EUROPEAN CENTRAL BANK

EUROSYSTEM

ESRB
European Systemic Risk Board
European System of Financial Supervision

Climate-related risk and financial stability

2021 RiskLab/BoF/ESRB Conference on Systemic Risk Analytics

1 July 2021

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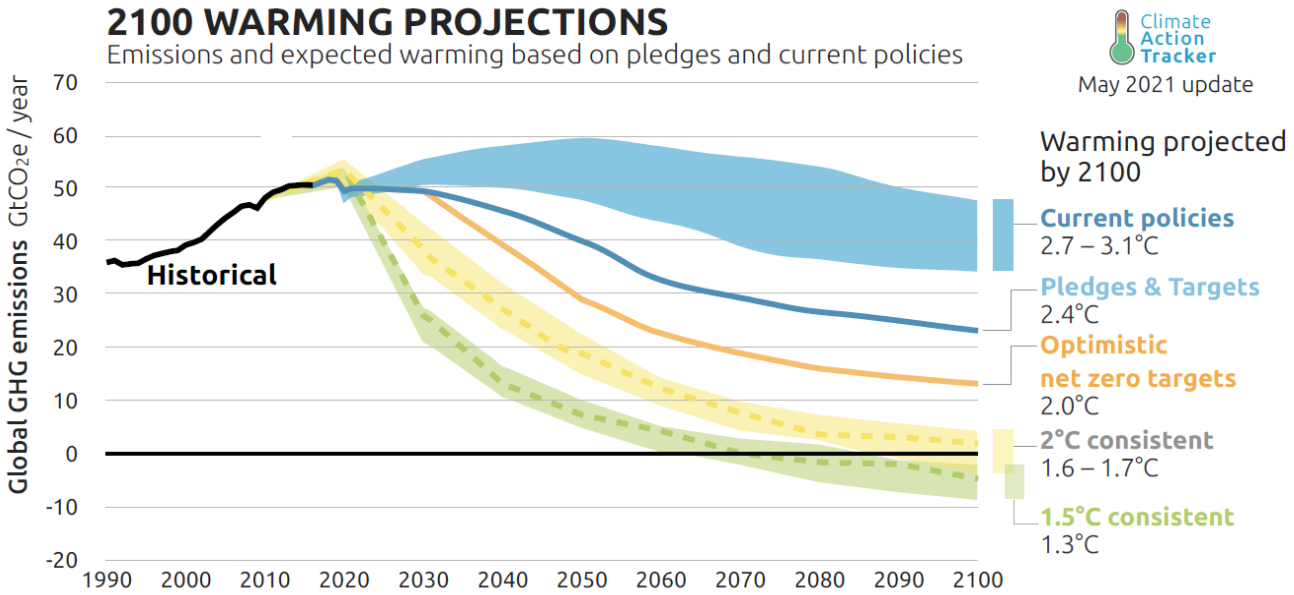
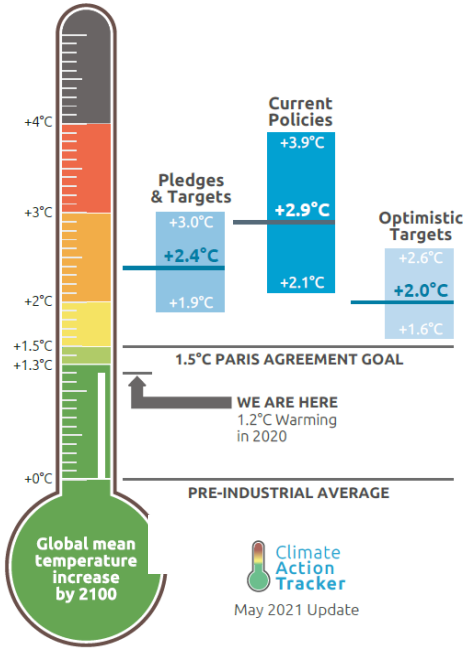
Physical and transition risk: *No free lunch*

- **Estimated costs of no action:** -10-25% GDP in 2100 (OECDm NGFS); USD 20 trillion of stranded assets by 2050 (IRENA)
- **Investment needed to reach Paris target** (global warming < 1.5˚C) : USD830 bn p.a. until 2050 (IPCC, 2018)

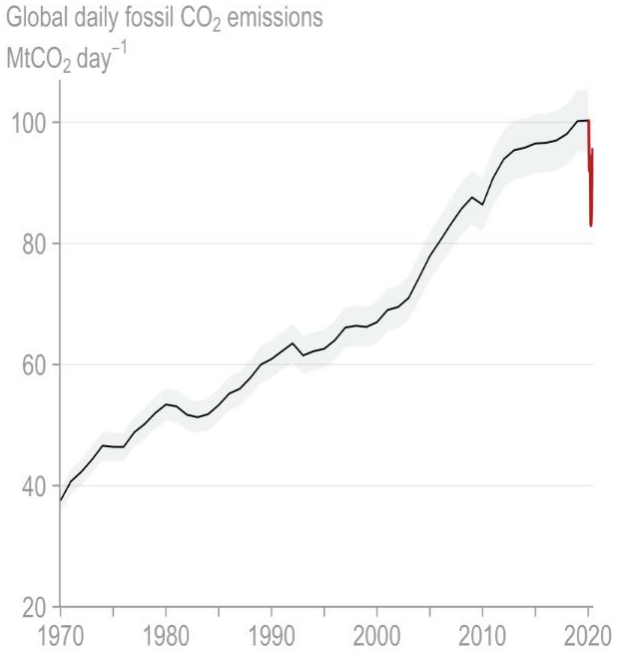




Source: Climate Action Tracker, Warming Projections Global Update, May 2021

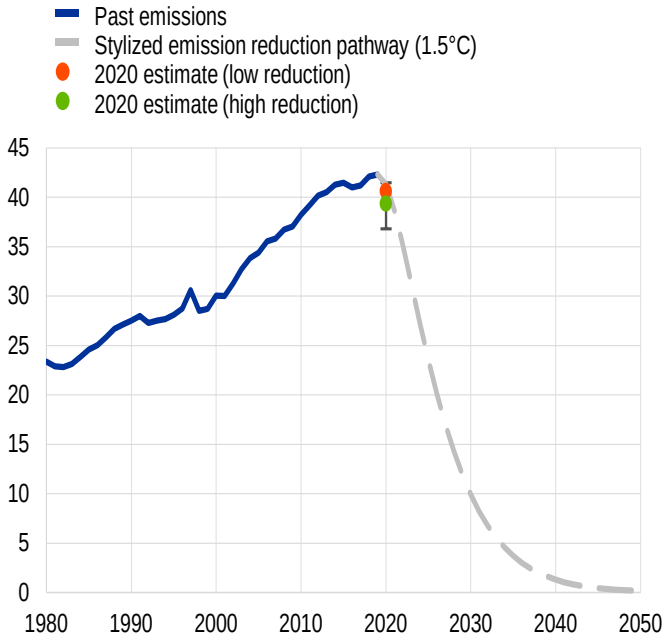
Necessary emission reductions: *Impact of Covid-19 lockdown measures in early 2020*

Drop in 2020 daily average CO_2 emissions in April 2020 = ca. -17%



Source: Le Quéré et al.: Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement, Nature Climate Change, 2020

Annual 2020 emissions fell by ca. 7%



Source: Global Carbon Project, ECB calculations

Starting point: June 2020 report findings*

Main findings:

