



EUROPEAN CENTRAL BANK

EUROSYSTEM



ESRB

European Systemic Risk Board

European System of Financial Supervision

Climate-related risks: *A financial stability angle for Europe*

SUERF and BAFFI Bocconi e-lecture

15 February 2022

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Overview

1 Climate shocks

2 Greening financial markets

3 Financial exposures to climate change

- Physical risk
- Transition risk

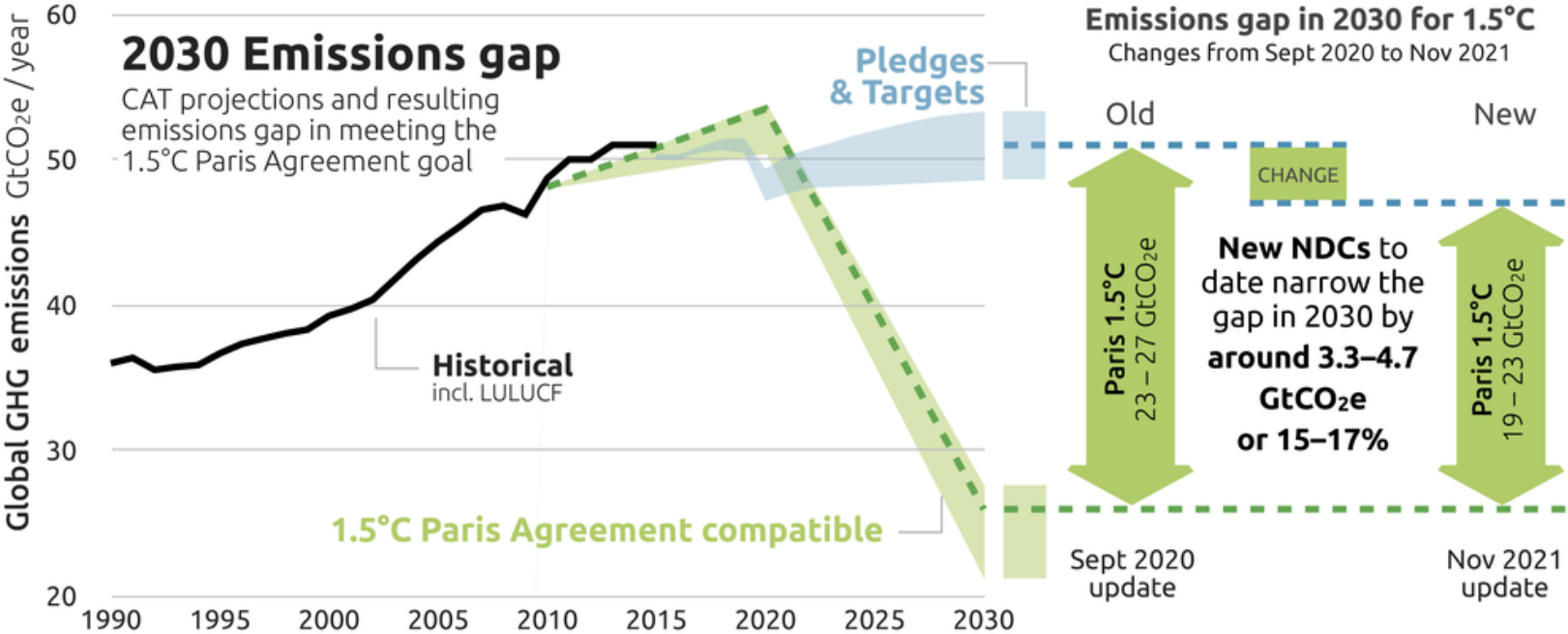
4 Forward-looking scenario analysis

5 Conclusions

No free lunch

Projections for carbon emissions & warming

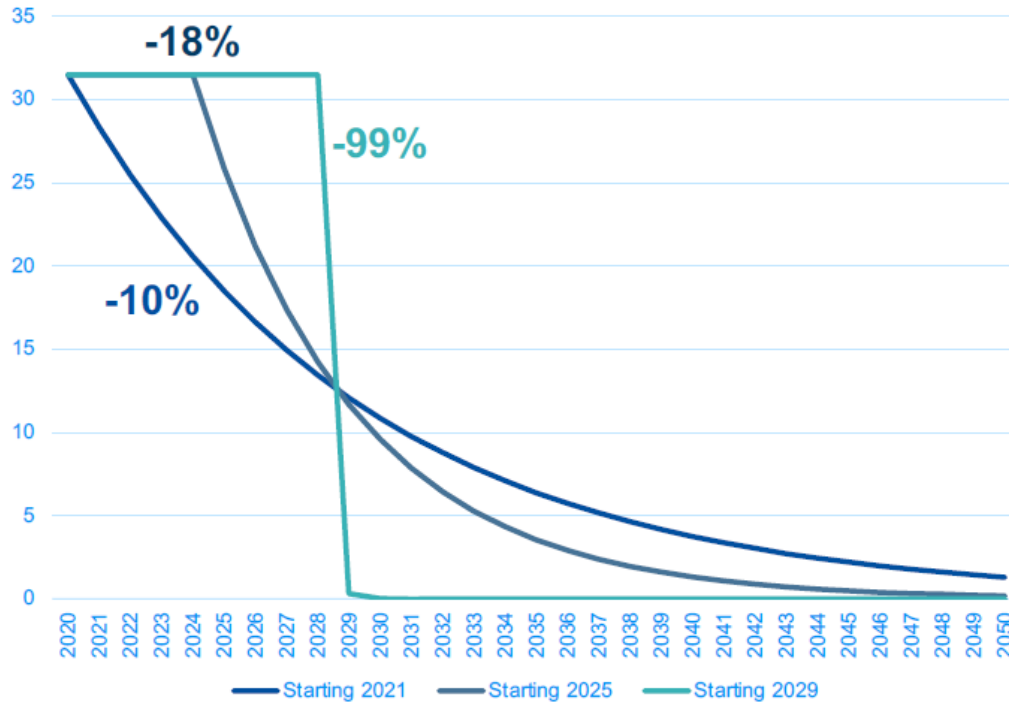
(Emissions in gigatonnes of CO2 per year)



Source: Climate Action Tracker, Warming Projections Global Update, November 2021.

Timing is everything

Decarbonization Rates Depending on the Entry Point



Source: Bolton, P., Kacperczyk, M., and Samama, F. (2022). Net-zero carbon portfolio alignment. SSRN, see <https://ssrn.com/abstract=3922686>

Why climate risks are special



Global dimension, while local impact varies



Amplification mechanisms such as non-linearities and tipping points



Uncertainty on evolution of climate change and impact and timing of policies...



