FINANCIAL SECTOR ADVISORY CENTER (FinSAC)

Renewed supervisory challenges in light of tightened financial conditions and economic slowdown

May 9–10, 2023 | Vienna, Austria

Session 8: Stress Testing of risks stemming from climate change: a viable approach

Presentations by:

Nepomuk Dunz – World Bank
Ralph Spitzer – National Bank of Austria
Reiner Martin – National Bank of Slovakia
Daniel Hardy – Vienna Institute for International Economic Research

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Finance, Competitiveness & Innovation
Financial Sector Advisory Center (FinSAC)

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Contents

Assessing Financial Risks from Climate Impacts – An EMDE perspective

FinSAC Annual Conference Vienna

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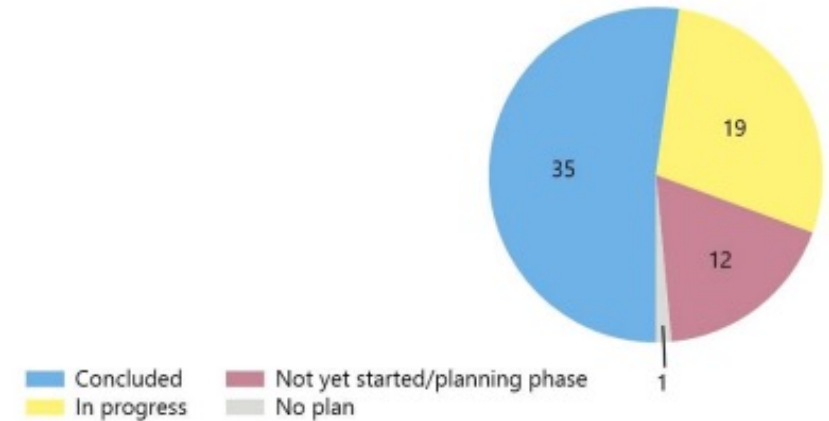Equitable Growth, Finance & Institutions

Dr. Nepomuk Dunz (Financial Sector Economist, World Bank)

May 10, 2023

A growing number of central banks and supervisors is conducting climate financial risk assessment

Information on 67 climate scenario analysis exercises was obtained by NGFS-FSB survey in 2022, most conducted within last year.
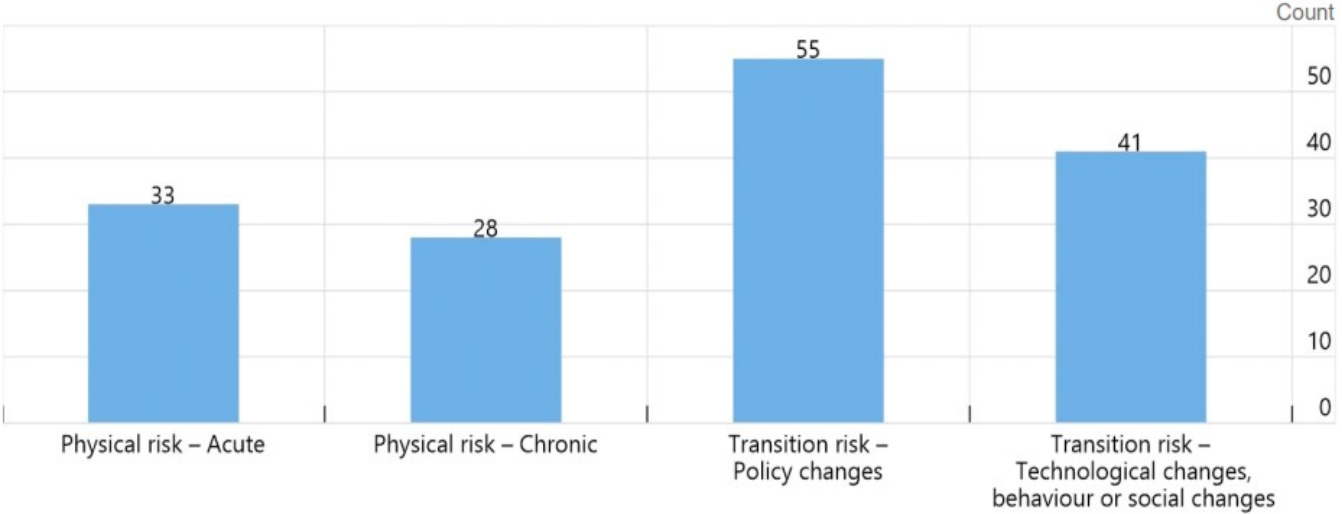
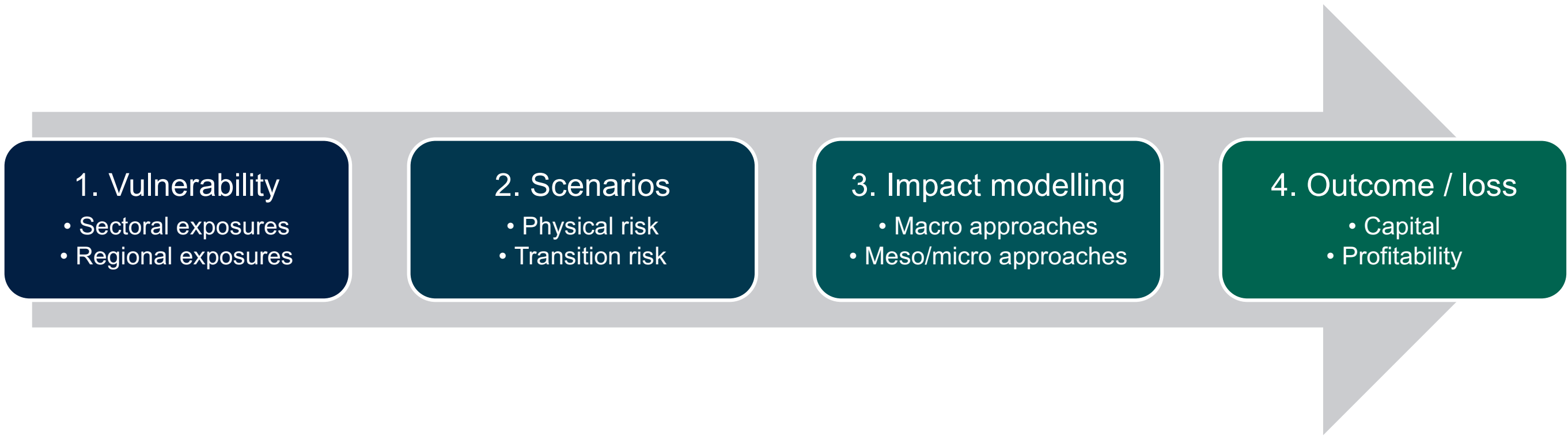**Almost 90% of the exercises explored the implications of transition risk, and about two-thirds explored physical risk.**

Current status of climate scenario analysis exercises examined — Graph 1

- 35 Concluded
- 19 In progress
- 12 Not yet started/planning phase
- 1 No plan

Source: FSB-NGFS survey

Climate risks considered in the exercises — Graph 4

Count

- Physical risk – Acute: 33
- Physical risk – Chronic: 28
- Transition risk – Policy changes: 55
- Transition risk – Technological changes, behaviour or social changes: 41

Source: FSB-NGFS survey

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Climate stress tests link physical and transition scenarios to outcomes or losses in the financial sector

1. Vulnerability
- Sectoral exposures
- Regional exposures

2. Scenarios
- Physical risk
- Transition risk

3. Impact modelling
- Macro approaches
- Meso/micro approaches

4. Outcome / loss
- Capital
- Profitability

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Multiple variants of climate stress tests are possible and currently conducted

Bottom-up vs. top-down

- **Bottom-up exercises**, central bank or supervisor defines scenarios and methodological rules. Financial institutions then run the scenarios against their balance sheet, using internal data and models.
- **Top-down exercise** run entirely by central bank or supervisor, without involvement of financial institutions.

Macro vs. micro approach

- **The macro approach** relies on macroeconomic models (e.g., DSGE, CGE) to simulate the impact of climate shocks on macro and financial variables. Models could differ with respect to the sectoral and geographical granularity.
- **The micro approach** directly examines the financial performance of affected sectors, to which FIs are exposed. This approach has a very high requirement for granularity of data and industry-specific knowledge.

Static vs. dynamic balance sheet approach

- **Static balance sheet** assumption with balance sheets 'frozen' over time, allowing only balance sheet changes that result directly from risks materializing in the scenario (e.g. assets going into default).
- **Dynamic balance sheet** assumption allows balance sheets to change over time, either because counterparty characteristics change (e.g. reduction in emissions or gaining market share), or because of portfolio allocation change

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EMDEs face specific climate-related challenges but important to get started