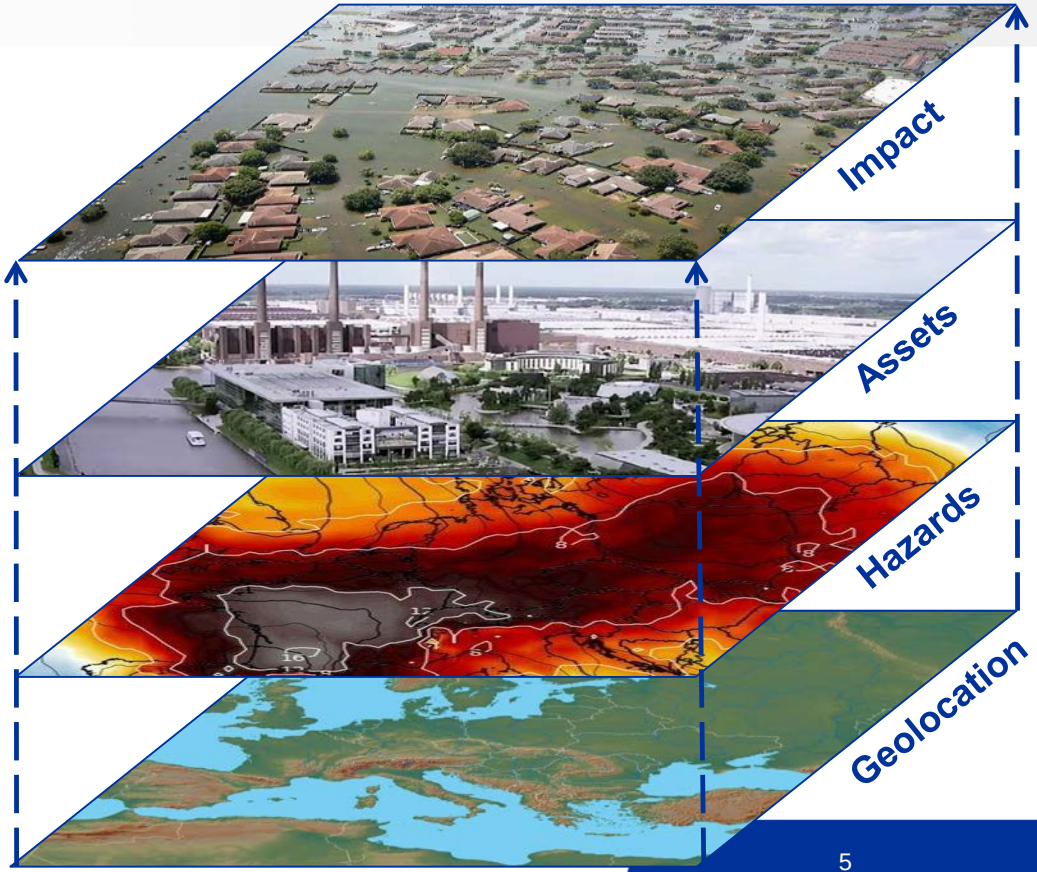
- Climate shocks inevitable (physical or transition, or both)
- Limited financial markets pricing of climate risk (yet), with scale building rapidly
- Euro area financial sector exposures to transition risk contained, concentrated, and abating only mildly
- The short-term costs of climate transition policies pale in comparison to the costs of unfettered climate change in the medium to long term

Needs for further work:

- Encompassing data – more complete, consistent and sufficient
- Additional modelling – to examine nexus of macrofinance with climate

* ESRB report, *"Positively green: Measuring climate change risks to financial stability"* at: https://www.esrb.europa.eu/pub/pdf/reports/esrb.report200608_on_Positively_green_-_Measuring_climate_change_risks_to_financial_stability~d903a83690.en.pdf

Physical risk: Data structure (layers)



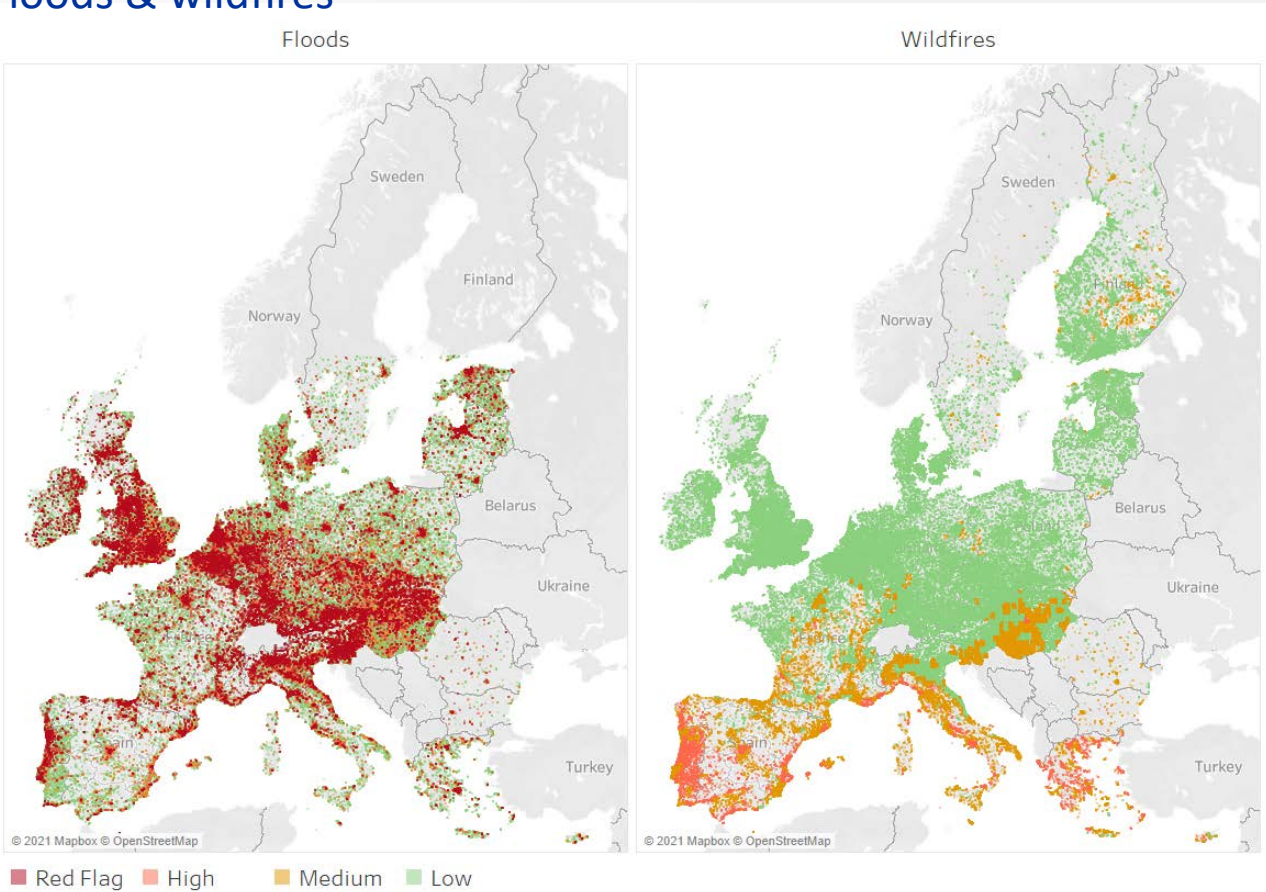
Impact
- Exposure * Vulnerability * Adaptation
  - ➔ Damage to NFC / HH / population
  - ➔ Portfolio exposure of financial institutions