... as well as **complex interactions** between transition and physical risk



Irreversibility of climate change if not timely mitigated



Long time horizons as impact mostly expected in the long run

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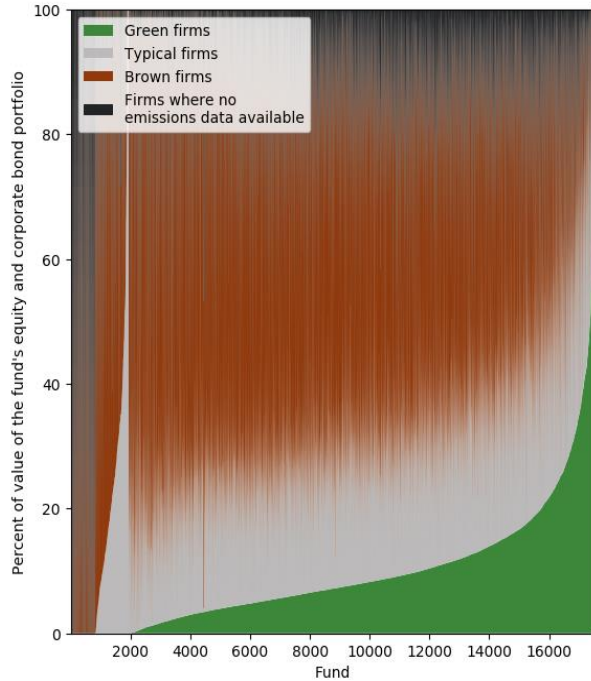
- Physical risk
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4 Forward-looking scenario analysis

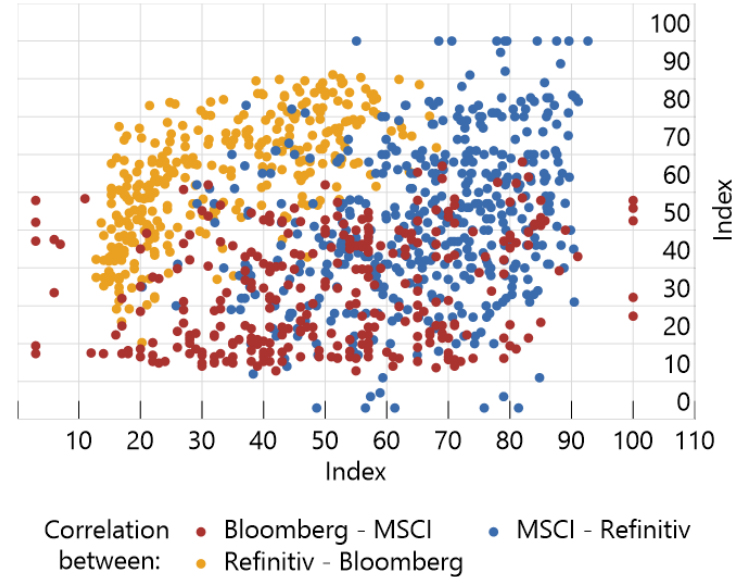
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A substantial portfolio adjustment may lie ahead, amid greenwashing risks

Share of portfolios in green vs. brown firms (%)



Correlation of firms' ESG scores provided by different providers (Indexes)

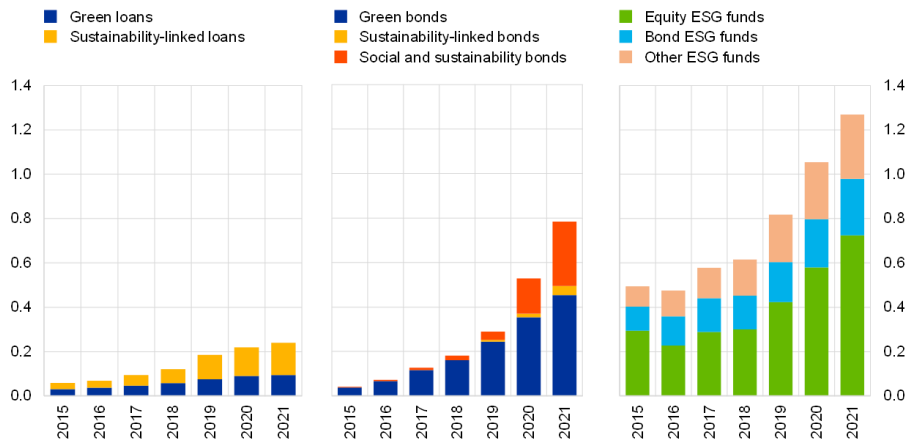


Sources: LHS: ECB/ESRB (2021), [Climate-related risk and financial stability](#) based on Artemis, Bloomberg, EMIR, EPFR, Lipper and ECB calculations RHS: Morningstar, Refinitiv, ESMA.
 Notes: LHS: Percent share of each individual fund's equity and corporate bond portfolio (vertical axis) that is allocated to firms classified according to their portfolio emissions. The horizontal axis denotes individual funds, sorted according to the percent share of exposures to green firms in the portfolio (from lowest to highest share). RHS: OECD Staff calculations; from Boffo and Patalano (2020).

Who will finance the adjustment?

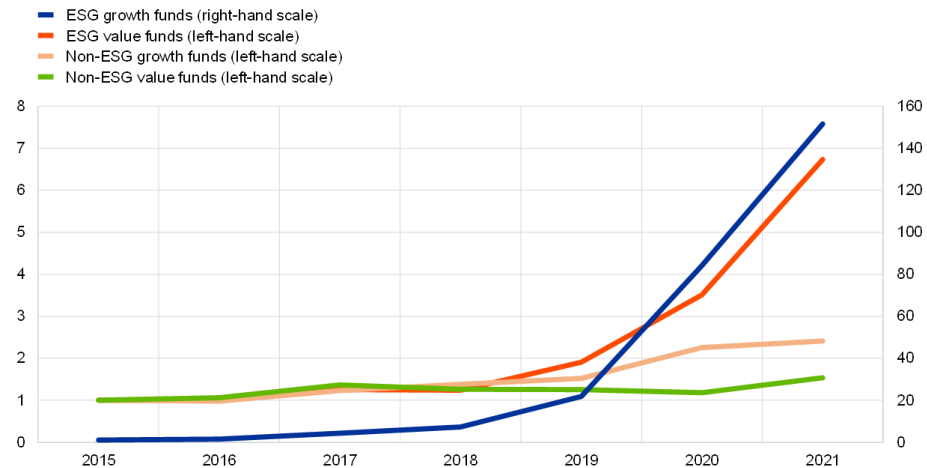
Sustainable capital market financing versus bank lending

(Outstanding amount and AuM of euro area sustainable financial instruments; EUR trillion, outstanding amount for bonds and loans, AUM for ESG funds, December 2015 to June 2021)



Rapid increase in growth ESG equity funds

Rebased total net assets (TNA) of euro area equity funds; TNA, rebased to 1 in 2015, December 2015 to June 2021



Source: Born, Guizio, Lambert, Salakhova, Schölermann, and Tamburrini, [“Towards a green capital markets union: developing sustainable, integrated and resilient European capital markets”](#), ECB Macroeprudential Bulletin, October 2021. Notes: Data based on Bloomberg and ECB calculations (LHS chart), Sources: EFPR and ECB calculations, based on representative sample of EPFR firms (RHS chart).