High vulnerability of EMDEs to climate risk but low macro-financial capacity EMDEs to deal with impacts
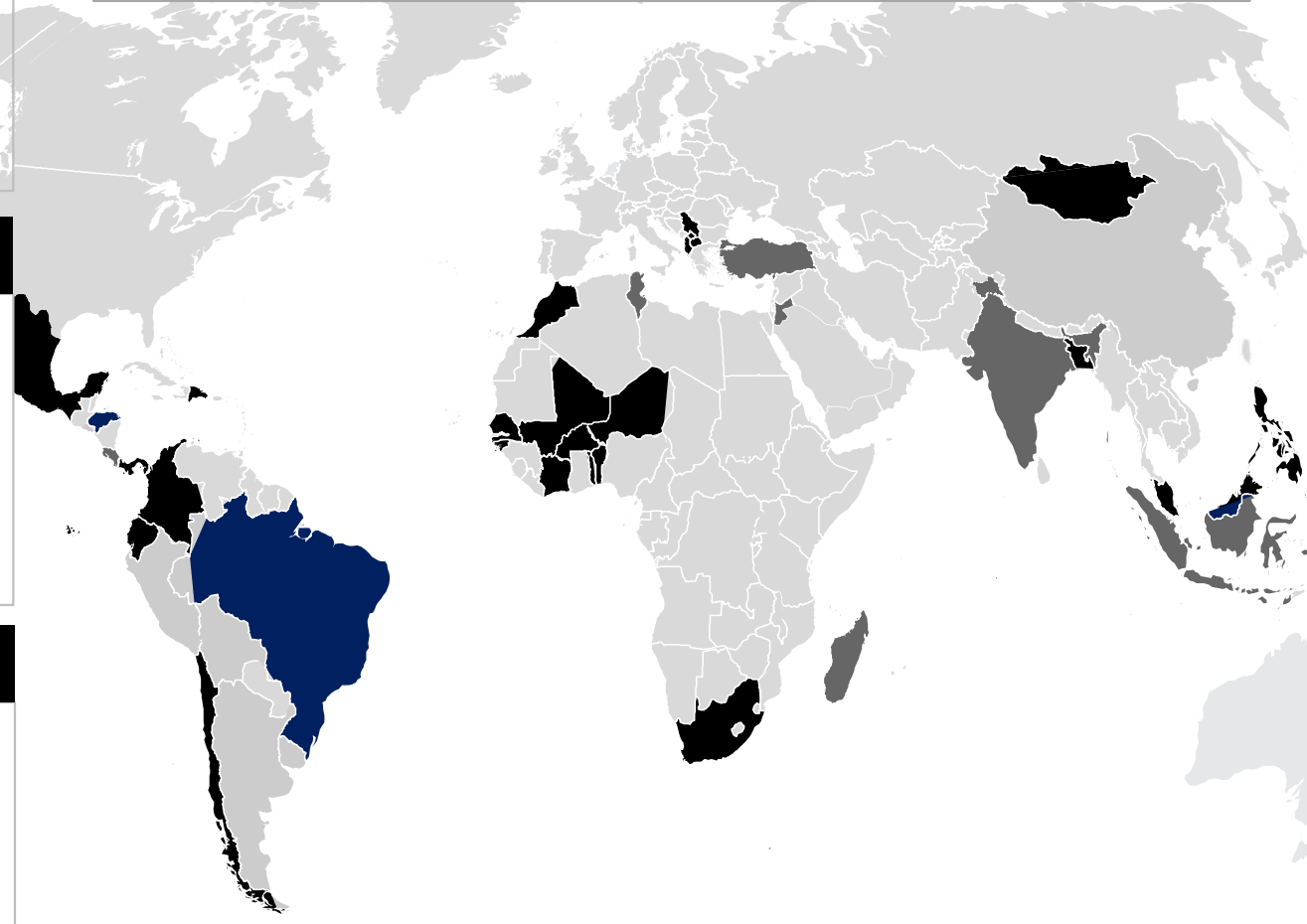*Climate vulnerability per region (1995-2017)*
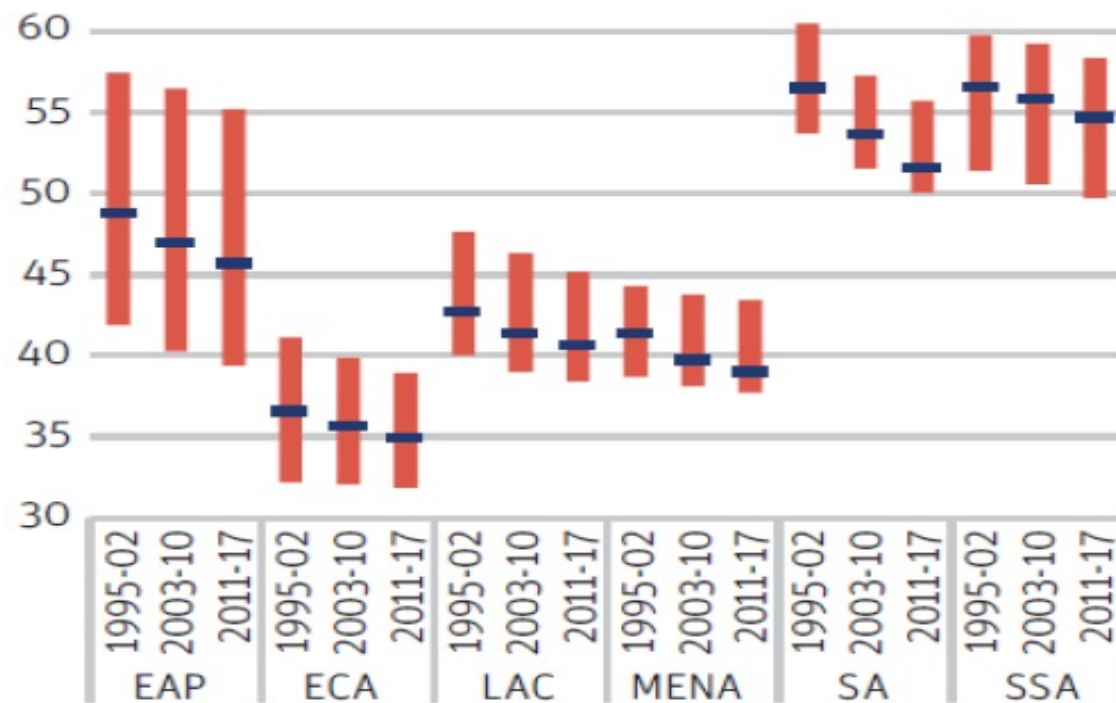
Source: ND-GAIN Vulnerability Index

- Despite increasing awareness and emerging work on climate risk analyses, supervisory and regulatory approaches to address the risk **are in their infancy in most EMDEs.**

- Central banks in EMDEs face **challenges** including **limited capacity** and **data** to assess climate risks and implement responses.

- The diverse nature of EMDE financial sectors (different type of risks, data, capacity, etc.) requires **tailored approaches** to manage local climate risks.

- But climate risk assessment can be done at various levels of granularity and is a **learning-by doing process** (insights on data gaps, etc.) for all participants.

→ **Important to get started**

Examples of World Bank climate risk analysis work

Morocco

- Climate risk analysis
- Climate risk guidelines
- Training & capacity building

Mexico

- FSAP Climate risk analysis
- ESG risk guidelines

Colombia

- Climate risk analysis
- Climate risk guidelines
- Taxonomy and capacity building

- **The World Bank is supporting efforts to green the financial sector in 60+ countries through technical assistance, analytical and lending activities**

South Africa

- FSAP climate risk analysis
- Advisory climate risk analysis
- Training/capacity building

Philippines

- FSAP climate risk analysis
- Transition risk analysis
- Development policy operation

Malaysia

- Nature risk analysis
- Training/capacity building
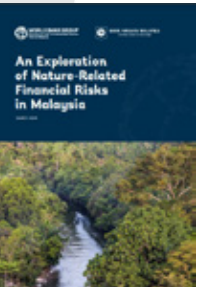
FSAP | CCDR | Stand-alone | Related advisory / studies

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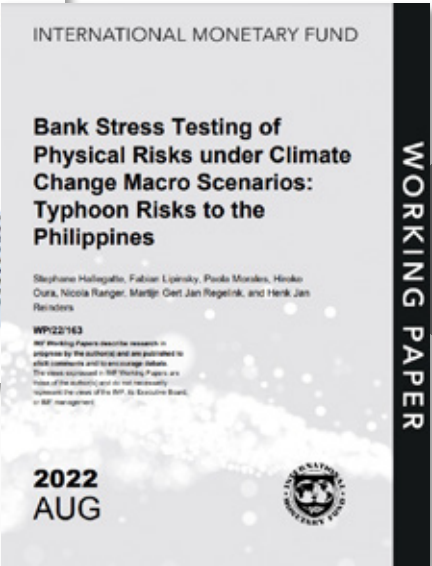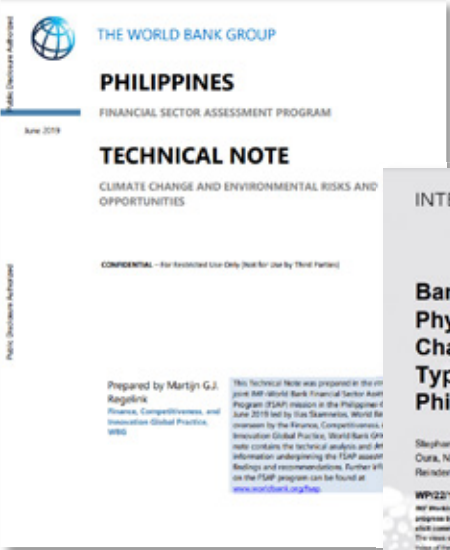# The Philippines: From Climate Analytics and TA to WBG investment operations

FSAP Climate Risk & Opportunity analysis

WB diagnostic of the **policy and regulatory framework** to manage risks and simulate green finance markets.

Joint **WB IMF** climate **physical risk stress test** of the banking sector. Also informed CCDR

2019-2020

30by30zero - TA & investment to scale private sector climate finance

Award winning joint **IFC / WB** program to **scale climate finance**. WB TA for climate risk regulations, taxonomy development and green finance incentives (WB). IFC providing TA and blended finance investments in banks.

2021-present

Climate finance and resilience in Development Policy Financing

World Bank financing with first-of-its-kind **greening financial sector pillars and prior actions,** informed by FSAP and TA recommendations on climate risk management and climate finance

2022-2023

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PHILIPPINES

FINANCIAL SECTOR ASSESSMENT PROGRAM

TECHNICAL NOTE

CLIMATE CHANGE AND ENVIRONMENTAL RISKS AND OPPORTUNITIES

INTERNATIONAL MONETARY FUND

Bank Stress Testing of Physical Risks under Climate Change Macro Scenarios: Typhoon Risks to the Philippines

2022 AUG

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Colombia: Multiple instruments for climate impact

01 **Methodology to incorporate ESG** aspects in infrastructure projects

02 **Blended Finance** strategy for local Development Bank (FDN)

03 **ESG Guidelines Investors / Issuers**
Integrating ESG factors in investment practices and investor and corporate reporting –supported by SSB work on new sustainability standards

04 **Green taxonomy**
World Bank IFC support for a taxonomy of economic activities to label and monitor green investments

05 **Green instruments**
Support to the issuance of a green bond for Bus Rapid Transit in the municipality of Bogota

06 Development of **Carbon credit markets**

07 **Green banking regulations**
TA for the banking regulator - stress testing climate risks and developing climate risk management and reporting guidelines

FINANCE, COMPETITIVENESS & INNOVATION

EQUITABLE GROWTH, FINANCE & INSTITUTIONS INSIGHT

Not-so-magical realism:
A climate stress test of the
Colombian banking system

sfc   FIRST

> > > TABLE 1.2. - Summary of main climate-related risks for the Colombian banking sector

Risk	Likelihood	Potential for banking sector stress	Channels
I. Gradually increasing carbon price and climate policies	Medium	Low	• Increasing loan losses in transition-sensitive sectors • Value of commercial real estate
II. Gradually increasing temperature and changing weather-patterns	High	Low/medium	• Increasing loan losses in vulnerable sectors (e.g., agriculture)
III. A sudden tightening of climate policies	Low/medium	Medium/Large	• Increasing loan losses in transition-sensitive sectors • Value of commercial real estate • Macroeconomic effects
IV. Severe flood	Medium	Medium	• Real estate, corporates, households in affected areas • Sovereign credit downgrades
V. Severe flood plus recession (double shock)	Low/medium	Large	• Real estate, corporates, households in affected areas • Sovereign credit downgrades • Macroeconomic effects

Source: World Bank staff.