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

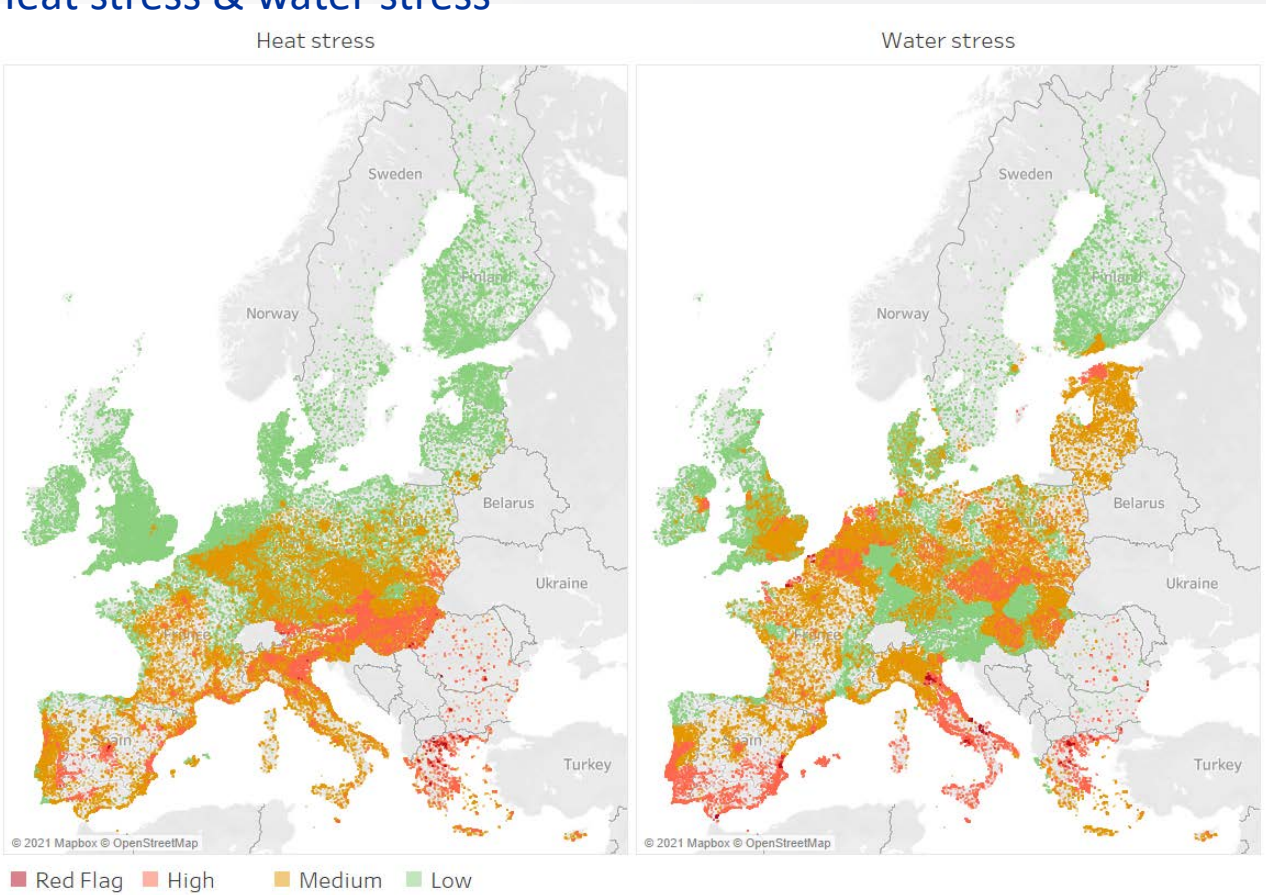
Hazards
- Hydrological: floods (river / coastal)
- Climatological: drought, wildfire, subsidence
- Geological: earthquake, landslide, volcano
- Meteorological: cold / heat wave, windstorm

Geolocation
- NUTS3, address, latitude / longitude

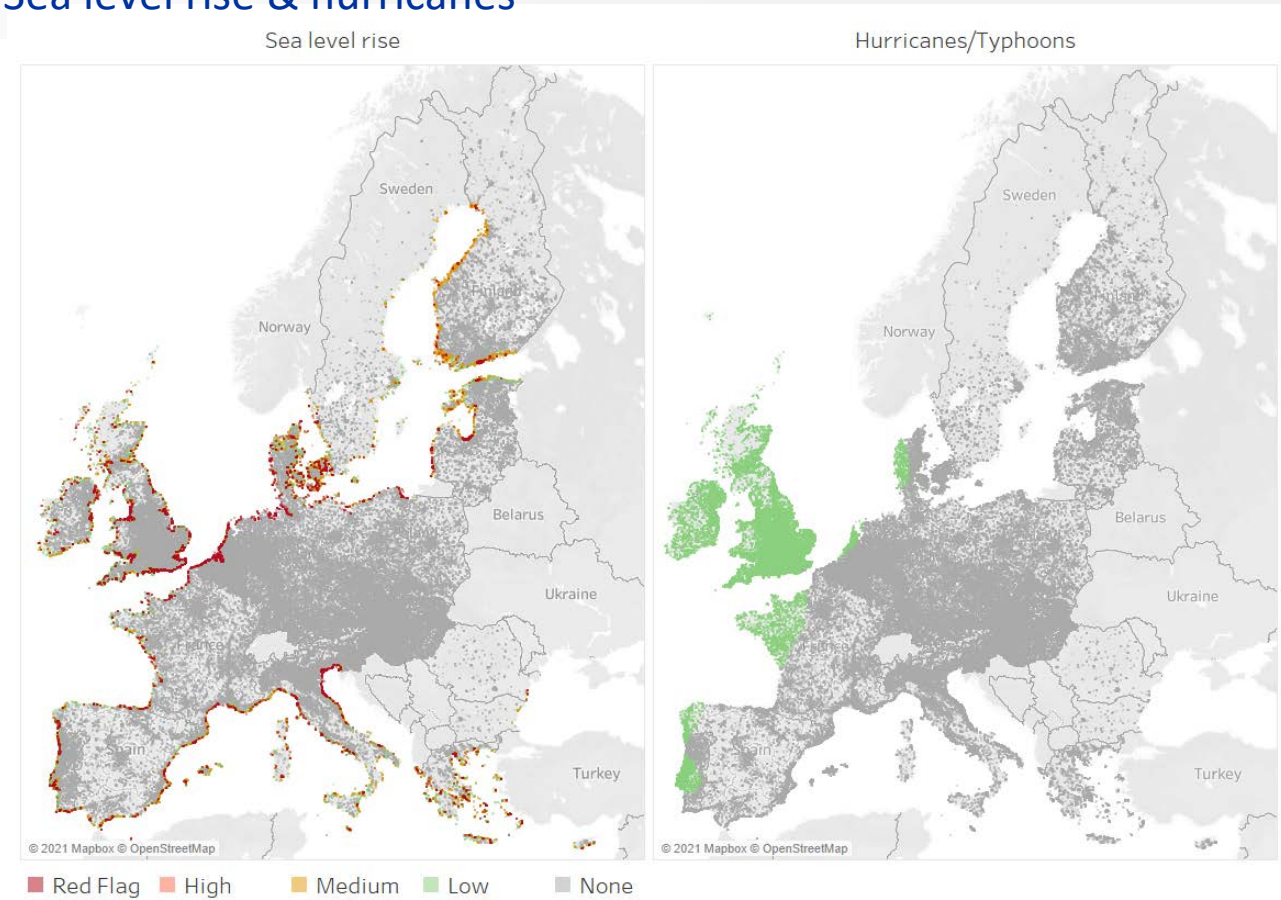
Physical risk: Floods & wildfires



Physical risk: Heat stress & water stress



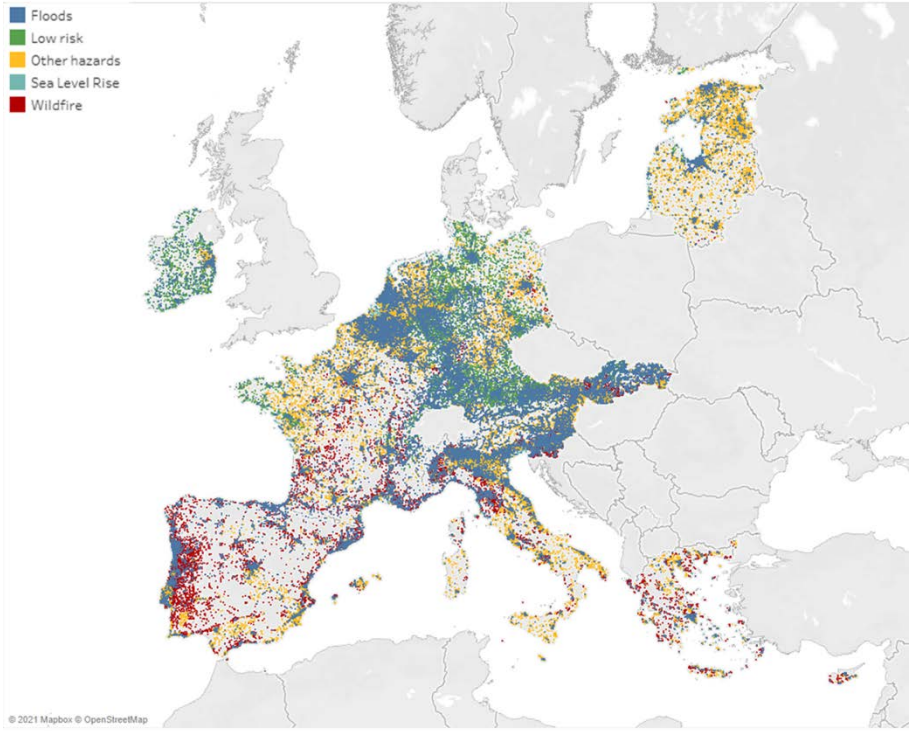
Physical risk: Sea level rise & hurricanes