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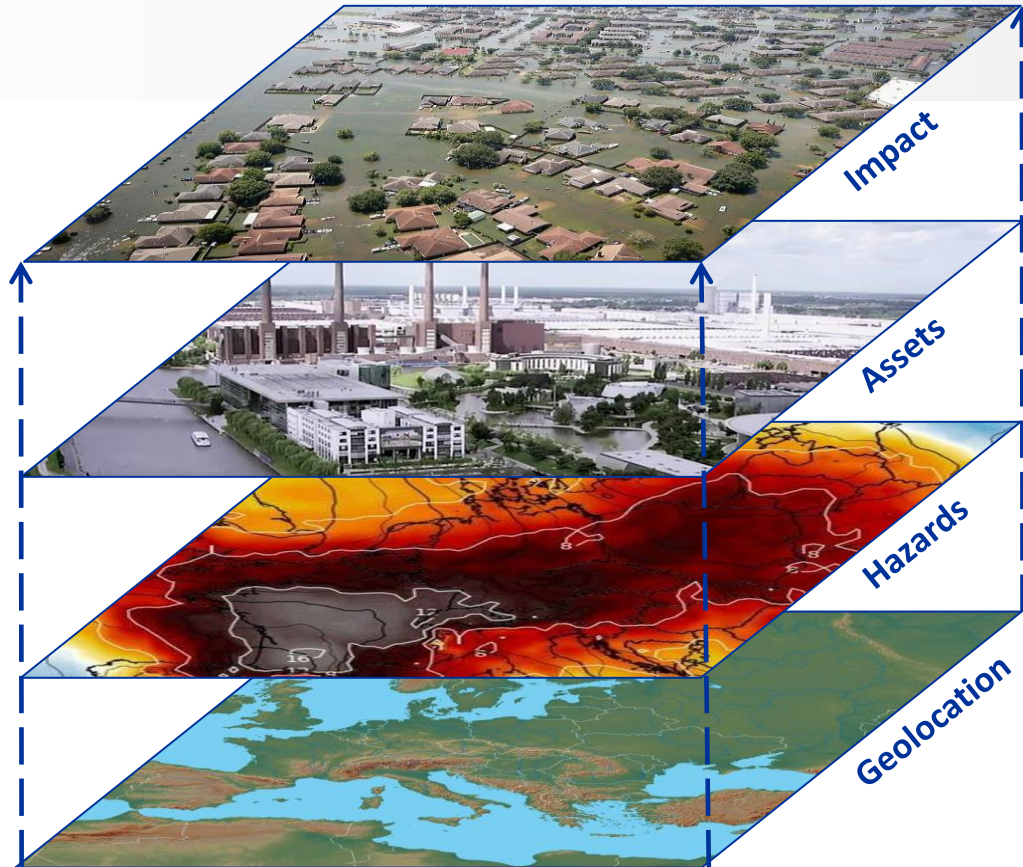
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From physical climate risk to financial risk



Impact

- $\text{Exposure} * \text{Vulnerability} * \text{Adaptation}$
Economic damages
Portfolio exposures of financial institutions

Assets

- By critical services and use of land
- **Financial variables:** fixed assets and financial statements
- **Socio-economic variables:** population, labour

Hazards

1. Hurricanes/ storms
2. Sea level rise
3. Floods
4. Water stress
5. Heat stress
6. Wildfires

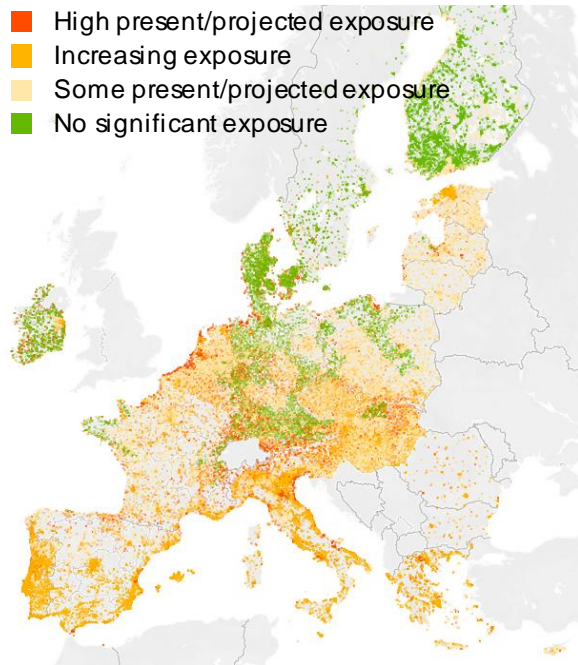
Geolocation

- Region, address, latitude / longitude

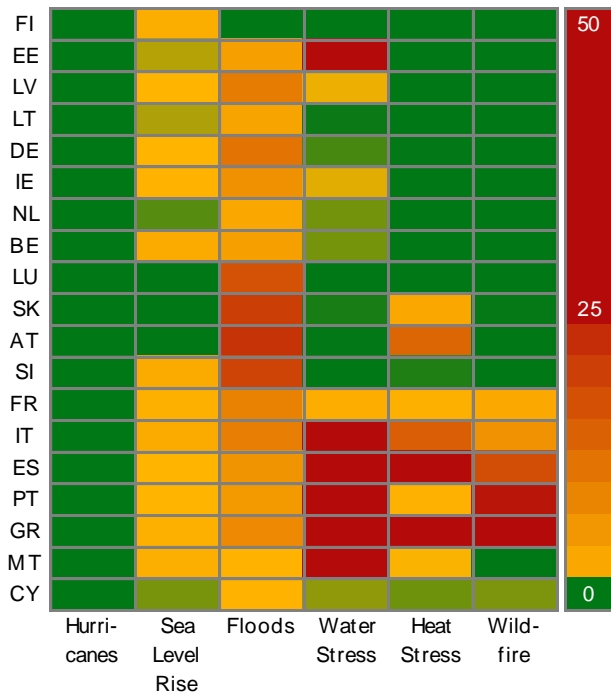
Regional concentration of exposures

Mapping firm exposures to physical hazards

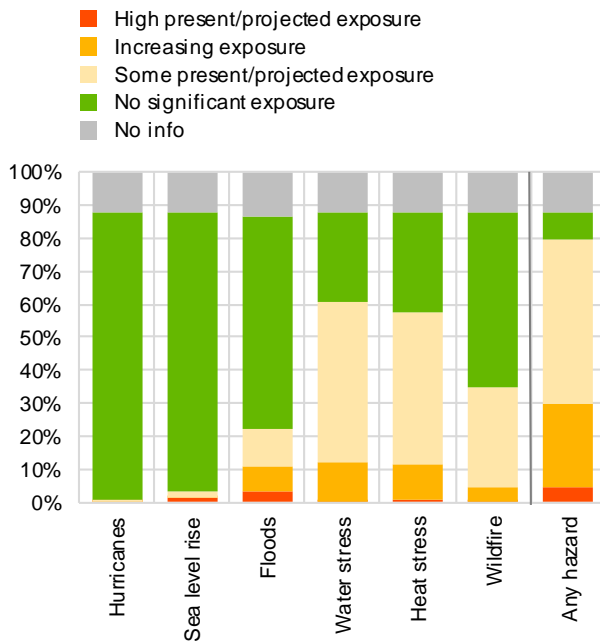
Index, Maximum firm exposure to physical hazards



Share of firms to high or increasing exposure to a physical hazard (%ages)



Share of euro area bank credit exposures to firms, by firm physical risk level (percentages of total bank exposures to NFCs)