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Morocco: Greening the Banking Sector by supporting the central bank
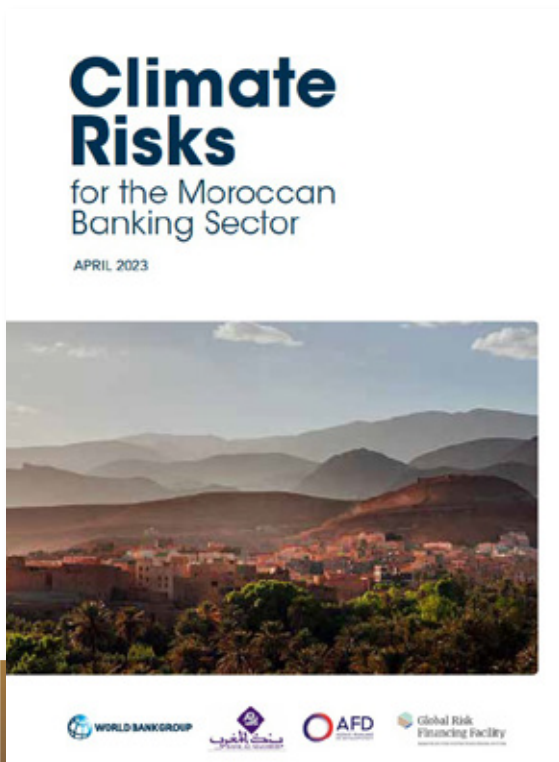
Assessing climate-related financial risks for the banking sector

Scenario analysis exercise with Bank Al Maghrib covering climate physical and transition risks to stress resilience of banking sector

Training and awareness program

Providing support to build supervisory and industry capacity on climate risk and green finance
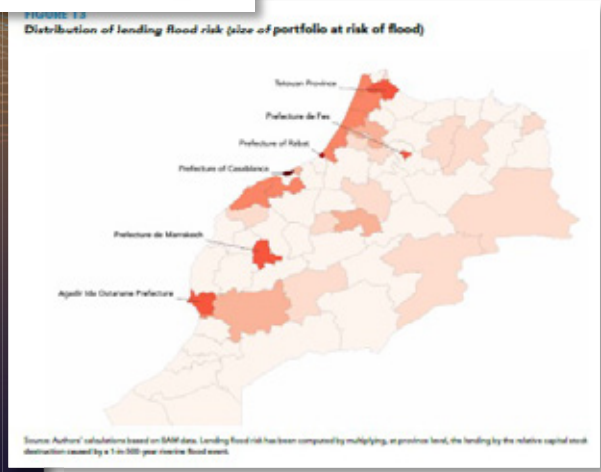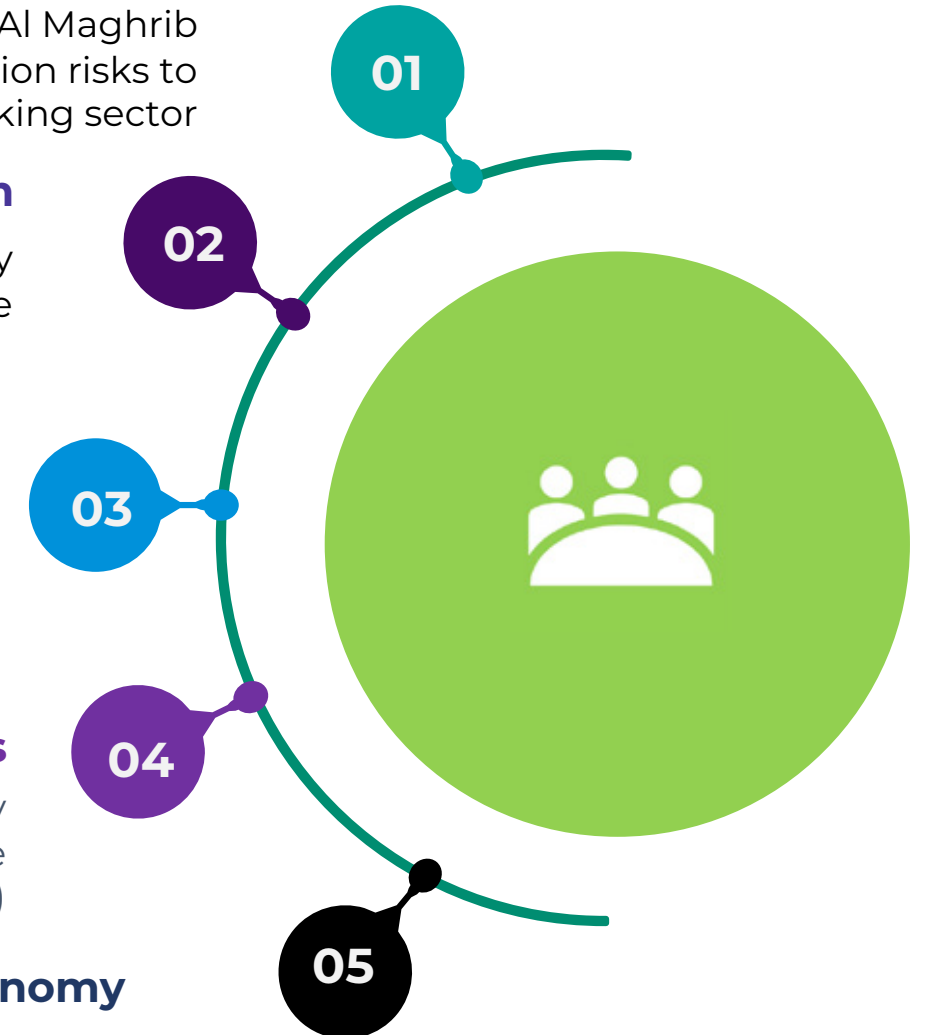
Climate risk guidance for banks

Sector guidelines for climate risk management, scenario analysis & stress testing, and reporting standards

Benchmarking policy developments

Assess and identify green finance policy priorities as part of the Country Climate and Development Report (CCDR)

Green taxonomy

Supporting authorities developing a green taxonomy to classify green (and climate risky) investment products and financial flows

01
02
03
04
05

Climate Risks for the Moroccan Banking Sector
APRIL 2023

WORLD BANK GROUP · AFD · Global Risk Financing Facility

MIDDLE EAST AND NORTH AFRICA
Benchmarking Financial Sector Policies for Climate Risk Management and Green Finance
World Bank Group
MOROCCO COUNTRY CLIMATE AND DEVELOPMENT REPORT (CCDR) BACKGROUND NOTE

9

FIGURE 13
Distribution of lending flood risk (size of portfolio at risk of flood)

Tetouan Province
Prefecture de Fes
Prefecture of Rabat
Prefecture of Casablanca
Prefecture de Marrakesh
Agadir Ida Outanane Prefecture

Source: Authors' calculations based on BAM data. Lending flood risk has been computed by multiplying, at province level, the lending by the relative capital stock destruction caused by a 1-in-500 year riverine flood event.

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Climate analysis is not an end in itself but a building block for a supervisory approach

01 Raise awareness and build capacity

For supervisors, financial institutions, and policymakers

02 Bridge data and modeling gaps

Informing disclosure and regulatory reporting, and advanced modeling of climate risk

03 Inform supervisory approach

Enabling a risk-based supervisory approach by identifying the most vulnerable sectors and firms