Physical risk: Risks from combined physical hazards

Key hazards for EA firms: floods, wildfires, heat, water stress

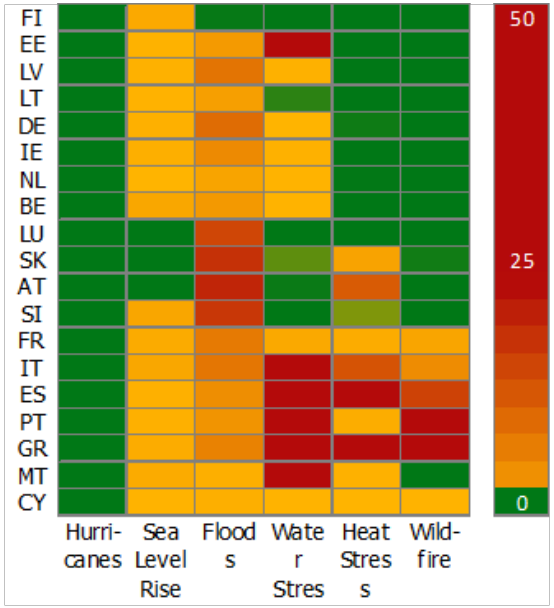
(geolocated physical risk scores)



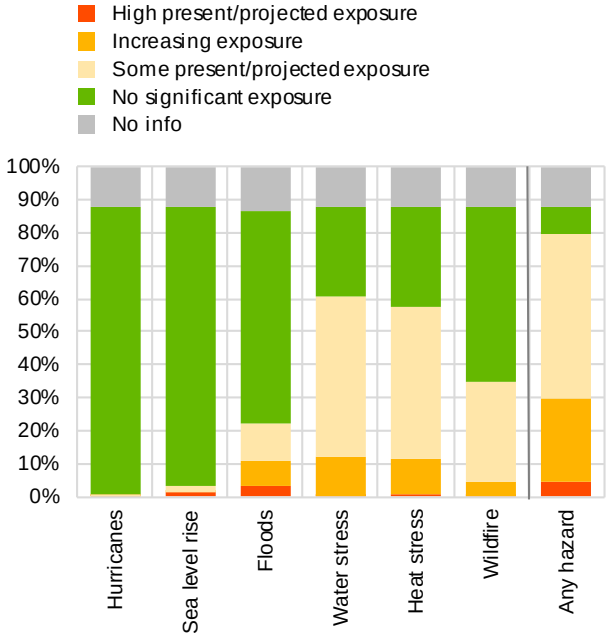
Source: 427 and ECB calculations. **Notes**: charts based on ca. 1.5 million firms in Europe (RHS) and ca. 1.1 million firms for the Euro Area (LHS), for which data was retrieved; information refers to firm HQ location. Scores for different risk categories may translate differently into risk levels and economic damages, depending on the risk category.

Physical risk: Regional concentration of exposures

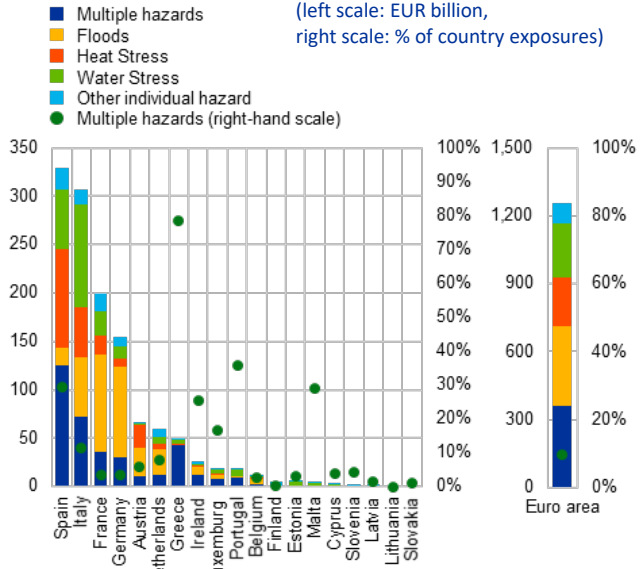
Share of firms in areas of high or increasing exposure to a physical hazard



Share of EA banks' credit exposures to firms, by firm physical risk level



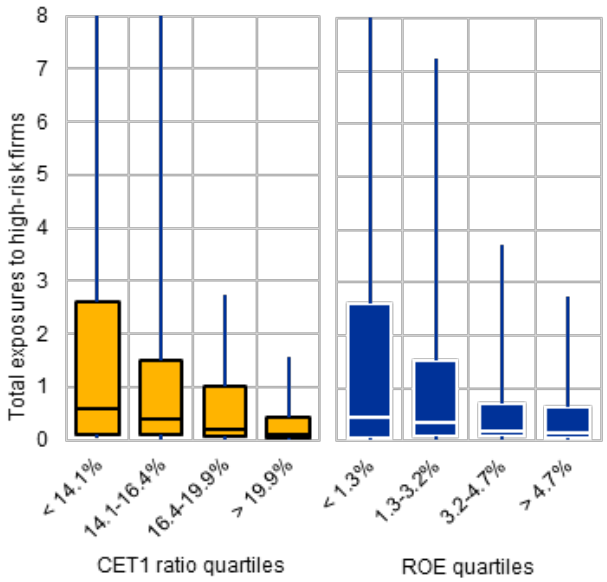
Bank exposures to firms located in areas of high or increasing physical risks



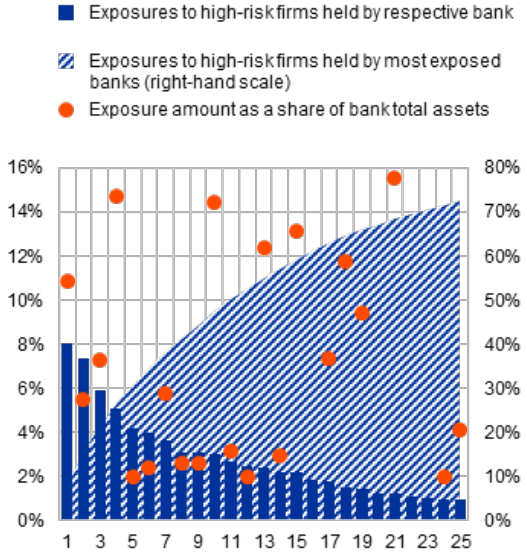
Sources: AnaCredit, Four Twenty Seven, ECB calculations.

Physical risk: Bank-level concentration of exposures

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



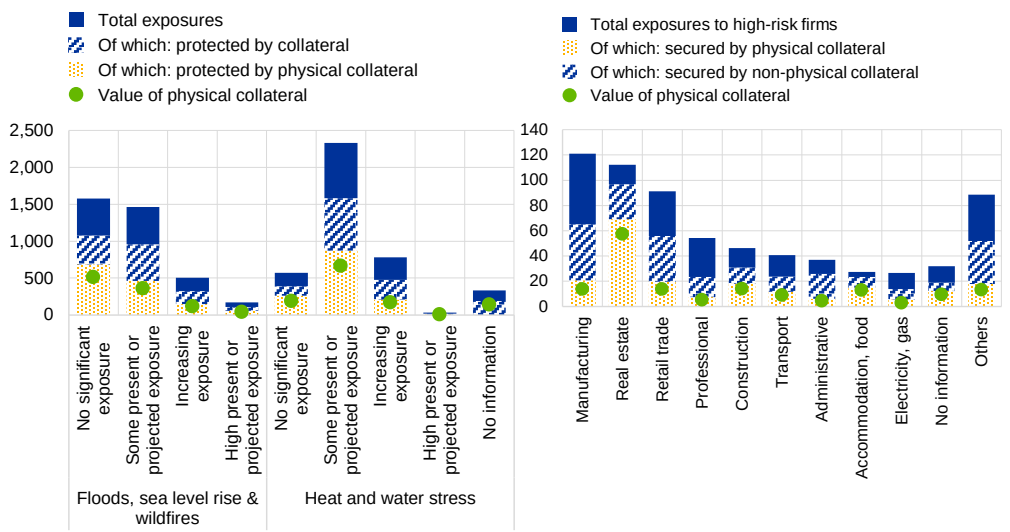
Concentration of exposures to firms located in areas of high or increasing physical risk in the banking system



Sources: AnaCredit, Four Twenty Seven, ECB calculations.