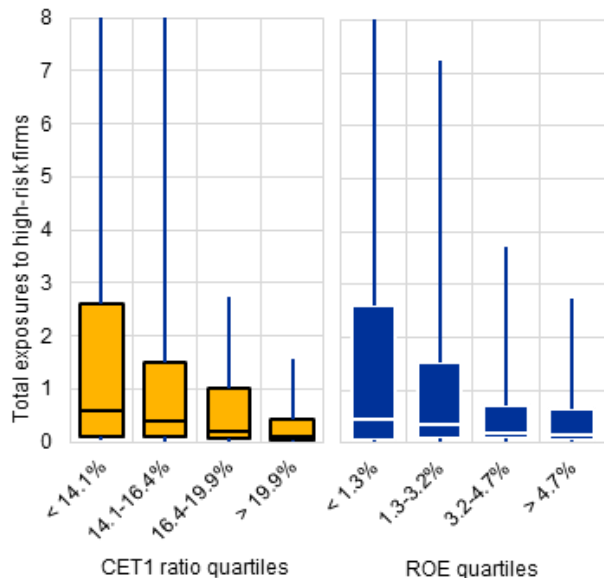


Sources ECB/ESRB (2021), [Climate-related risk and financial stability](#) based on AnaCredit, 427. Notes: Physical risk hazard scopes over a 20-year horizon. information refers to firm HQ location. Scores for different risk categories may translate differently into risk levels and economic damages,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

The confluence of climate and financial risk, at the bank level

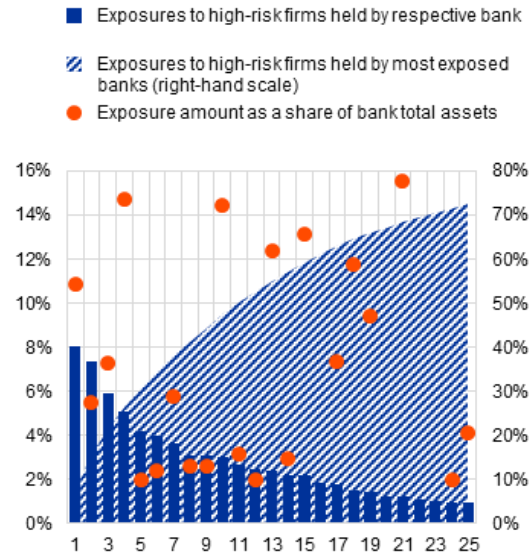
Distribution of banks' exposures to firms located in areas of high or increasing physical risk, by level of capital and profitability

(EUR billions)



Concentration of exposures to firms located in areas of high or increasing physical risk in the banking system

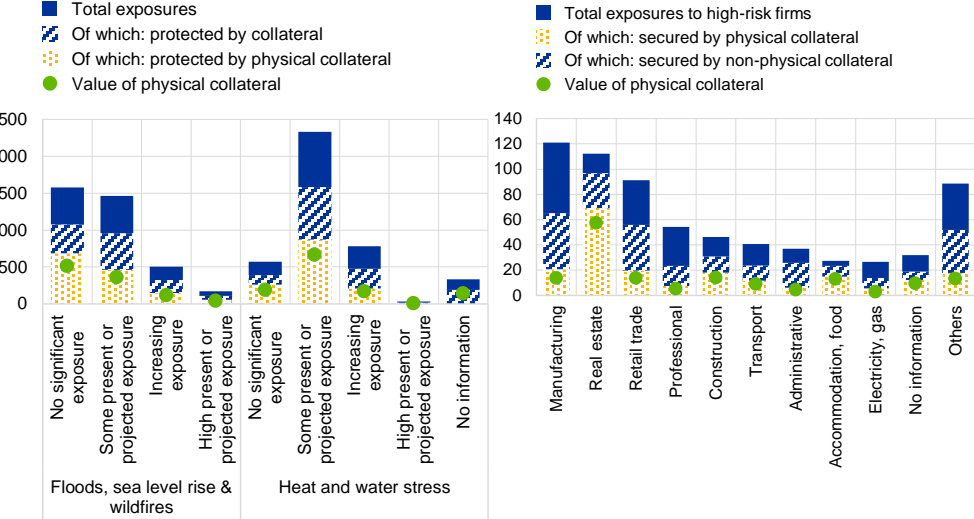
(EUR billions)



What role for mitigants?

Banks' credit exposures secured by physical and financial collateral by risk category / sector (EUR billion)

(EUR billion)

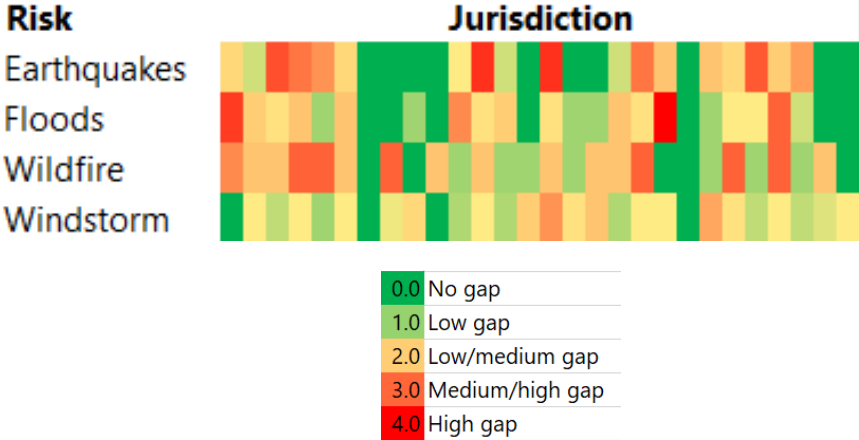


Sources: ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on AnaCredit, and 427 data.

Notes: Maximum risk level across the following risk categories is considered: floods, sea level rise and wildfires; only credit exposures to NFCs above €25,000 are considered; €4.2 trillion of exposures overall; NFC location used to assign risk levels refers to the headquarters; the total collateral value at instrument level is capped at the value of the instrument; insurance coverage not included. Data as at December 2020.

Protection gap for European countries by hazard

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



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

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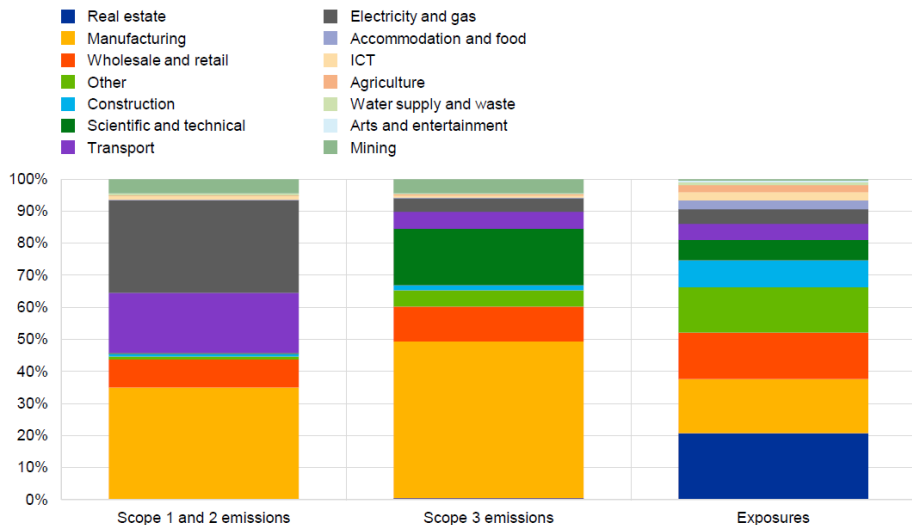
- Physical risk
- **Transition risk**

