capturing the degree to which firms can pass the cost of a transition risk shock to consumers.

Potential systemic amplifiers (*transition risk*)

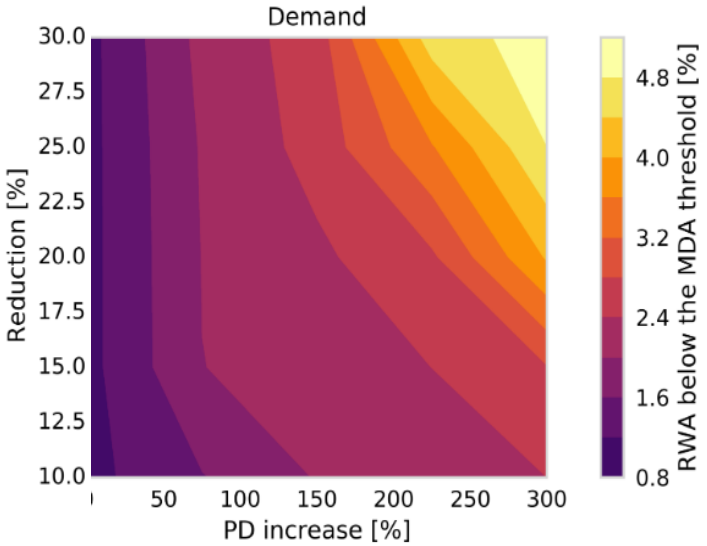
Euro area sectoral impacts of demand shocks
[percentage share of production]



Source: ECB/ESRB (2022), The Macroprudential Challenge of Climate Change.

Note: Results for the five most affected sectors only.

Banks' risk-weighted assets (RWA) below the MDA threshold
(percentages of total euro area risk-weighted assets))



Notes: Increases in PD refer to increases for firms hit by an average euro area output loss, with the credit quality associated with higher (lower) output loss deteriorating proportionally more (less). The sample includes 2,130 banks comprising significant institutions and less significant institutions.

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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

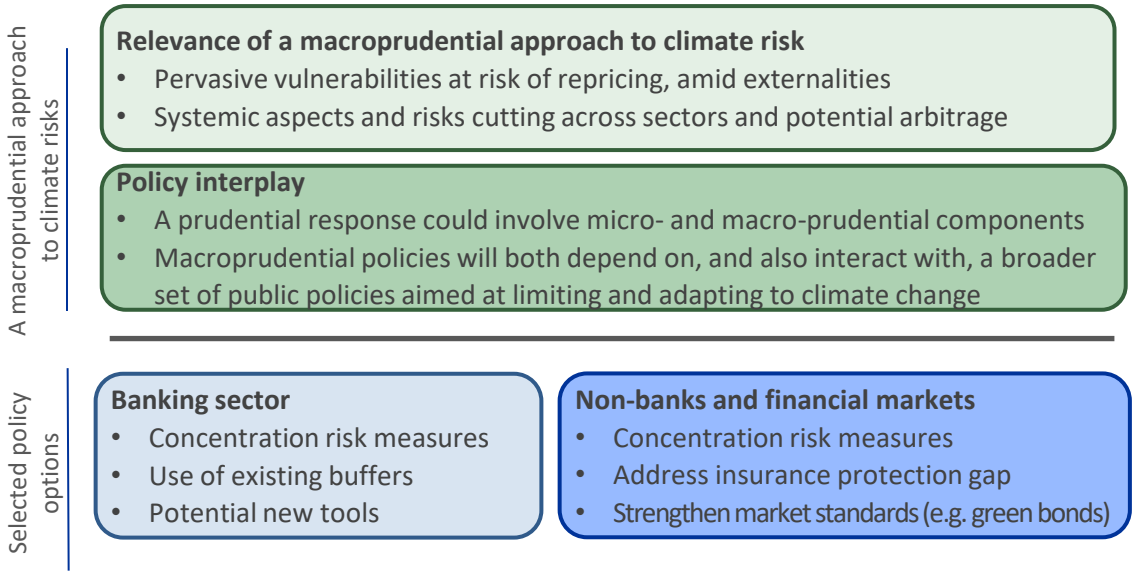
- Climate shocks initially impact market risk (nonbanks), followed by credit risk (banks), with financial system risk propagation potentially amplifying revaluation losses up to four times
- The path to reduced climate risk may be bumpy, with near term tradeoffs inherent to climate risk benefits from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