Physical risk: Mitigants

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



Protection gap for European countries by hazards

COUNTRY	Estimate of protection gap today All Peril	Estimate of protection gap today Earthquake	Estimate of protection gap today Flood	Estimate of protection gap today Wildfire	Estimate of protection gap today Windstorm
EU	1.0	1.0	1.0	1.6	1.0
Austria	2.0	1.8	3.4	2.6	0.0
Belgium	1.7	1.3	1.9	2.0	1.6
Bulgaria	2.0	3.2	1.7	2.0	1.2
Croatia	2.4	2.8	2.0	3.0	1.6
Cyprus	1.9	2.5	1.0	3.0	1.0
Czech Republic	1.9	1.8	2.0	2.0	1.6
Denmark	0.0	0.0	0.0	0.0	0.0
Estonia	1.1	0.0	0.0	3.0	1.5
Finland	0.7	0.0	1.0	0.0	1.8
France	0.5	0.0	0.0	2.0	0.0
Germany	1.6	1.6	2.6	1.0	1.1
Greece	2.2	3.5	1.7	2.0	1.6
Hungary	1.3	1.3	1.9	1.0	1.1
Iceland	1.0	1.0	1.0	n/a	1.0
Ireland	0.7	0.0	0.0	1.0	1.9
Italy	2.4	3.5	1.7	2.0	2.5
Latvia	0.9	0.0	1.0	1.0	1.7
Lithuania	1.3	0.0	1.0	2.0	2.0
Liechtenstein	n/a	n/a	n/a	n/a	n/a
Luxembourg	1.6	1.3	2.0	2.0	1.1
Malta	2.3	2.8	1.7	3.0	1.6
Netherlands	1.9	2.0	4.0	0.0	1.6
Norway	0.0	0.0	0.0	0.0	0.0
Poland	1.6	2.0	1.0	1.0	2.3
Portugal	2.0	1.8	1.6	3.0	1.7
Romania	1.7	3.1	1.6	1.0	1.2
Slovakia	2.4	1.9	3.0	3.0	1.6
Slovenia	1.5	2.4	1.3	1.0	1.2
Spain	0.9	0.0	0.0	2.0	1.4
Sweden	0.4	0.0	0.0	0.0	1.6

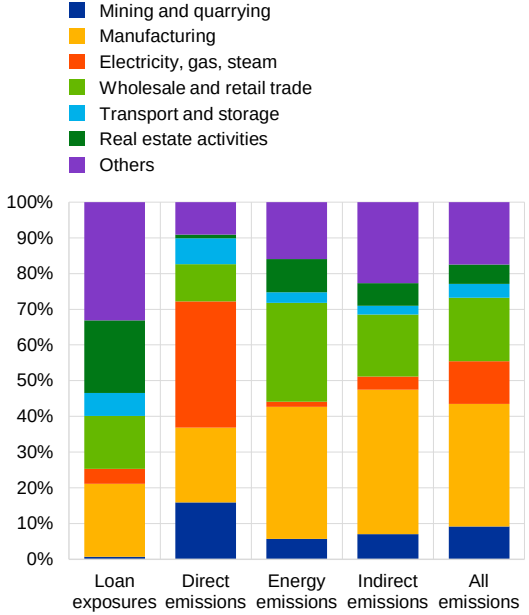
0	No risk
1	Low risk
2	Low/medium risk
3	Medium/high risk
4	High risk
n/a	Not available

Sources: AnaCredit, 427 data and ECB calculations

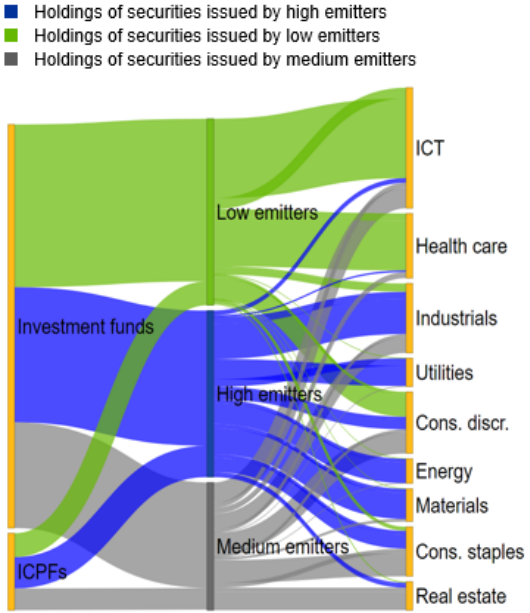
Notes: December 2020. Maximum risk level considered across floods, sea level rise and wildfires; EUR 4.2 tn of exposures considered; NFC location used to assign risk levels refers to the HQ.

Transition risk: Sectoral concentration of risk exposures

Banks' loan exposures and share of corporate emissions by sector



Non-banks' exposure to transition risk via equity and debt securities

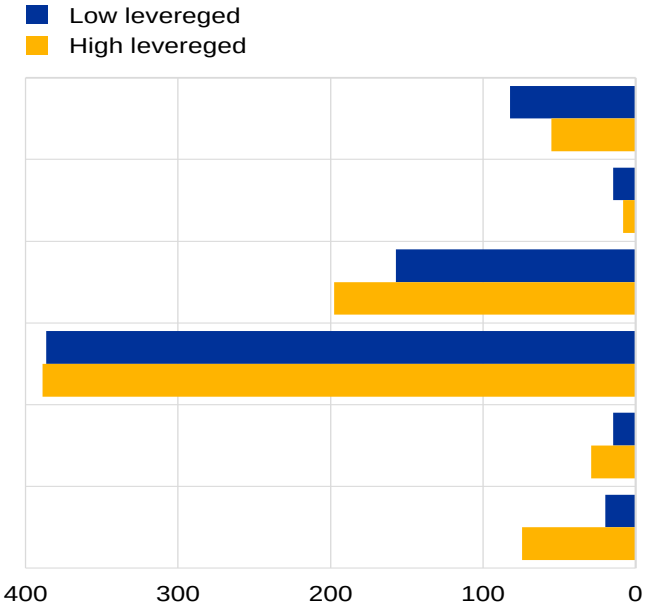


Sources: AnaCredit, Urgentem, ECB. Note: The sample covers 80% of euro area loans to NFCs. To infer emissions for non-disclosing NFCs, analysis relies on modelled GHG emissions calibrated on data self-reported by firms

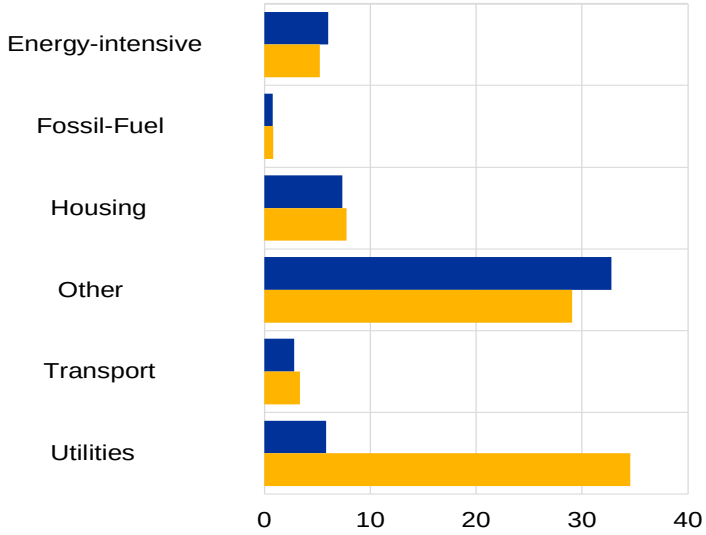
Transition risk: Focus on bank loans' climate risk exposures

Pockets of vulnerability are concentrated in highly indebted firms and emission intensive firms

Loans for high and low indebtedness bucket
(in EUR billions)



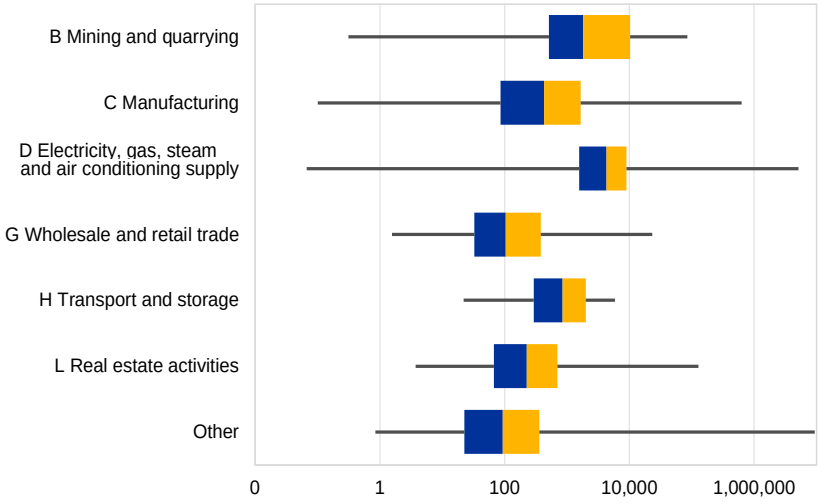
Average emissions intensity
(in g CO2e per euro of revenue by high)



Source: AnaCredit, Orbis, Urgentem and iBach. Notes: Emission intensity is as total scope 1 and 2 emissions over revenues. High-(low-) leveraged firms are firms with a liability to assets ratio above 75th (25th) percentile, i.e. 0.737 (0.625). 'Other' refers to all NACE sectors not included in the CPRS definition.