Scenario analysis and stress testing face challenges that need to be addressed

01 Addressing data gaps

02 Better incorporating climate change in modeling approaches

03 Building capacity to conduct scenario analysis and stress testing
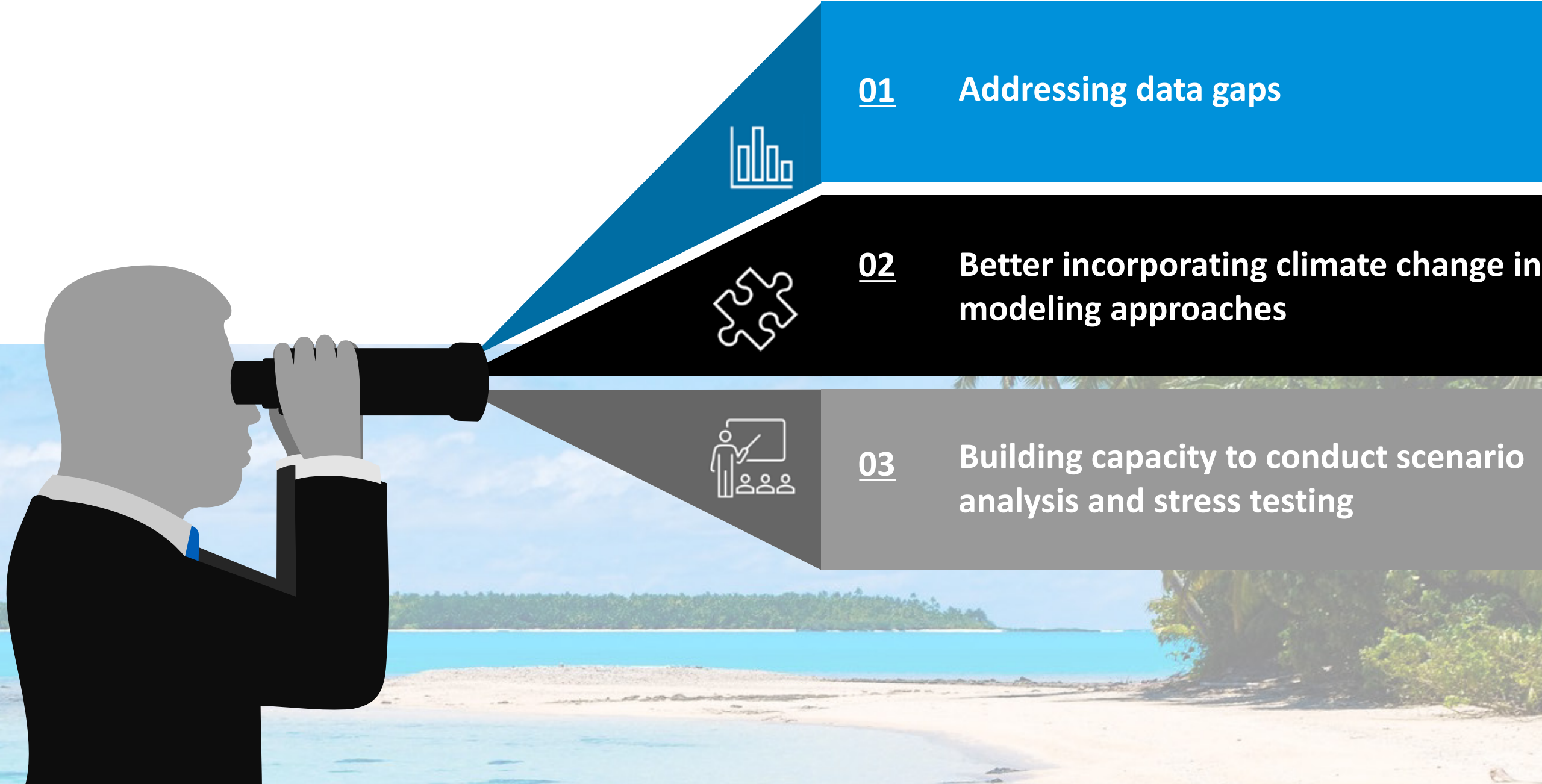
Annex

Cross-country analyses shows climate-related NPL impacts aren't just theoretical

Estimated effects of disaster episodes on NPLs (184 countries – 1980-2019)
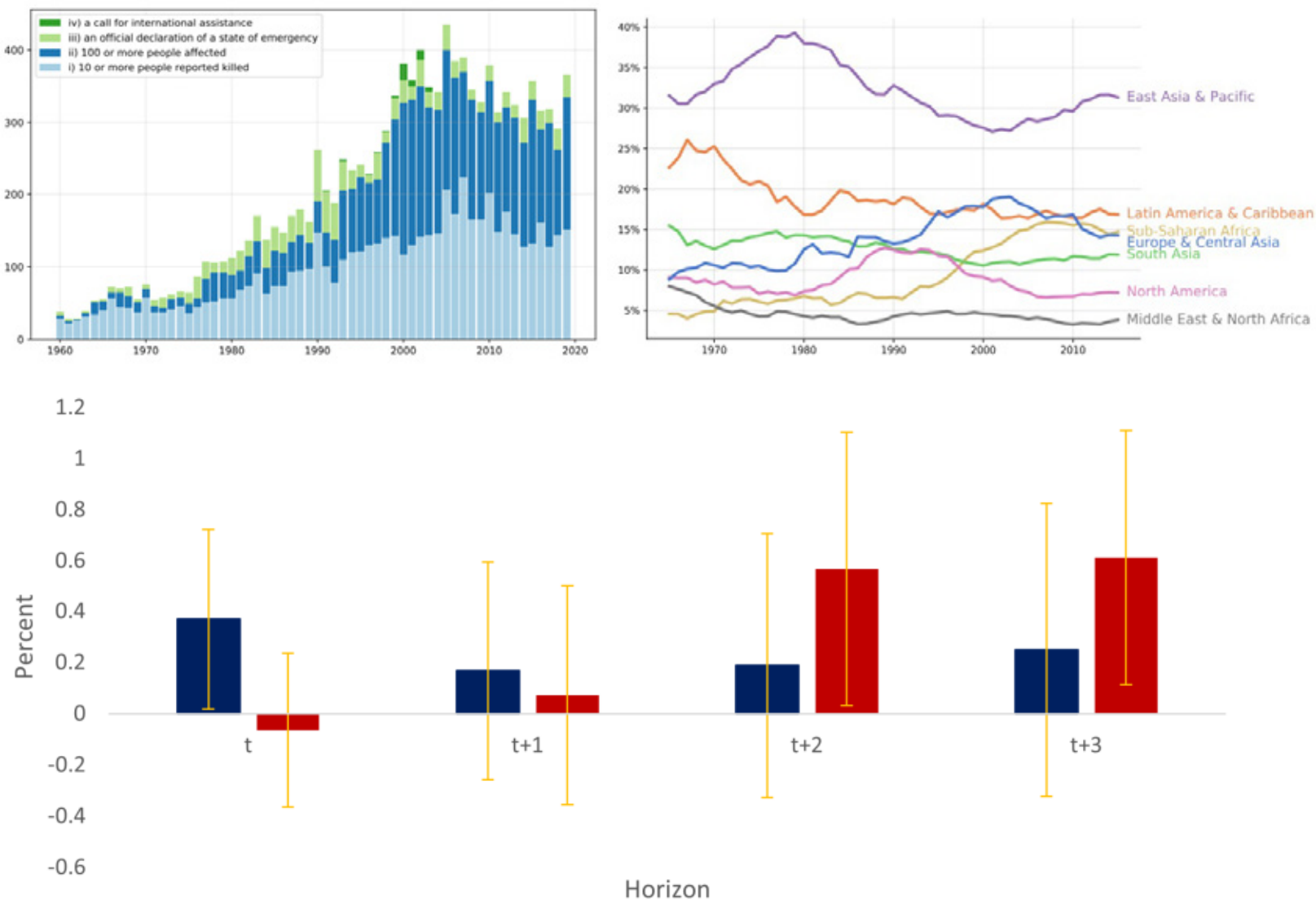
Country case: Philippines
Impacts of a 1 ppt increase in the damage ratio

(b) Total loan portfolio

−0.522%
−1.744%
−2.259%
−1.593%

(c) Non-performing loan ratio

2.3% increase in NPL ratio

+1.188%
+2.229%
+2.272%
+1.178%
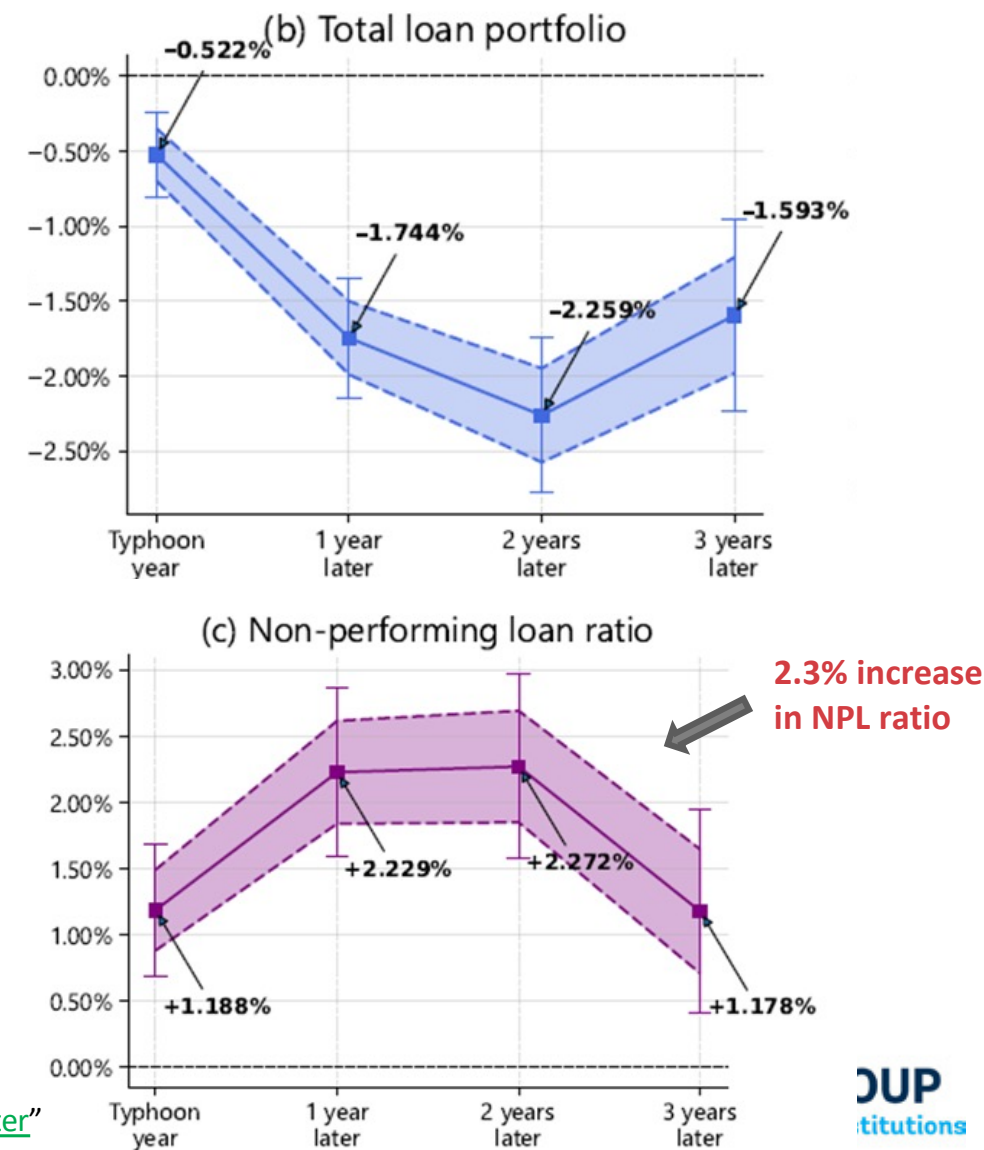
Nie, O., Regelink, M., Wang, D. (2023). "Banking sector risks in the aftermath of climate change and environmental-related natural disaster"

Toolkits for Policymakers to Green the Financial System

Strategy and coordination	Green Finance Roadmap	National Climate Finance Strategy	
Build skills & capacity	National Taskforce	International Networks	Paris Alignment by FIs
Regulation & central banks	Climate & Env. Risk Analysis	Supervisory Practice	Supervisory Guidance	Greening Central Bank Activities
Transparency	Disclosure & Reporting	Taxonomy	
Green(ing) FIs	Greening NDBs	New Green Bank/ Finance Entity	
Tools and instruments	Corporate Green Bonds	Sovereign Green Bonds	Blended Finance Products	Green/Sustainability-linked Loans

GREEN FINANCE TOOLKITS FOR POLICYMAKERS

Practical Guide to Support Public Authorities with Greening the Financial System

Prepared by
Finance, Competitiveness, and Innovation Global Practice, WBG

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- Menu of options
- High-level guidance
- Based on good practice and country experience

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FSB-NGFS (2022) survey results on motivation for conducting climate risk assessment