4 Forward-looking scenario analysis

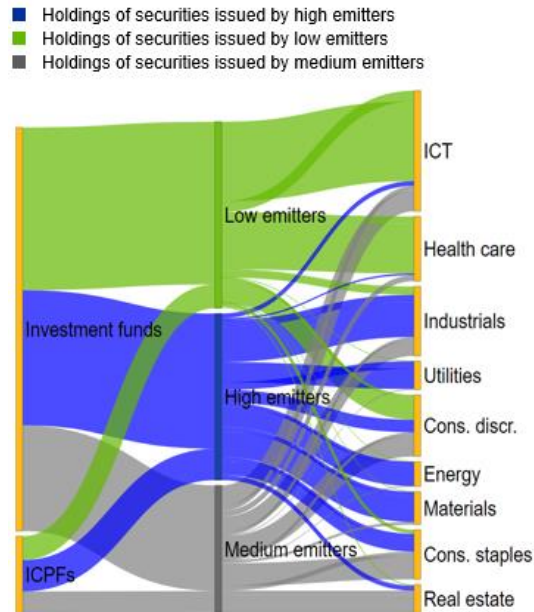
5 Conclusions

Sectoral concentration of transition risk exposures

Emissions by sector, and banks' loan exposures (percentages)



Non-banks' exposure to transition risk via equity and debt securities (exposures and emissions: Q4 2019; total holdings of NFC securities by sector)

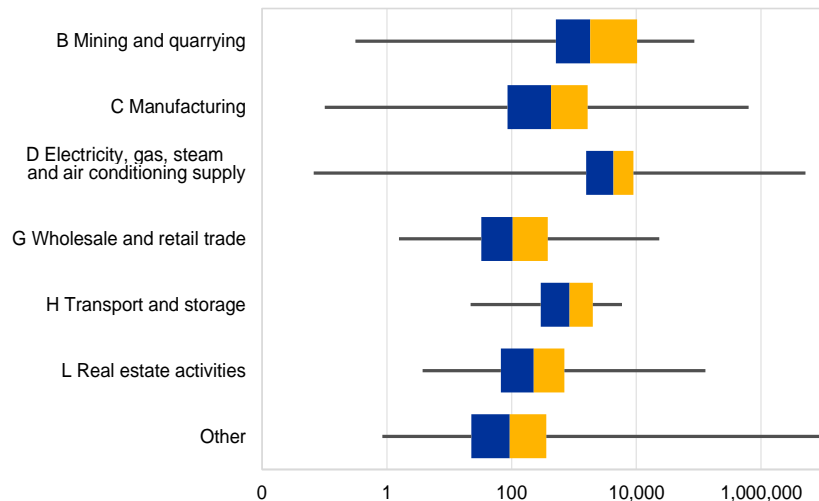


Sources: LHS: Alogoskoufis et al (2021), [ECB economy-wide climate stress test](#), based on Urgentem and Anacredit data. RHS: ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on Securities Holding Statistics, SHSS, Urgentem, Eikon. Notes: The panel captures the exposure of non-bank financial institutions to firms that issue bonds or are listed in the equity market. These firms are classified as low, medium and high emitters according to their emissions intensities (scope 1, 2 or 3) in December 2019, i.e. the ratio of CO2 emissions to revenue. Low emitters are firms with less than 309 CO2 equivalent tonnes/USD million of revenue (33rd percentile), while high emitters are firms with more than 1,068 CO2 equivalent tonnes/USD million of revenue (66th percentile).

Transition risks not just *across*, but also *within* sectors

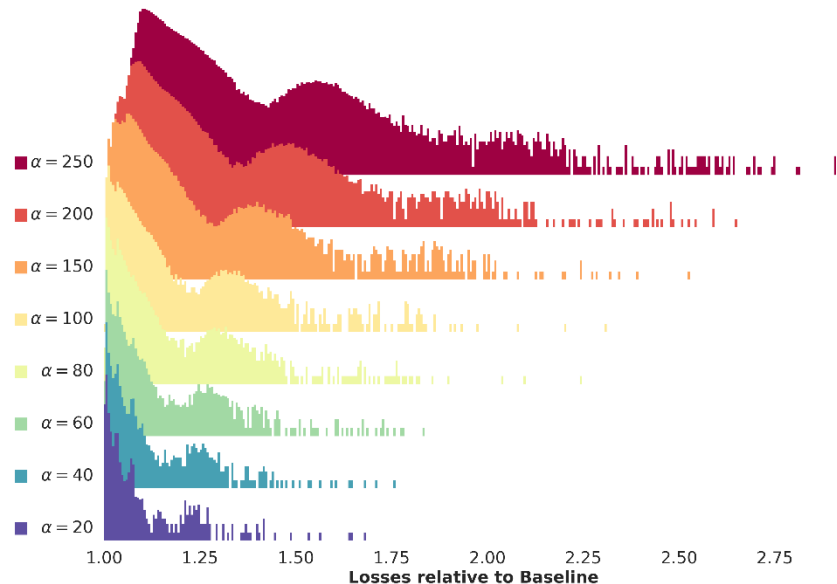
Firm-level emission intensities within and across sectors in the euro area

(Scope 1,2 and 3 emissions in tonnes of CO2 equivalents per USD million revenue)



Banking system losses for different changes in carbon price

(α : change in carbon price; loss difference = loss in simulation relative to baseline)



Source: ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on Urgentem. Note: Only firms directly reporting emissions are considered (approximately 3000 European firms)

Sources : ECB/ESRB (2021), [Climate-related risk and financial stability](#), based on Supervisory Statistics, Urgentem and ECB calculations. Notes: Results are based on a sensitivity study using a banking system interconnectedness model based on firm-level exposures and emissions of euro area large exposures. The quantifications assume full pass-through of changes in carbon (alpha) price to firms and no reductions in firm emission for different levels of carbon price. Firms' assets are impacted proportionally to their emissions, in turn affecting their PDs (Merton model). Heights of densities are in logs.

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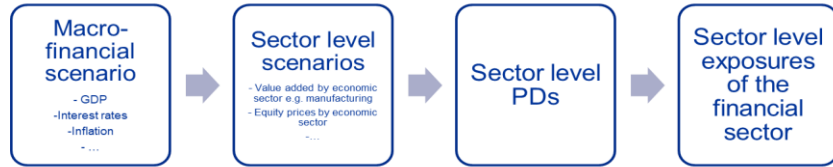
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Evolving stress test methodologies