Transition risk: Banking sector sensitivity to carbon prices … *within* sectors

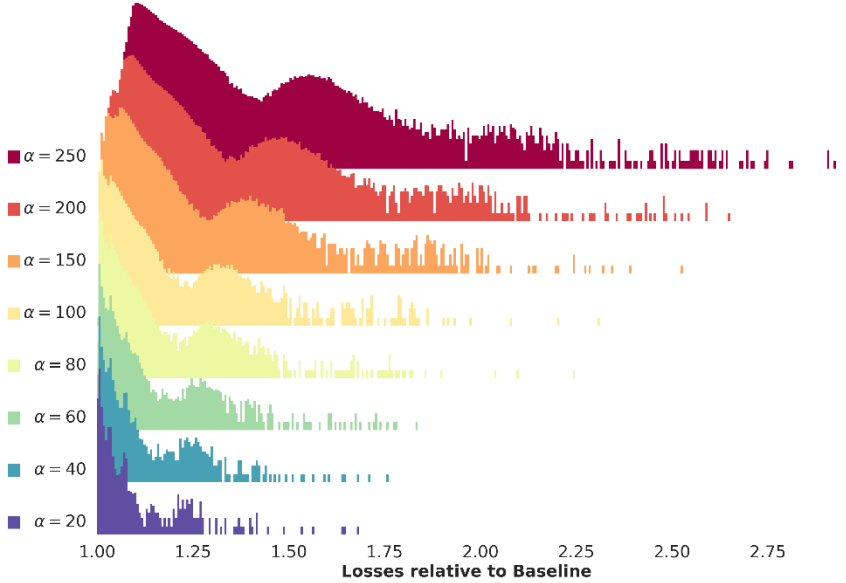
Firm-level emission intensities within and across sectors in the euro area (Scope 1,2 and 3 emissions in tonnes of CO2 equivalents per USD million revenue)



Source: Urgentem.

Note: Only firms directly reporting emissions are considered (approximately 3000 European firms)

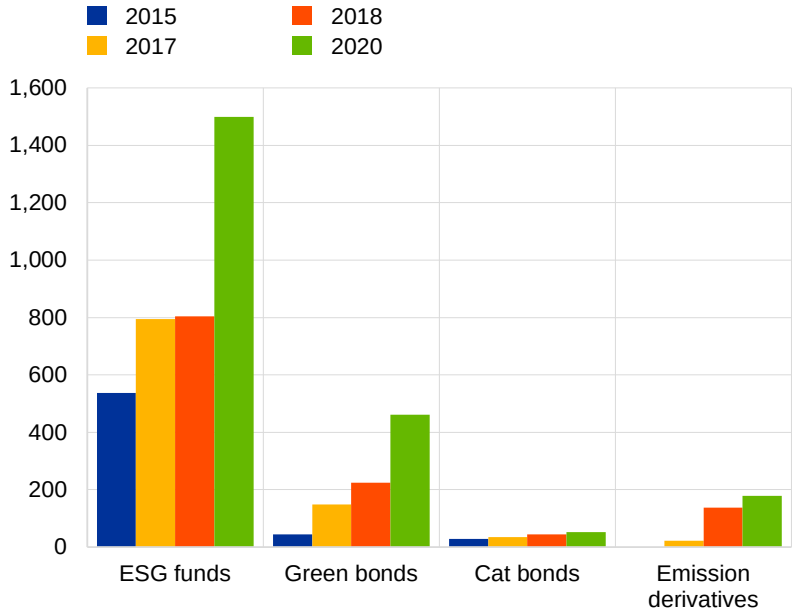
Banking system losses for different changes in carbon price (alpha: change in carbon price; loss difference calculated as loss in simulation relative to baseline)



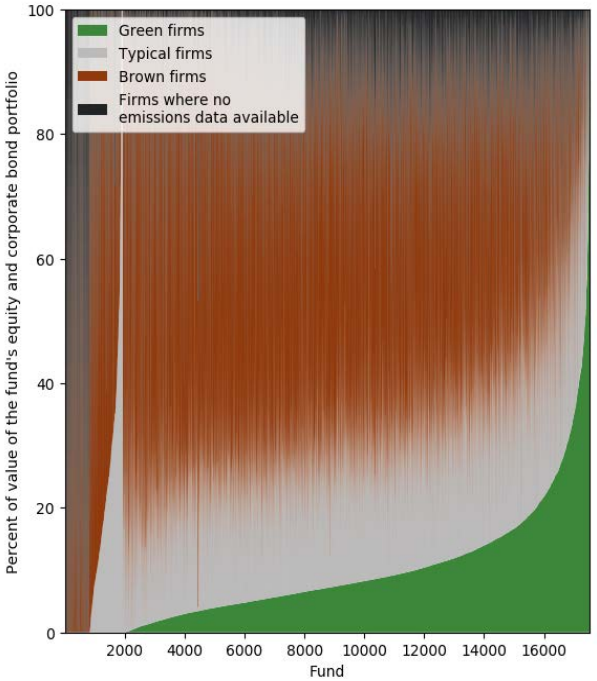
Sources: Supervisory Statistics, Urgentem and ECB calculations. Notes: Results are based on a sensitivity study using a banking system interconnectedness model based on firm-level exposures and emissions of euro area large exposures. The quantifications assume full pass-through of changes in carbon (alpha) 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.

Transition risk: Financial markets rapidly greening amid portfolio adjustment needs

Market growth in 'green' financial instruments
(in EUR billion)



Share of portfolios in green vs. brown firms

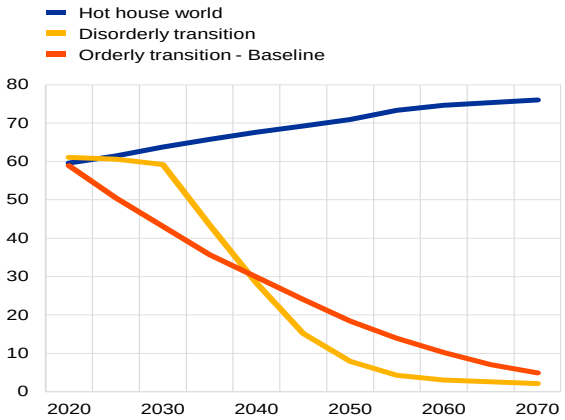


Sources: LHS: Artemis, Bloomberg, EMIR, EPFR, Lipper and ECB calculations RHS: Morningstar, Refinitiv, ESMA. See on Trends, Risks and Vulnerabilities No 1, 2021
Note: Percent share of each individual fund's equity and corporate bond portfolio (vertical axis) that is allocated to firms classified according 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).