Main purpose of climate scenario analysis exercises — Graph 2
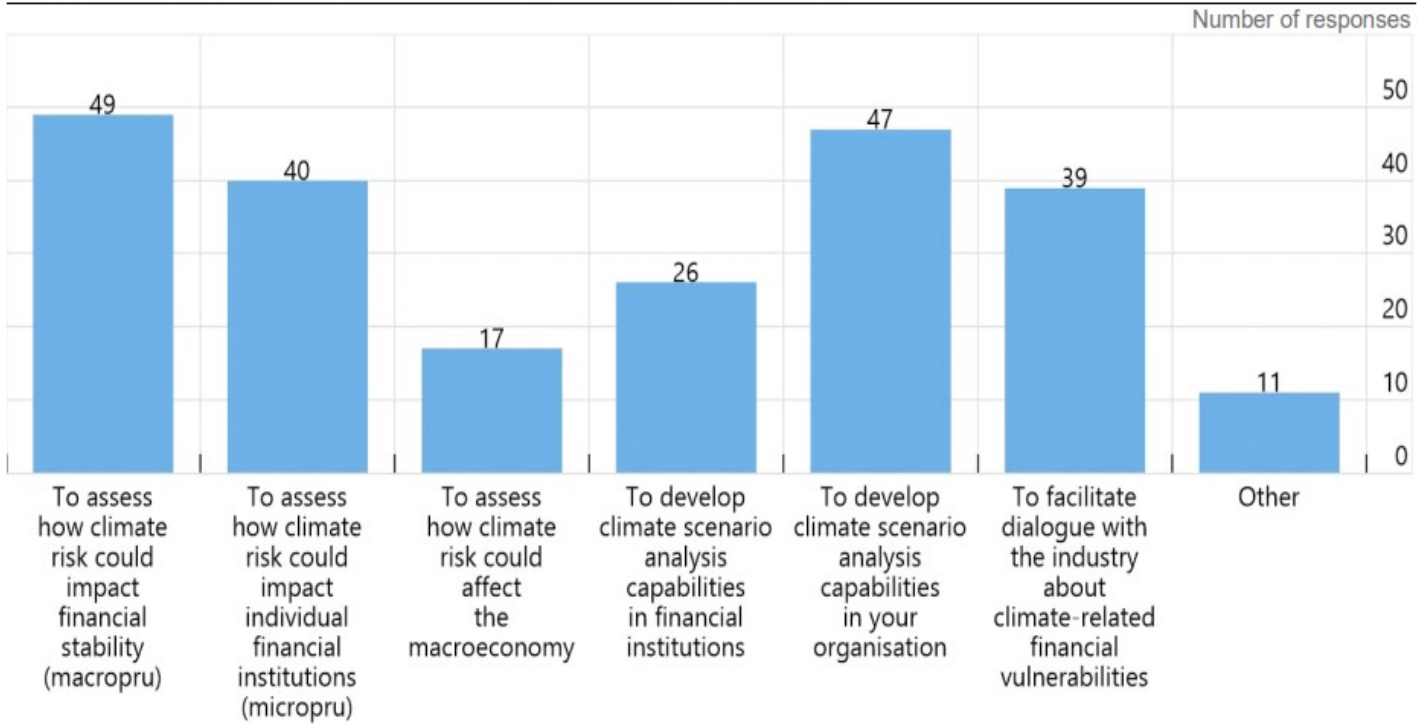
Source: FSB-NGFS survey

The OeNB Pilot Climate Risk Stress Test

FinSAC Conference on "Renewed supervisory challenges
in light of tightened financial conditions and economic slowdown"

Vienna, 10 May 2023

Ralph Spitzer *)
OeNB / Supervision Policy and Strategy Division

*) The views expressed in this presentation are those of the author and not necessarily those of the OeNB or the Eurosystem.

Result: Carbon pricing not a risk to Austrian financial stability

ƎONB

- **2021 EBA baseline** as a **reference scenario**

- Calculate **additional impact** from carbon pricing

- 5Y deviation from baseline 70 bps (orderly) and 267 bps (disorderly)

- **Main observations:**

  - Limited exposure to highly affected sectors

  - AT exposures are less affected by transitions risks than CESEE exposures

  - Strong baseline scenario (post crisis)

CET1 ratio of the Austrian banking system in the OeNB climate risk stress test

difference to baseline in ppt

-0,7%

-2,7%

- - - • Orderly   - - - • Disorderly
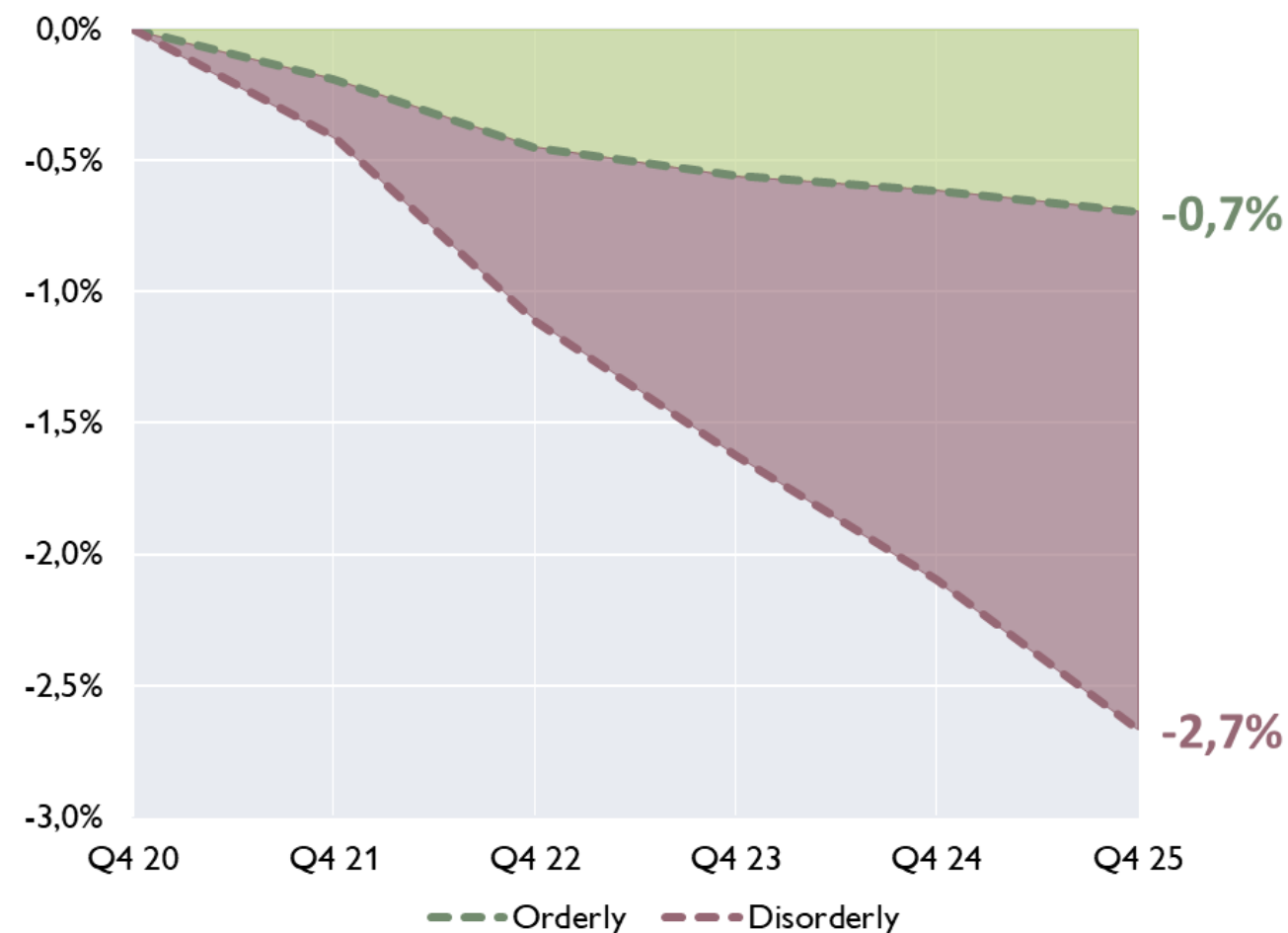
Quelle: OeNB.

General approach

OeNB

- **Pilot exercise** at system and individual bank level
- **Extends** proven OeNB top-down stress test **infrastructure** (corporate insolvency model, ARNIE)
- Uses (relatively well) **established data sources**
- Focus on **transition risk** with front-loaded carbon price shock as main risk driver
- **Compatible time horizon** of 5y (2021 – 2025)
- **Focus on modelling credit risk impact** with Austrian and foreign exposures
- Additional **market risk module**

1 **Sectoral Carbon Price Model** → cost & turnover changes → **2** **Insolvency Model** → sectoral insolvency rates → **Market Risk** — valuation losses → **ARNIE** → **Bank-specific Capital Impact**

Linking Equations — PDs for all countries

Carbon price scenarios
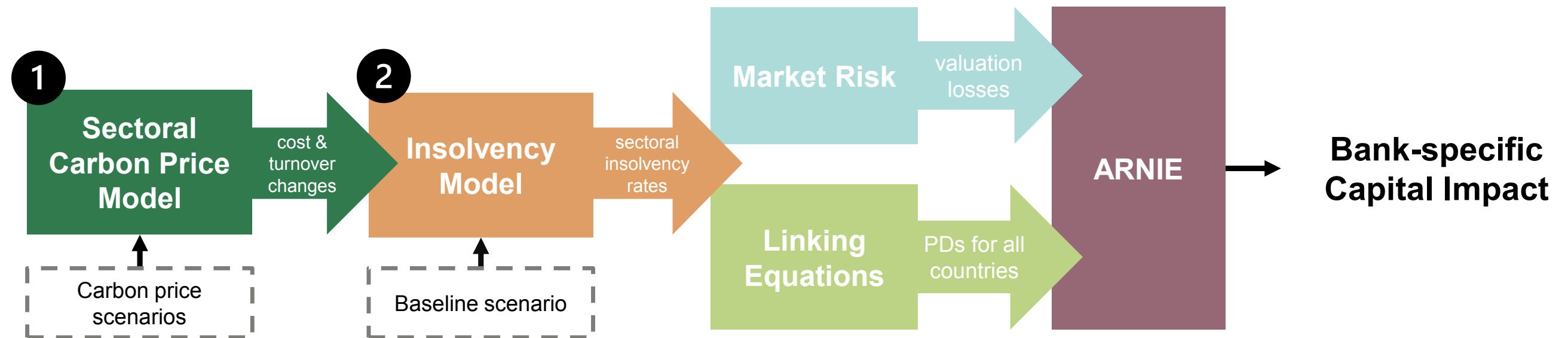
Baseline scenario

→ Link: https://www.oenb.at/dam/jcr:2c2077e8-9729-441a-bb43-3b7a50ec2228/05_FSR_42_OeNB-climate-risk-stress-test.pdf