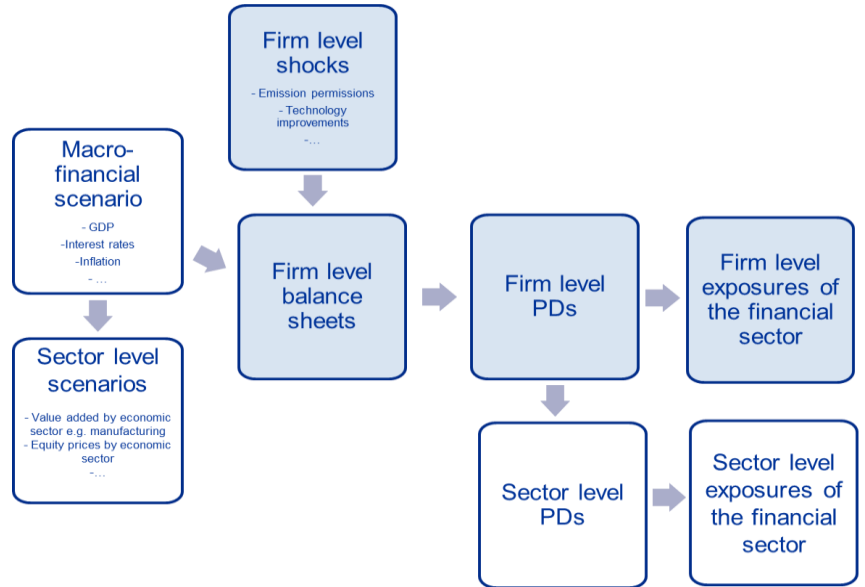
Vintage 1:

Sector-level approach for credit risk in climate stress-tests

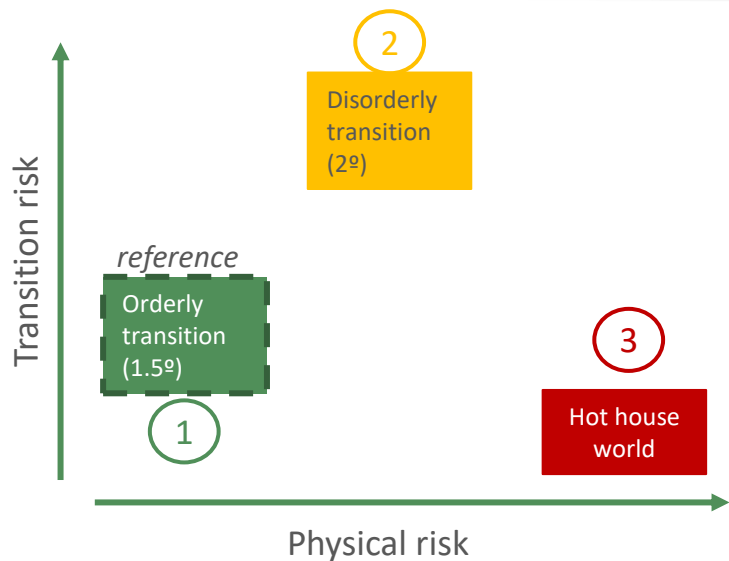


Vintage 2:

Firm-level approach for credit risk in climate stress-tests



The scenarios



Expected impact

1. Orderly transition with limited physical risk

Early and effectively implemented policies
Limited costs from transition and physical risk

2. Disorderly transition with average physical risk

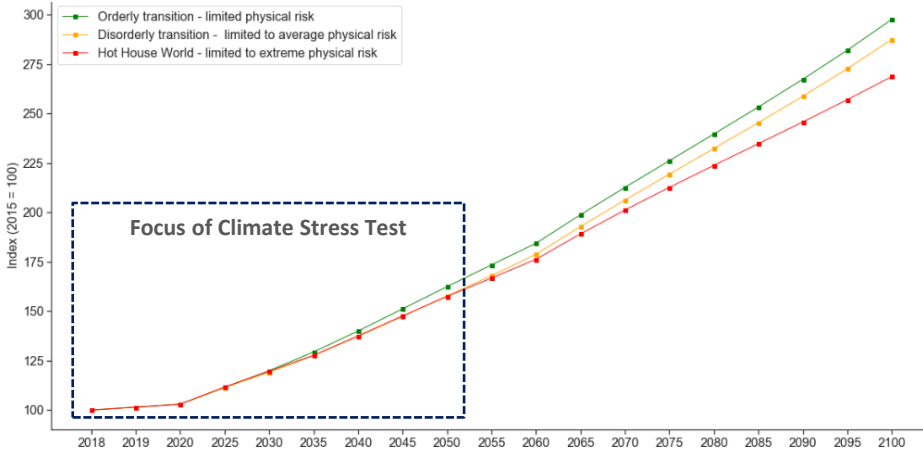
Delayed policies implemented
High costs from transition and average costs from physical risk

3. Hot house world with extreme physical risk

No new policies implemented (only current policies)
Very limited costs from transition but extremely high costs from physical risk

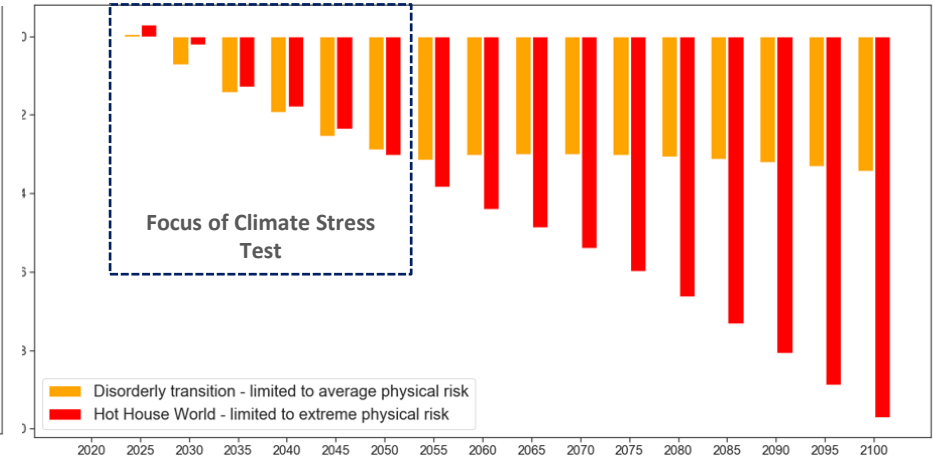
The scenarios: *Underlying economic paths*

GDP evolution (Indexed, 2005=100)



Source: ECB calculations on NGFS references scenarios (2020)

GDP deviation from orderly transition scenario (%)



Channels of bank risk

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



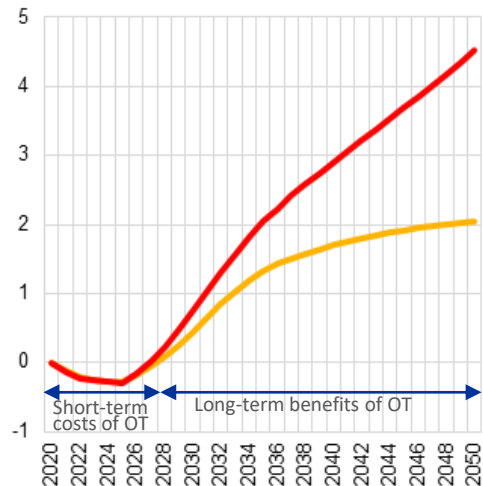
Mitigants: Insurance coverage protects capital from damages