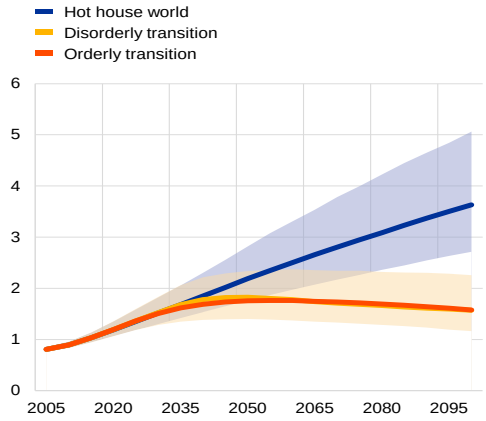
Representative climate scenarios: Long-term and policy trade-offs

Scenario	Orderly (Baseline)	Disorderly	Hot house world
NGFS label	Orderly 2°C with CDR	Disorderly Delayed 2°C with limited CDR	Current policies 3.5°C
Policy	Immediate action (emission price introduced in 2020) taken to reduce emissions in line with the Paris Agreement	More stringent need to be implemented from 2030 onwards	Only current policies are implemented ('business as usual scenario')
Median temperature rise by 2100	well-below 2°C	below 2°C	about 3.5°C
CRD	The use of CDR permits negative emission in the second half of the century.	Only limited technologies available	No major progress

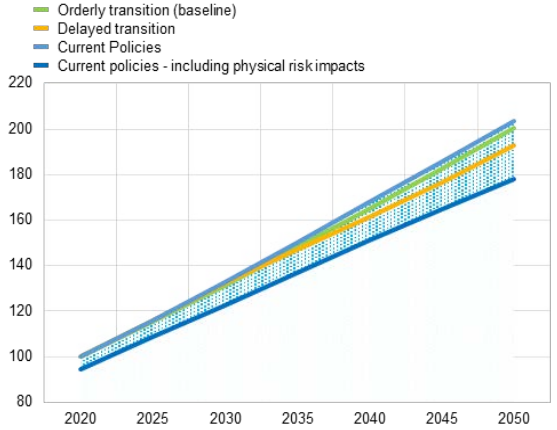
GHG emissions



Mean temperature



GDP impacts from transition and physical risks



Source: Climate-related risk and financial stability, 2021. NGFS.

Notes: Left panel: GHG stands for greenhouse gases (GHG) in gigatons (Gt) emissions and includes carbon dioxide, methane, nitrous-oxide and fluorinated gases. Middle panel: lines are median values, and shaded areas are 90% confidence intervals

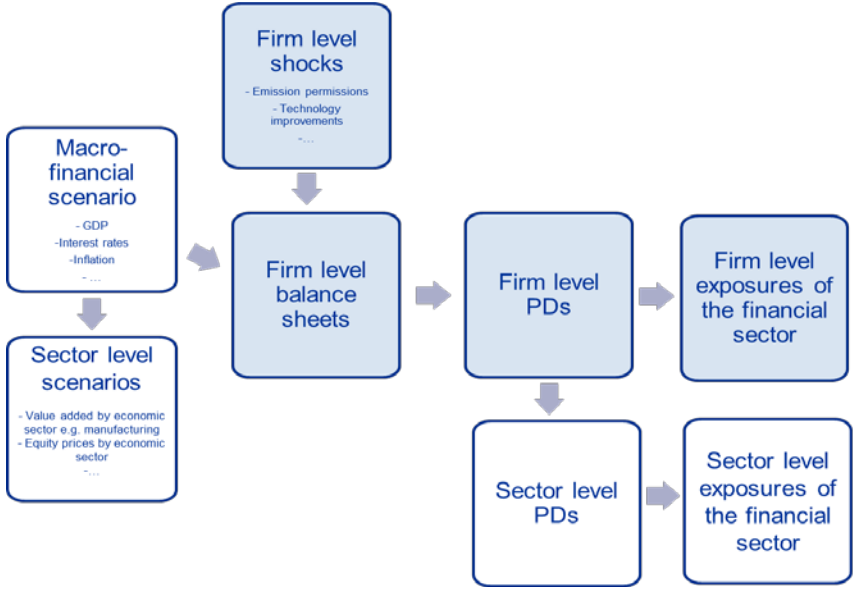
Evolving stress test methodologies

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

Source: Climate-related risk and financial stability, 2021

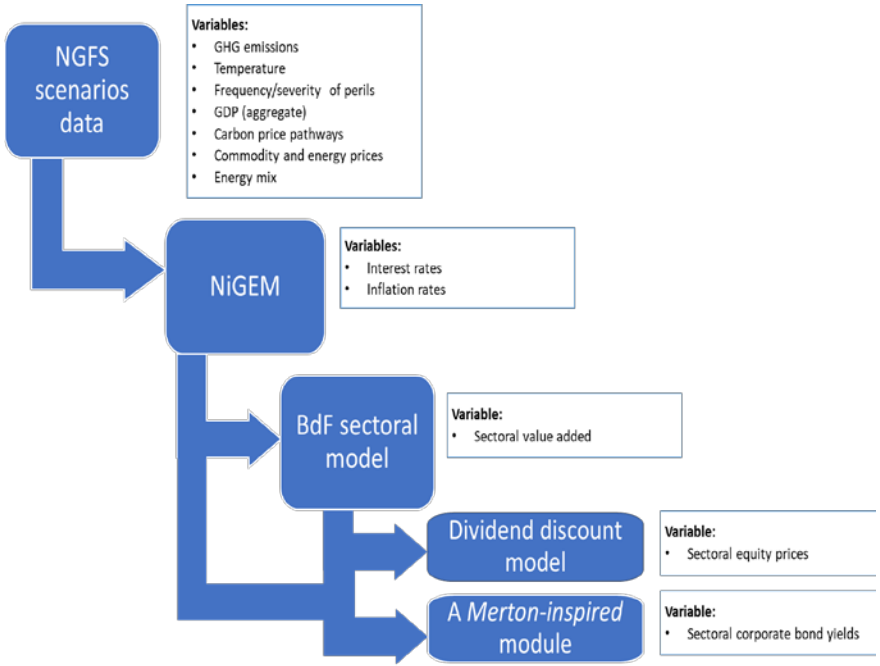
- Move toward firm-level models to fully explore the distribution of climate-related risks in the corporate sector
- Increasing use of firm- and security-level data

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



Filling the gaps

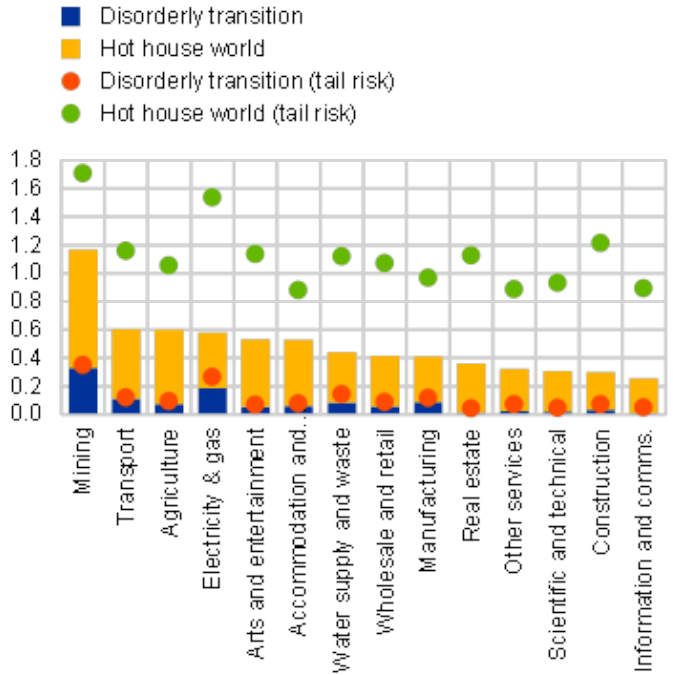
Figure: Modelling approach



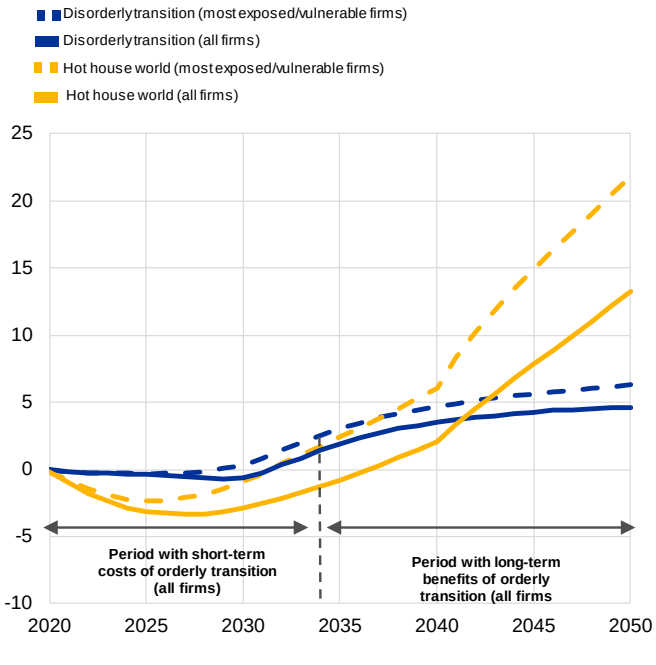
Default risk: Non-financial firms

Projected differences in firms' default probabilities
(2020-50, percentage differences in PDs)