Carbon price scenario definition aligned with NGFS narratives

ƏNB

- ECB/EBA macroeconomic scenario baseline (ST 2021) as starting point
- **Orderly and disorderly** transition shocks (inspired by NGFS narrative)
- Carbon price introduced as **additional tax** in **all EU countries**, on all GHGs in all sectors
- Inclusion of a **carbon border adjustment mechanism** (CBAM)
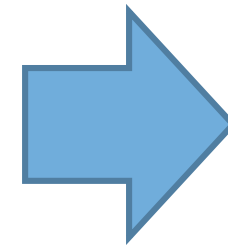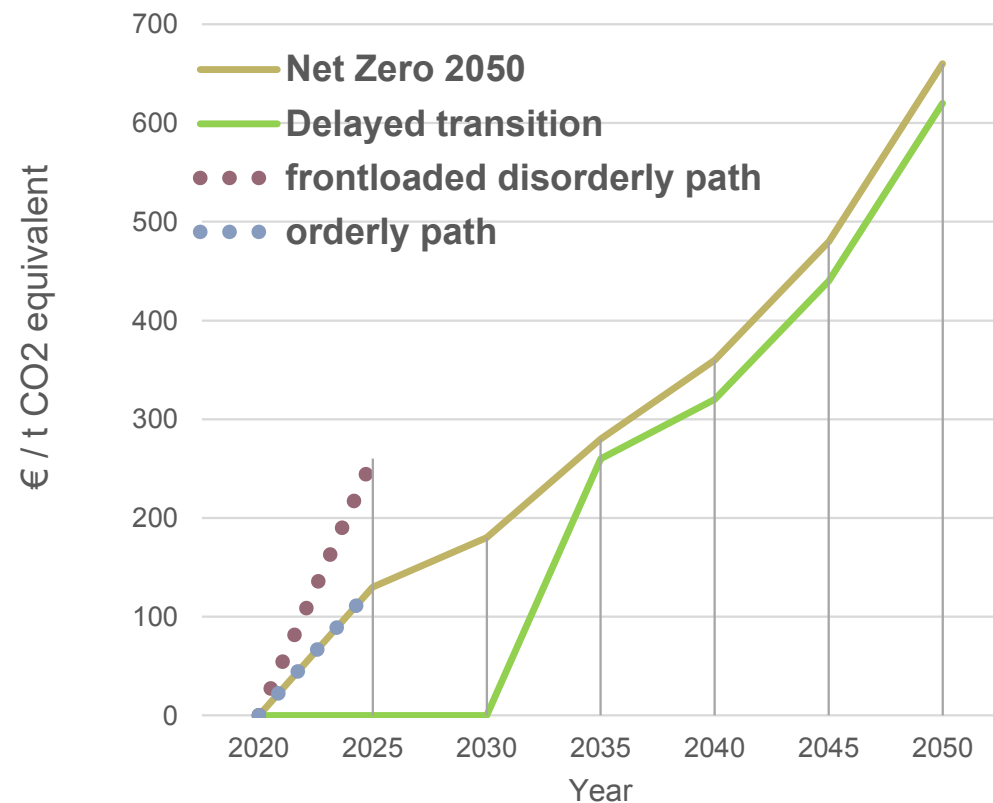
Carbon price paths for the orderly and disorderly scenario
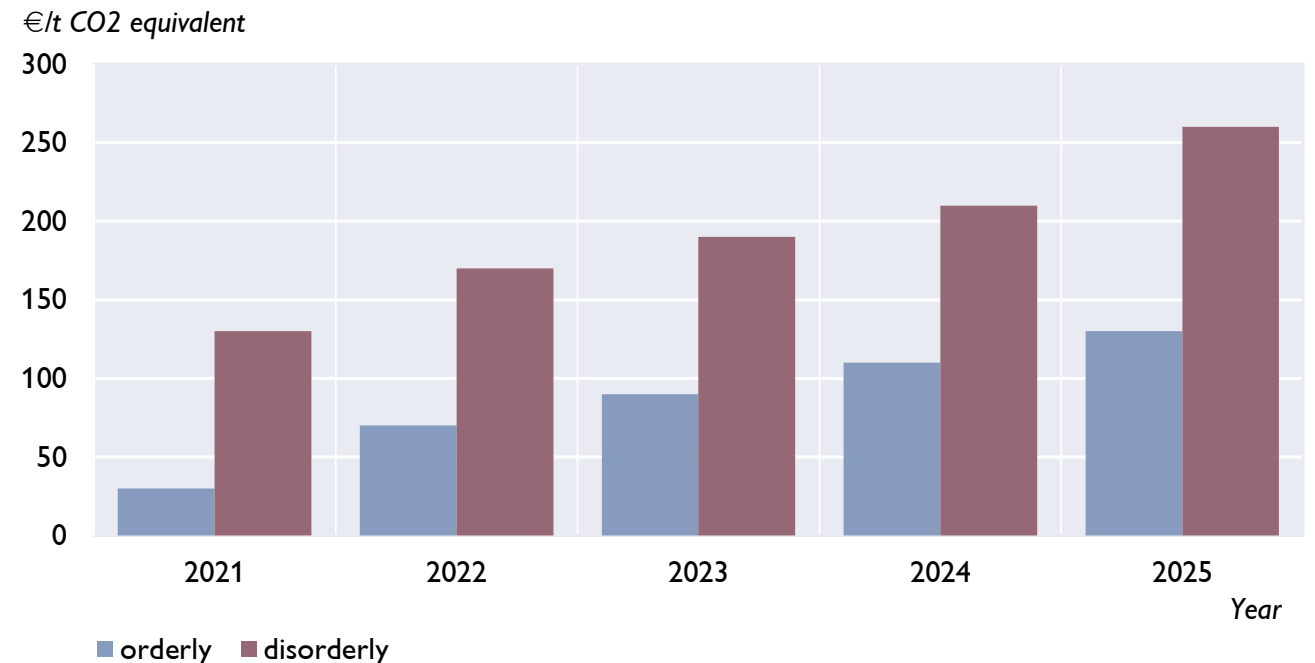
❶ Sectoral carbon price model – Stylized view

⊖NB

- **Multi-Regional Input-Output Analysis** with 21 NACE sectors for 27 EU countries
- Latest available input-output data for 2019 from FIGARO database, Emission data from Eurostat
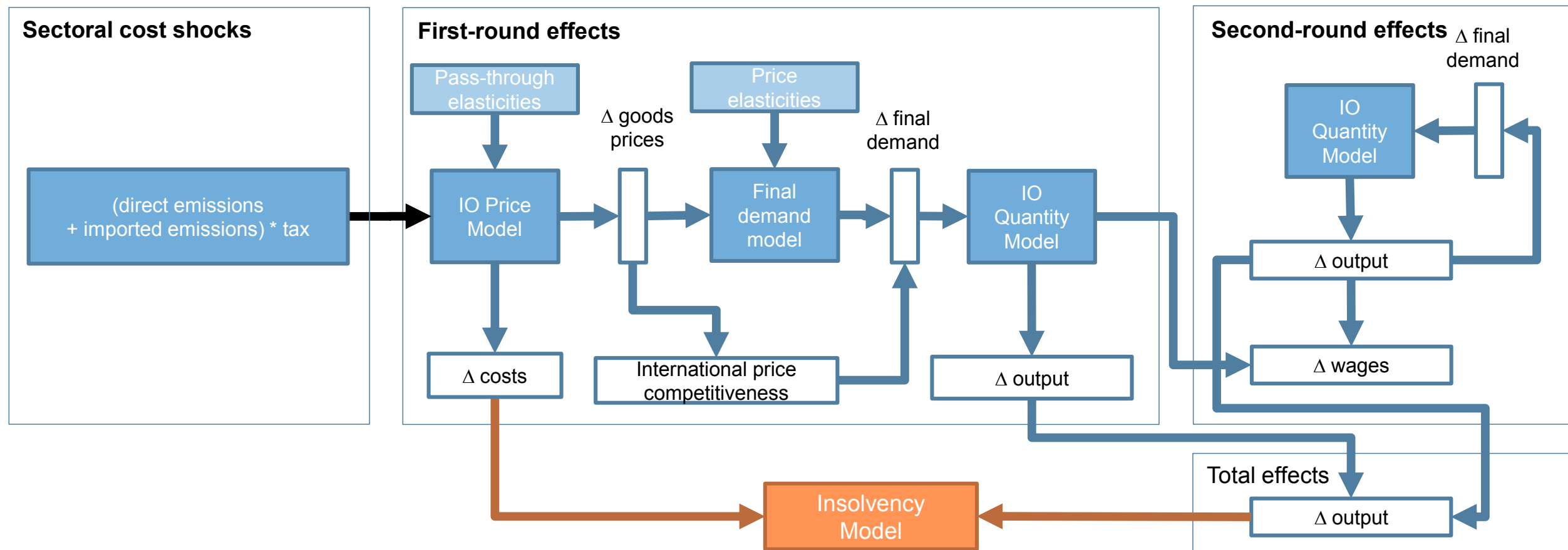
❷ **Sectoral corporate insolvency model – Stylized view**

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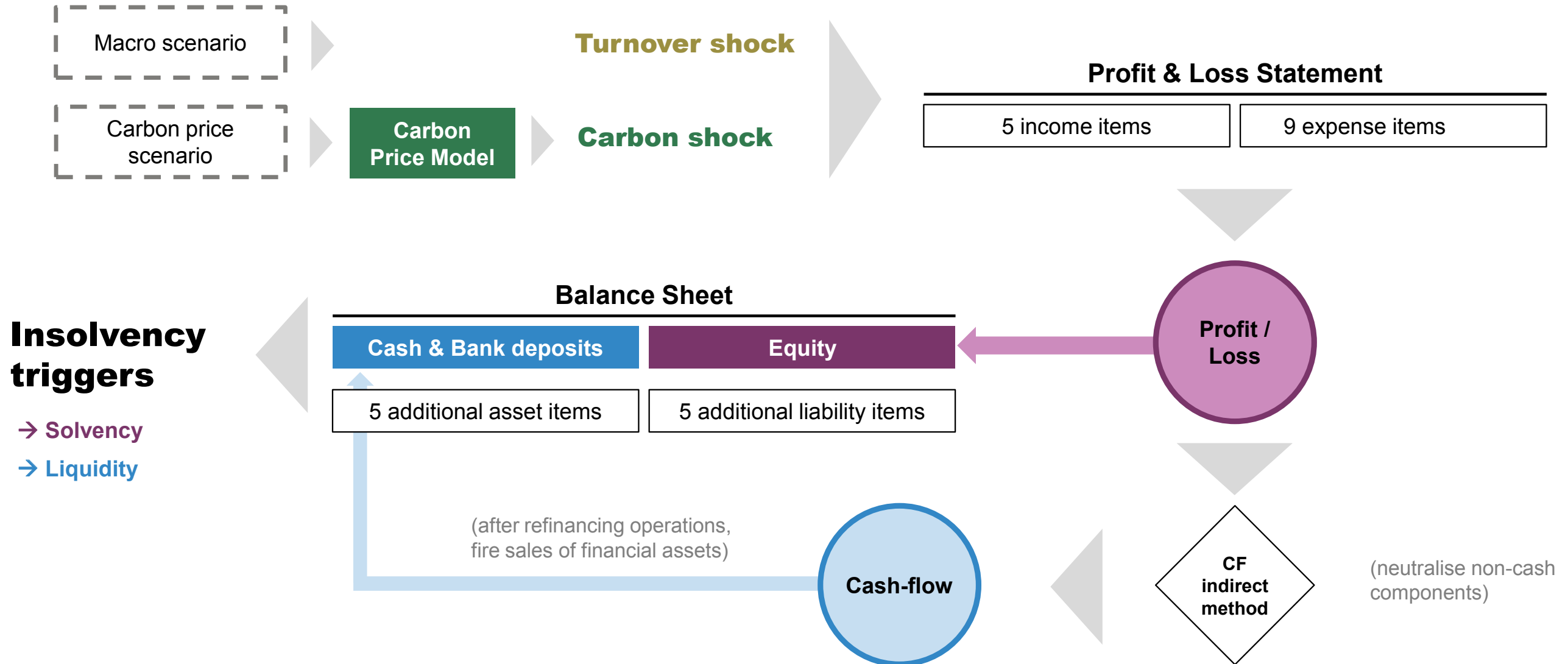
→ Link: https://www.oenb.at/dam/jcr:72edc4bb-aab0-4593-aa2f-b102365c8c0a/06_FSR_40_Modeling_the_COVID-19_effects_.pdf
→ Link: https://www.oenb.at/dam/jcr:560528ca-26fc-4d1e-ad2c-9b01e4b1287b/06_mop_Q4_20-Q1_21_Have-mitigating-measures-helped.pdf

Strengths and weaknesses of our framework

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Strengths

- Consistent framework with NGFS scenario narratives

- Sectoral I/O analysis approach stable and reduces complexity

- Uses strengths of existing OeNB ST framework (insolvency model & ARNIE)

- Relatively simple and transparent

Weaknesses

- EBA baseline scenario not consistent with carbon price shock scenario

- No tax redistribution, no technological change, no product substitution

- Static assumptions: 1) Misses dynamic interactions of a general equilibrium macro model, 2) bank level: no growth, no portfolio rebalancing, 3) company level: no newly founded companies

Climate risk stress testing – What is it good for?