Amplifiers: Insurance costs increase in some vulnerable areas

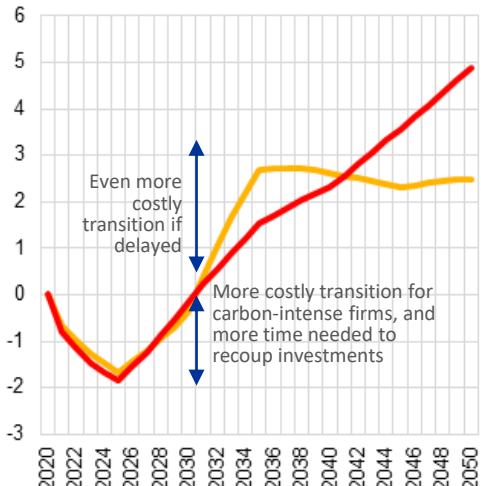
Corporates

PDs: Median firm

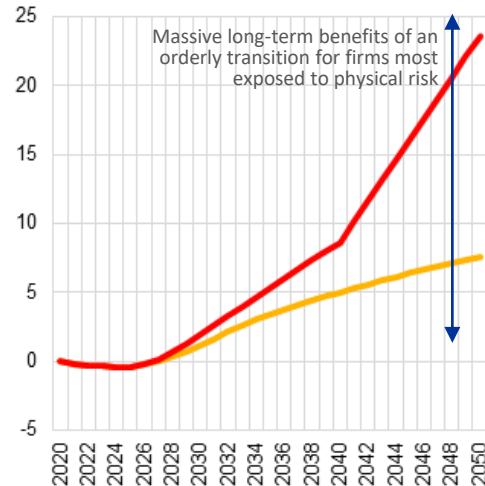
All charts: % differences in adverse scenarios compared to orderly transition scenario



PDs: Carbon intensive firms



PDs: High physical risk firms

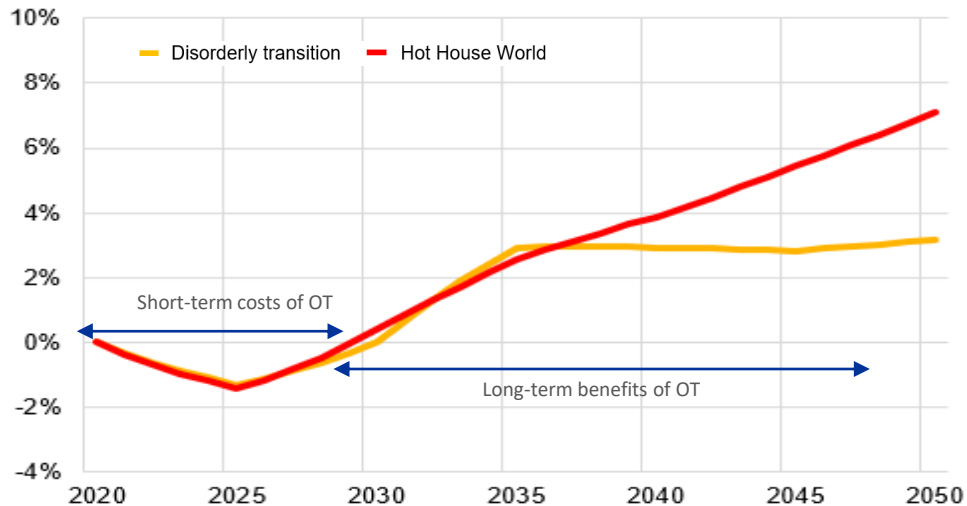


— Disorderly transition — Hot House World

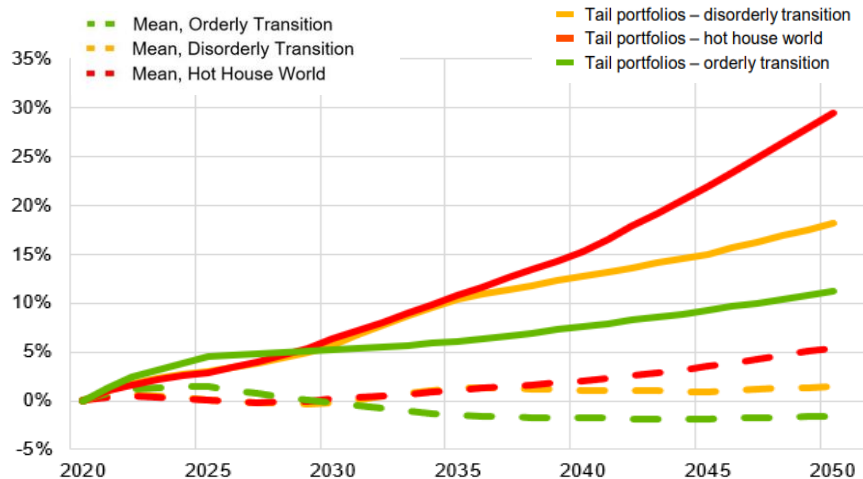
Banks: Default probabilities

Portfolio PDs: Time evolution

% differences in adverse scenarios compared to orderly transition scenarios



% differences from 2020 for the tail of banks (upper 10th percentile)



Scenario analysis: System-wide deployment of long-term scenarios

	Banking sector	Insurance sector	Investment funds
NGFS Scenarios	Disorderly and Hot house	Disorderly vs. Orderly (baseline)	Disorderly vs. Orderly (baseline)
Horizon	30 years	15 years (data as of 2035)	15 years (data as of 2035)
Sample	26 volunteer EU banks participating in the EBA pilot exercise	1569 EEA (excl. UK) domiciled insurance companies on a solo basis	23,332 (therein 18,513 UCITS, 1,555 AIFs and others not classified) (EUR 8 trillion investment holdings)
Financial exposures	Non-SME exposures to non-financial obligors domiciled in EU countries	Equity, corporate debt (excl. covered bonds) to climate-sensitive sectors (power, fossil fuels, transport, manufacturing) and government bonds	Equity, corporate debt exposures to 21,107 unique non-financial corporations.
Transmission channels	Credit risk via change in Probability of Default and Loss Given Default)	Asset price revaluation (equity, corporate and government bond prices)	Asset price revaluation (equity and corporate bond prices)
Relevant information	Data collected in the EBA pilot exercise as of end of 2019 (at the level of obligor). PDs from ECB's top-down (2021) stress test exercise	Regulatory reporting under Solvency II. Detailed production level data from 2° Investing Initiative	Morningstar, Refinitiv, ESMA

Scenario analysis: Limited but concentrated losses (under static balance sheets)

Banks:

- Credit risk losses up to 1.75% of risk-weighted exposures to firms in adverse climate scenario
 - Particularly concentrated in electricity and real estate

Insurers:

- Revaluation losses in disorderly scenario on corporate bonds and equity holdings of ca. 5pp
 - Particularly large losses of 15% for equity (less bond) holdings in oil, gas and vehicles