See ESRB/ECB (2022), *The macroprudential challenge of climate change*, *and* ESRB/ECB (2021), *Climate-related risk and financial stability*

The case for a macroprudential approach to climate risks

With its system-wide perspective, a macroprudential approach to climate risks, as for other systemic risks, could help to address risks that cut across sectors and to limit arbitrage:

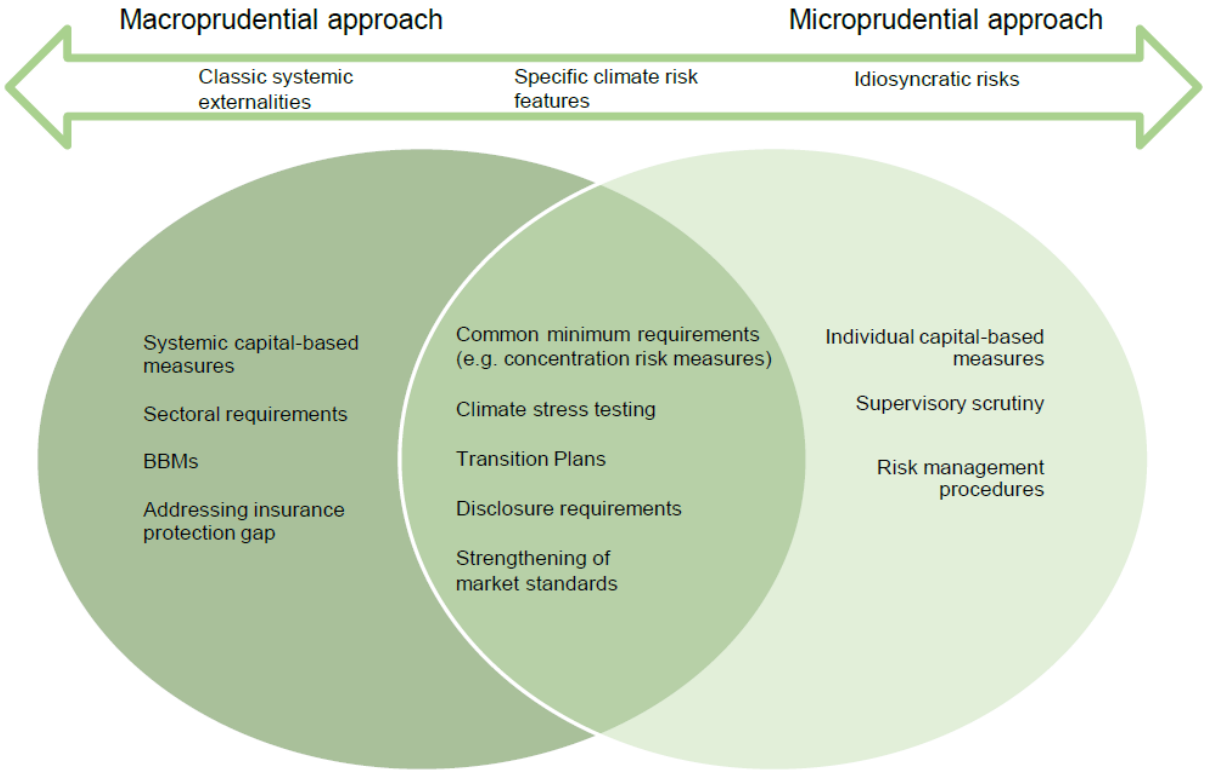
- *Crossholdings and common exposures across the financial system will likely amplify a materialisation of climate risks.*
- *The externality associated with excessive lending to high carbon projects*