Good for …

- Creating awareness, thinking about risks and channels

- Incentivising banks to

  - improve own climate risk identification and assessment capabilities

  - improve risk governance

  - actively manage concentration risk and adjust business strategy

  - adequately reflect climate risks in loan pricing

  - collect better and more relevant data (energy performance certificates, carbon intensity, …)

- Short-to-medium term projections with relative risk rankings (with a lot of caveats)

Not so good for …

- Long-term projections (even with a lot of caveats)

- Saving the world – Central banks cannot compensate for policy inaction

References

- **Guth, M., C. Lipp, C. Puhr and M. Schneider (2020):** "Modeling the COVID-19 effects on the Austrian economy and banking system", in: Oesterreichische Nationalbank (Eds.): Financial Stability Report 40, p. 63-86.

- **Guth, M., J. Hesse, C. Königswieser, G. Krenn, C. Lipp, B. Neudorfer, M. Schneider, and P. Weiss (2021):** "OeNB Climate Stress Test – Modelling Climate Risk Effects for the Austrian Banking Sector", in: Oesterreichische Nationalbank (Eds.): Financial Stability Report 42.

- **Hesse, J., Puhr, C. and M. Schneider (2021):** "A structural corporate insolvency model to predict sectoral Austrian insolvencies amid the COVID-19 pandemic and beyond", an update of Puhr and Schneider (2021) for EBA's Research Workshop, 16 November 2021. Mimeo.

- **Puhr, C. and M. Schneider (2021):** "Have mitigating measures helped prevent insolvencies in Austria amid the COVID-19 pandemic?", in: Oesterreichische Nationalbank (Eds.): Monetary Policy and the Economy Q4/20 – Q1/21, p. 77-110.

- **Schneider, M. and W. Waschiczek (2021):** "Unternehmensinsolvenzen: Auswirkungen der Hilfsmaßnahmen im Jahr 2020 und Ausblick für 2021 und 2022", in: Oesterreichische Nationalbank (Eds.): Konjunktur aktuell – März 2021, p. 39-43. (German only)

ANNEX

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Sectoral Carbon Price Model shows most affected sectors & regions

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Turnover Losses
at an additional EU-wide carbon price of 130€/t CO2e

■ AT ■ EU ■ CESEE (EU)
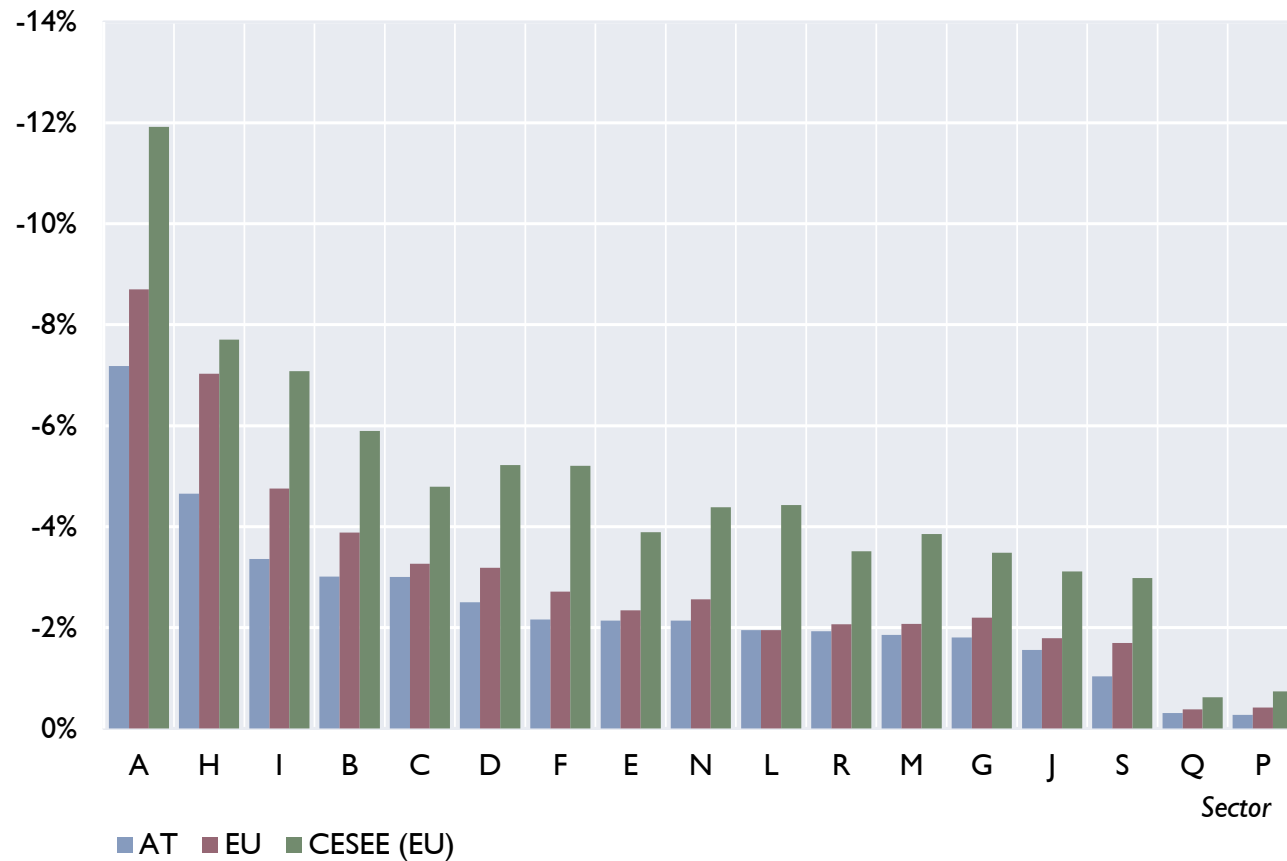
Cost Changes
at an additional EU-wide carbon price of 130€/t CO2e

■ AT ■ EU ■ CESEE (EU)
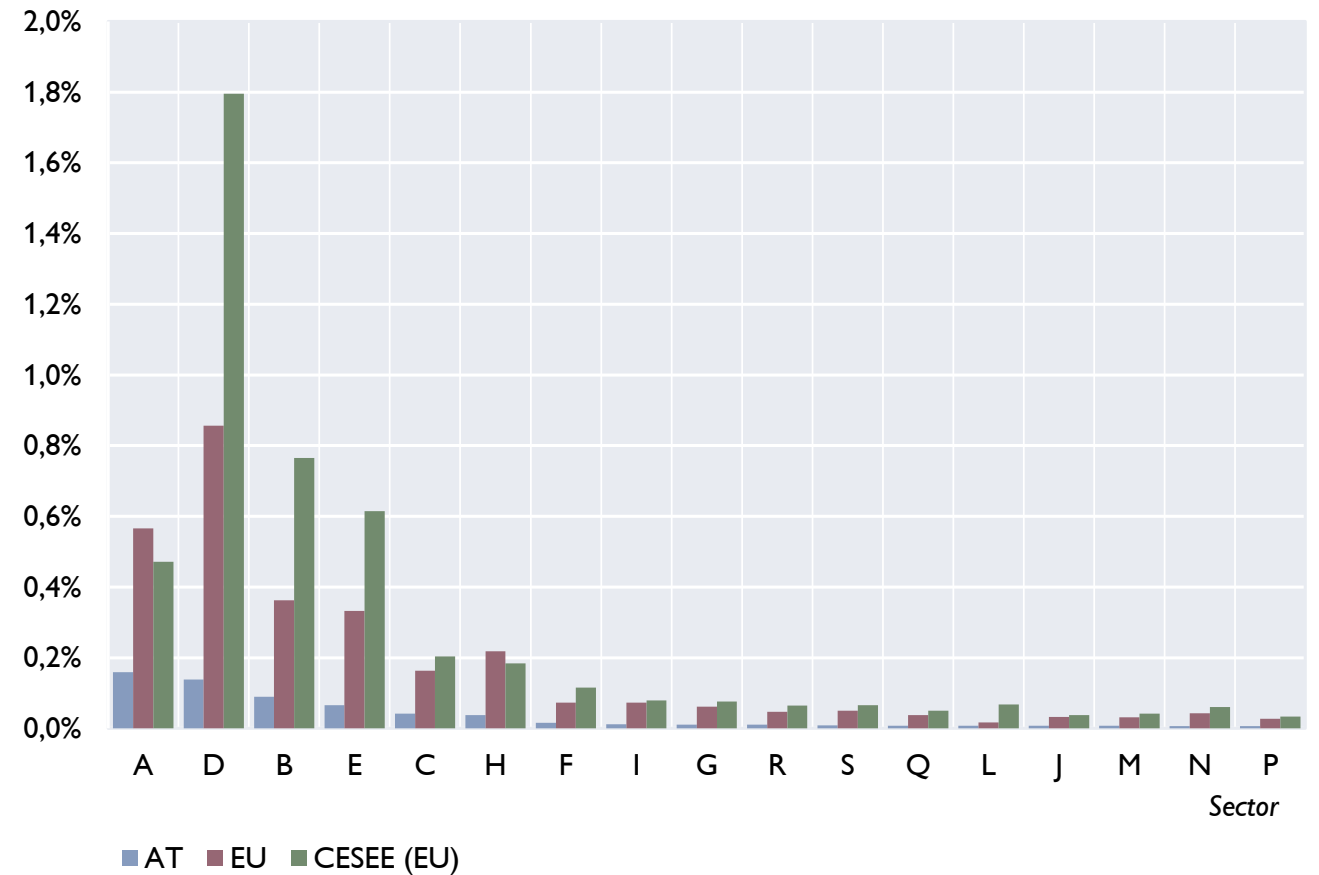
A - Agriculture, forestry and fishing, B - Mining and quarrying, C – Manufacturing, D - Electricity, gas, steam and air conditioning supply, E - Water supply & sewerage, F – Construction,
G – Trade, H - Transportation and storage, I - Accommodation and food services, J - Information and communication, L - Real estate, M - Professional, scientific & techn. Services,
N - Administrative and support services, P – Education, Q - Human health and social work activities R - Arts, entertainment and recreation, S - Other service activities