.. across industries



.. across time



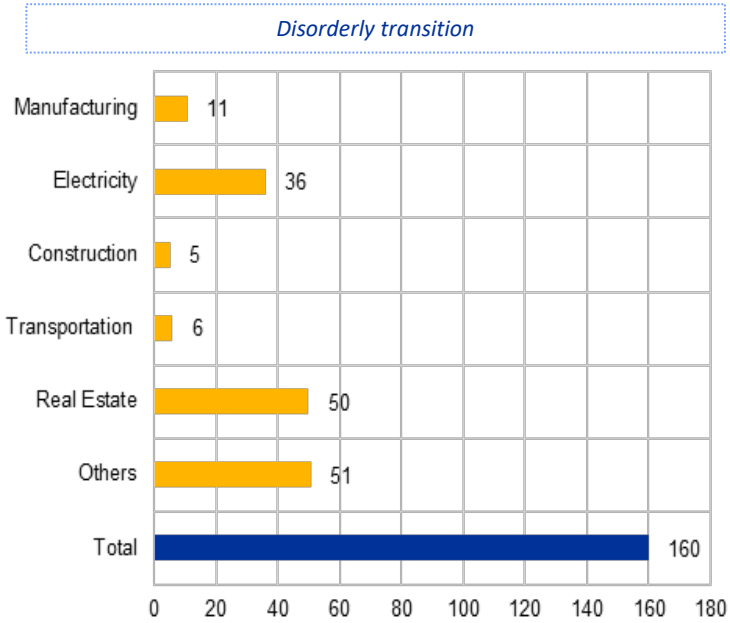
Climate scenario analyses

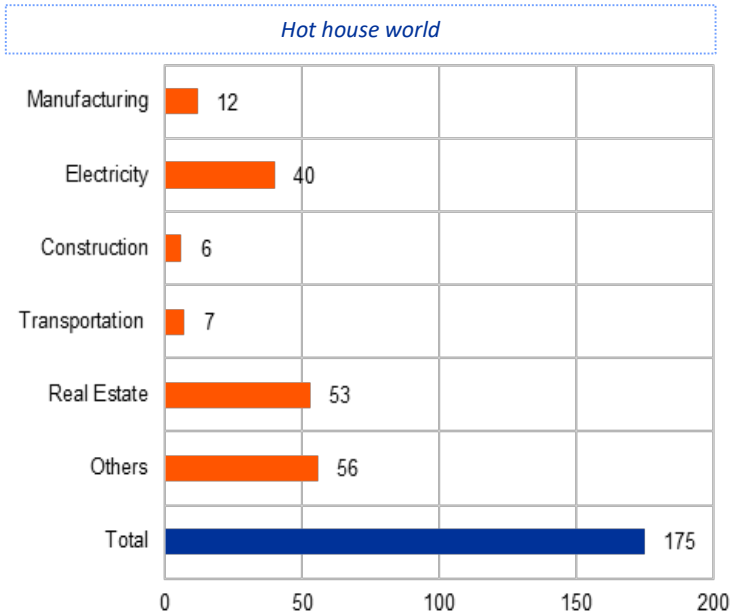
	Banking sector	Insurance sector	Investment funds
NGFS Scenarios	Disorderly and Hot house	Disorderly vs. Orderly (baseline)	Disorderly vs. Orderly (baseline)
Horizon	30 years	15 years (data as of 2035)	15 years (data as of 2035)
Sample	26 volunteer EU banks participating in the EBA pilot exercise	1569 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

Source: Climate-related risk and financial stability, 2021

Climate scenario analysis: Banks

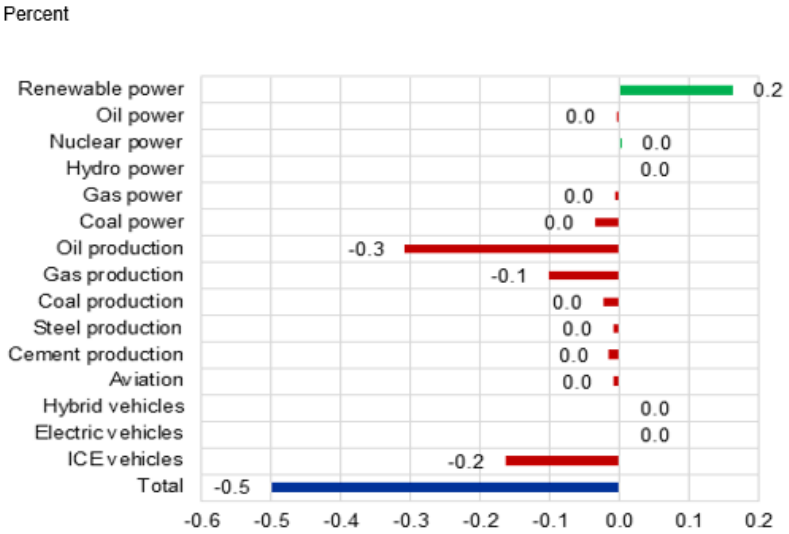
Banks credit losses by sector and scenario: disorderly scenario (LHS) and hot house world scenario (RHS)
(Change in expected losses over credit risk RWA, in basis points)





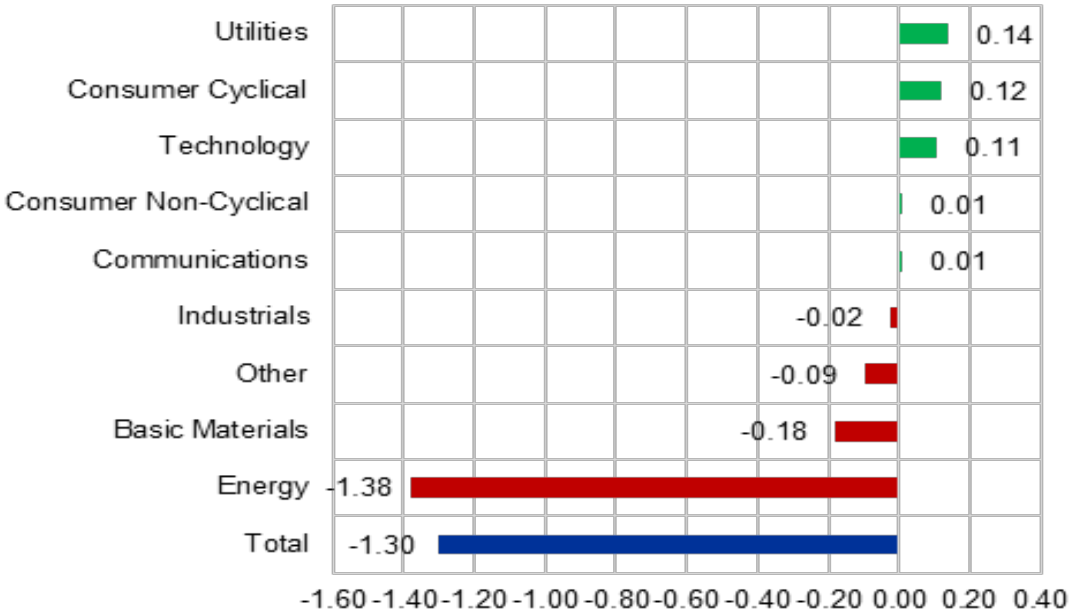
Climate scenario analysis: Insurers

Cumulative change in the value of re-priced equity and corporate bonds as a share of all assessed equity and corporate bonds in the disorderly NGFS scenario



Climate scenario analysis: Investment funds

EU investment fund losses and sector contributions as % of funds assets



esma European Securities and Markets Authority

Conclusions: July 2021 report findings*

- **Risk concentration of financial exposures to climate at regional, sectoral, and firm level**
  - *Physical risk*: Uneven exposures to hazards across regions, with potential stranding risks
  - *Transition risk*: Exposures to emissions-intensive firms concentrated, leaving parts of financial system vulnerable to destabilising financial market corrections

- **Path dependence, with credit and market risk losses from insufficient /ineffective transition**
  - *Firms*: Physical risks dominant in 15 years, leading to 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:* Revaluation losses of 5 percentage points (insurers) and 1.2% (asset managers) on average, but up to 14% for some investment funds, concentrated in fossil fuel dependent industries

- **Notwithstanding progress, analytical and policy mapping needs remain**
  - Data gaps and modelling of novel forward looking aspects remain challenges
  - Evidence-based policy mapping

* *ECB/*ESRB report, *"Climate-related risk and financial stability"* (available at ECB and ESRB websites)