Source: *The macroprudential challenge of climate change*
Note: This figure is for illustration purposes and not meant to be comprehensive

Policy interplay and coordination

- Macroprudential measures need to be seen in the context of a holistic prudential approach to climate risk.
- Some measures may form part of both micro-and macroprudential approaches
- Macroprudential and microprudential authorities should take into account existing risk-mitigating policies
- Global coordination in addressing systemic climate risks is paramount



Source: *The macroprudential challenge of climate change*
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Summary takeaways

Build on growing body of empirical evidence, addressing analytical gaps (*scope*, *scale* and *horizon* of climate risk)…

Measurement

- Combining climate and financial risk metrics suggests pockets of vulnerabilities
- These could be amplified by correlated shocks and overlapping portfolios

Modelling

- Systemic risk will be aggravated by system-wide dynamics along the transition
- Impacts on financial system likely to begin with market risk which extends to credit losses

… to support a reflection on macroprudential policy options

Macroprudential policy, to…

… complement and mutually reinforce microprudential efforts

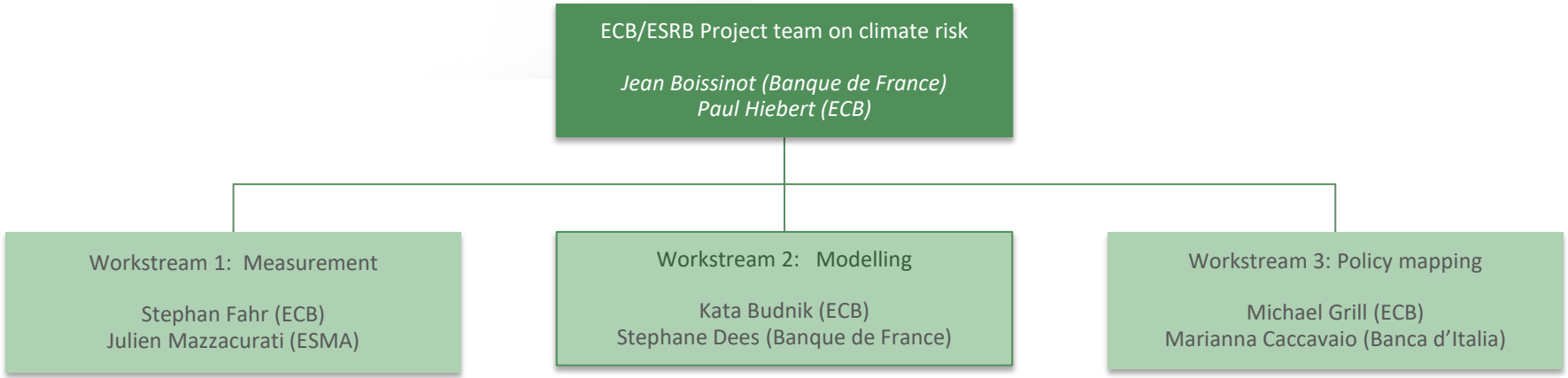
… address risks that cut across sectors & countries and to limit arbitrage

... depend on, and interact with, a broader set of policies aimed at adapting to climate change and limiting its impacts

Source: ECB/ESRB (2022)
The macroprudential challenge of climate change

Background slides

The ECB/ESRB Project Team on climate risk



European institutions: European Central Bank | European Commission | European Banking Authority | European Securities and Markets Authority | European Insurance and Occupational Pensions Authority

National Macroprudential Authorities: Austria | Belgium | Bulgaria | Croatia | Cyprus | Czech Republic | Denmark | Estonia | Finland | France | Germany | Greece | Hungary | Ireland | Italy | Latvia | Lithuania | Luxembourg | Malta | Netherlands | Poland | Portugal | Romania | Slovakia | Slovenia | Spain | Sweden