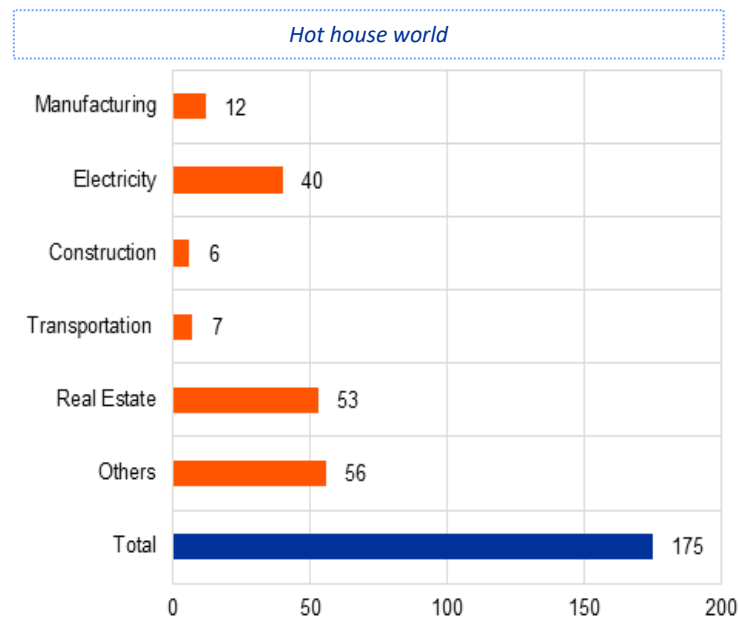
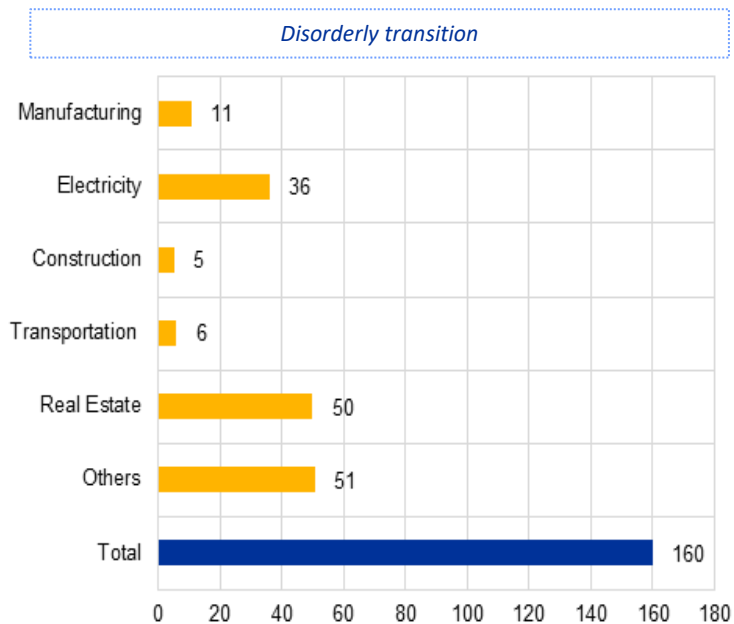
Investment funds:

- Average write down of 1.3% in holdings of equity and corporate bonds in disorderly scenario
 - Particularly driven by investments in energy producers
 - At the fund level, higher emitting investment portfolios could see losses of up to 14%

Climate scenario analysis for banks

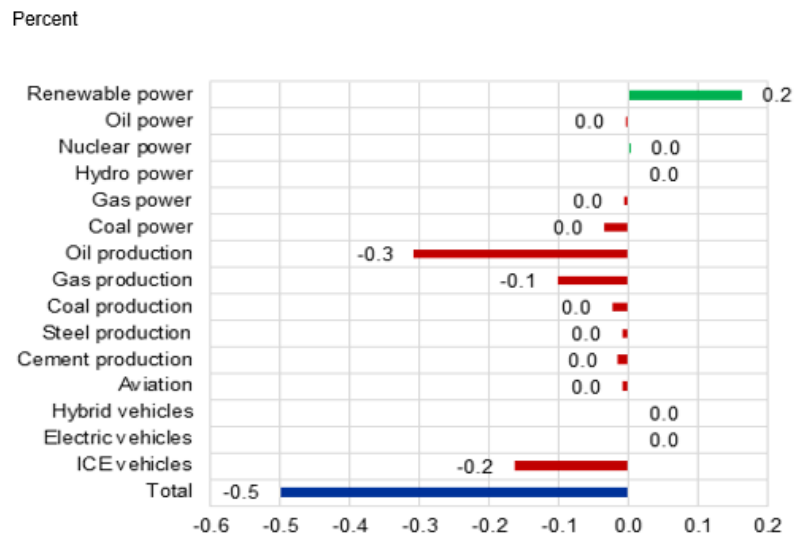
Banks credit losses by sector and scenario: disorderly scenario (LHS) and hot house world scenario (RHS)

(Change in expected losses over credit risk RWA, in basis points)

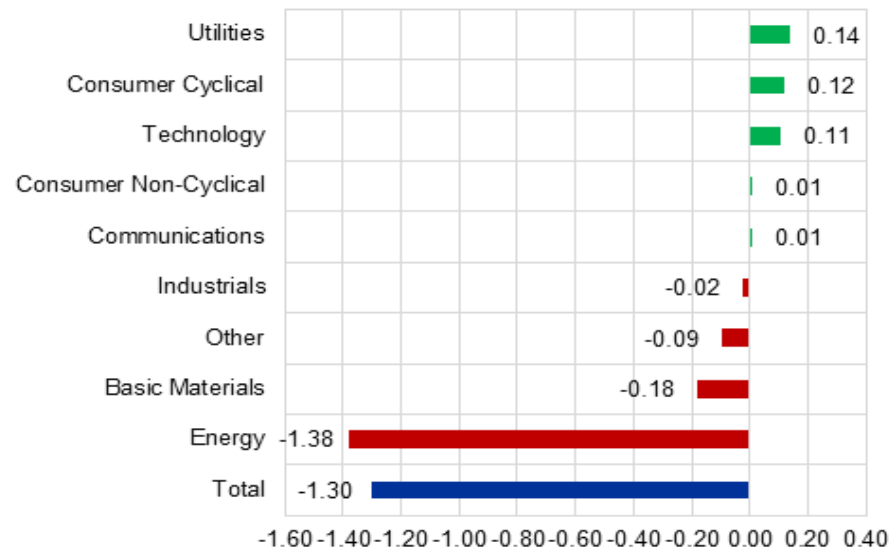


Climate scenario analysis for *insurers* and *investment funds*

Insurance: Cumulative change in the value of equity and corporate bonds as a share of all assessed equity and corporate bonds in the disorderly NGFS scenario



EU investment funds: Losses and sector contributions as % of funds assets



Firm-level climate stress testing: *A conceptual framework*

Top-down exercise
30y horizon, based on NGFS

Climate scenarios

Rich climate data
worldwide

Counterparty level analysis
~4 mn firms worldwide: financials,
emissions and physical risk score
(geolocated)
>2,000 consolidated banks (all
MFIs)

Climate specific:

- *Damages to physical capital*
- *Impact of energy prices/efficiency and technology substitution*
- *Mitigants and amplifiers: insurance, insurance premia*

Novel models to
assess climate
risks

Climate stress-test of non-financial and
financial institutions

Feedback loop to real economy

Economy wide

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Conclusions

Main findings

1. Concentration

- Financial risks concentrated at regional (physical risk) as well as sectoral and firm level (transition risk)
- Associated stranding risks, leaving financial system vulnerable to potentially destabilising financial market corrections

2. Path dependence

- *Banks*: Credit and market risk losses from insufficient /ineffective transition
 - Clear benefits to acting early; physical risks dominant already next decade, with disproportionate losses for vulnerable firms
 - Losses also concentrated in certain geographical areas and sectors
- *Non-banks*: Limited revaluation losses of insurers and asset managers, but concentrated in securities of fossil fuel dependent industries

Needs for further work

- Measurement
- Modelling
- Mapping to prudential policy options