Insolvency rates: Agriculture and transportation most affected

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Cumulative annual insolvency rates of Austrian non-financial corporates

Insolvency rates in percentage points	Share of EAD 2020	KSV Avg. 2017- 2019	Orderly (Delta to Baseline)					Disorderly (Delta to Baseline)				
			2021	2022	2023	2024	2025	2021	2022	2023	2024	2025
Agriculture, forestry and fishing (A)	0,8%	0,2	0,0	0,3	0,5	0,9	1,4	0,0	2,5	5,8	10,0	15,9
Mining and quarrying (B)	0,6%	0,5	0,0	0,1	0,1	0,2	0,2	0,1	0,2	0,3	0,4	0,6
Manufacturing (C)	15,4%	0,7	0,0	0,1	0,2	0,3	0,5	0,0	0,4	0,8	1,4	2,1
Electricity, gas, steam and air conditioning supply (D)	2,8%	0,3	0,0	0,0	0,1	0,1	0,2	0,0	0,1	0,3	0,7	1,2
Water supply and sewerage (E)	1,0%	0,7	0,0	0,3	0,7	1,1	1,6	0,2	1,3	2,6	3,9	5,2
Construction (F)	8,7%	2,0	0,0	0,1	0,3	0,5	0,7	0,0	0,4	0,8	1,2	1,7
Trade (G)	10,1%	1,0	0,0	0,3	0,3	0,4	0,4	0,0	1,1	1,4	1,5	1,7
Transportation and storage (H)	3,3%	2,6	0,3	0,9	1,6	2,3	2,9	1,7	4,5	7,6	10,3	12,9
Accomodation and food services (I)	4,3%	2,0	0,0	0,3	0,5	0,7	0,9	0,0	1,2	1,8	2,5	3,2
Information and comunication (J)	1,9%	0,6	0,0	0,0	0,1	0,1	0,1	0,1	0,2	0,3	0,3	0,4
Real estate (L)	29,9%	0,3	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,2	0,2	0,2
Professional, scientific, and techn. Services (M)	14,9%	0,5	0,0	0,0	0,1	0,1	0,1	0,0	0,1	0,1	0,2	0,3
Administrative and support services (N)	3,0%	1,6	0,1	0,2	0,3	0,3	0,4	0,3	0,7	0,8	0,9	1,0
Education (P)	0,1%	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1
Human health and social work acitivities (Q)	1,7%	0,4	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,4
Art, entertainment, and recreation (R)	0,4%	0,6	0,1	0,4	0,8	1,2	1,6	0,5	1,3	2,2	2,9	3,7
Other service acitivities (S)	0,9%	0,7	0,0	0,2	0,4	0,5	0,8	0,2	0,6	1,0	1,3	1,8
Total	100,0%	0,9	0,0	0,2	0,3	0,4	0,6	0,0	0,8	1,3	1,8	2,5

Source: KSV 1870, OeNB, Authors´ calculations.

Danke für Ihre Aufmerksamkeit

Thank you for your attention

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OeNB

What's The Cost Of Saving The Planet For Banks?

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Motivation

- Climate change is a source of financial risk $\longrightarrow$ central banks have an interest in stability of financial system.

- Key question I: Through which channels are climate change risks affecting the financial system, and how can they be properly assessed?

- Key question II: How much could these risks costs the financial system?

- The questions at hand cannot be adequately answered by recent stress-testing frameworks.

- Thus, there is a need to develop new instruments and upgrade existing ones.

Agenda

Backdrop

- HH and NFC loans dominate SK banks' balance sheets.

- Indirect transition risk is prominent.

  - SK banking sector has relatively low credit exposure to high-emitting sectors → transformation to a NZC economy does not pose a significant direct risk.
  - The transformation to a NZC economy will cause structural changes in the economy → indirect risks to financial stability.

- SK industry is energy intensive → profitability is sensitive to energy prices.

Figure 1: Asset structure of the Slovak banking sector's balance sheet
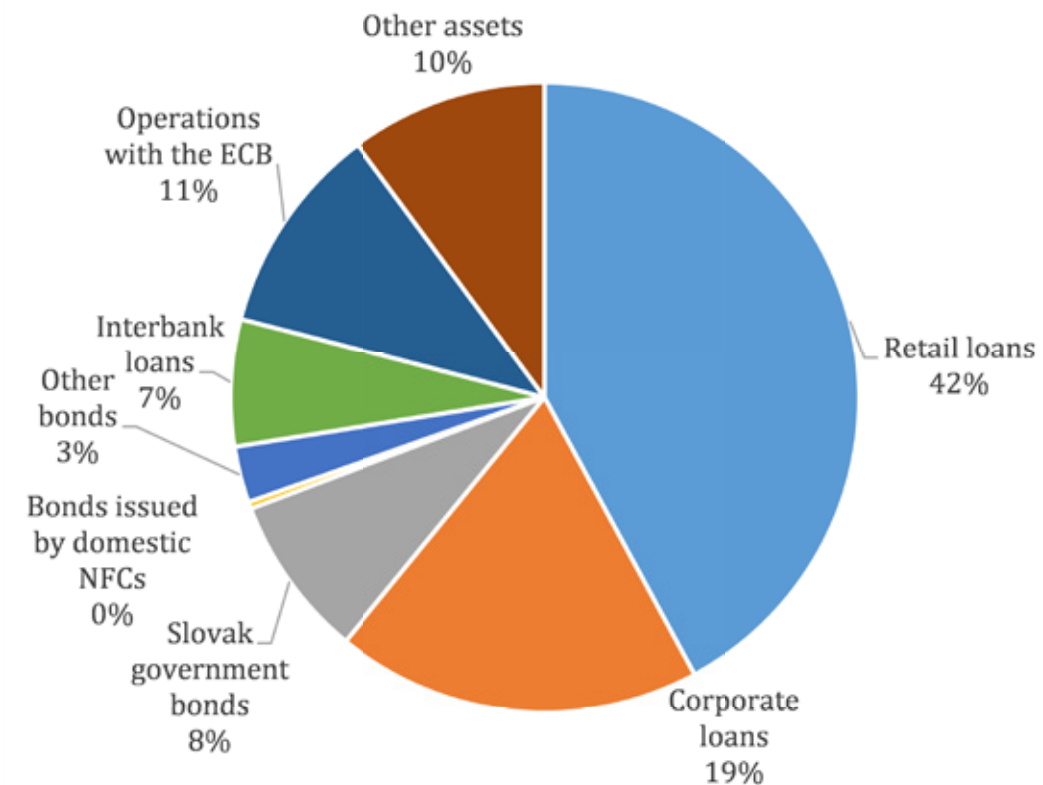
Source: NBS

Outline of NBS Stress Testing Framework

- Standard top-down solvency ST model used by NBS.

- Using supervisory bank-by-bank data for eleven banks.

- Focus on credit-risk.

- Model description is available in Klacso 2014.

NGFS Phase II Scenarios

- Six scenarios are based on different assumptions about the evolution of climate policy, temperature, and emissions.

- The transition risk is well-captured by the Divergent NZ and NZ 2050 scenarios.

- We integrate NGFS scenarios into our stress-testing model, using the macro financial variables from the scenarios as an input.

- Focus on a short-term horizon reduce the effect of high modeling uncertainty in the results.

Figure 2: NGFS Scenarios
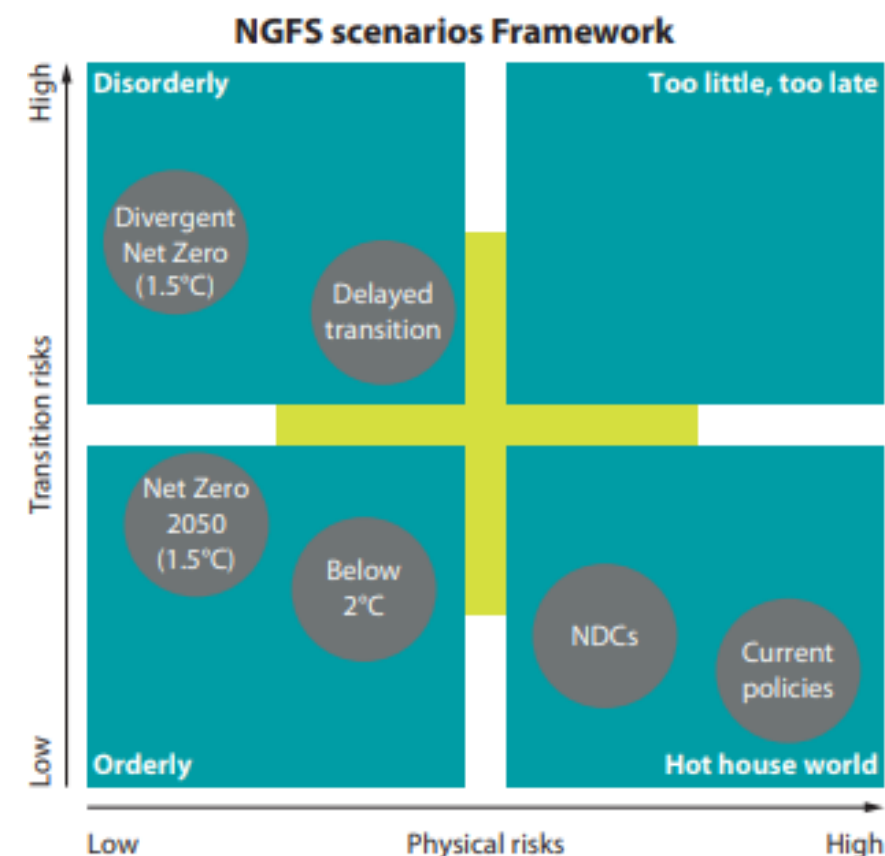
Positioning of scenarios is approximate, based on an assessment of physical and transition risks out to 2100.

Source: NGFS

Impact on Household Credit Risk

- Unemployment rate is a main driver of households' credit risk.

- The increase in unemployment rate is larger under DNZ compared to NZ 2050.

- Reason is success rate of substituting emission-intensive sectors at the start of the transition period.

- Peak increase occurs one year post-shock in both cases.

- If a default occurs, the value of collateral is considered.

**Figure 3:** Unemployment rate - difference compared to baseline
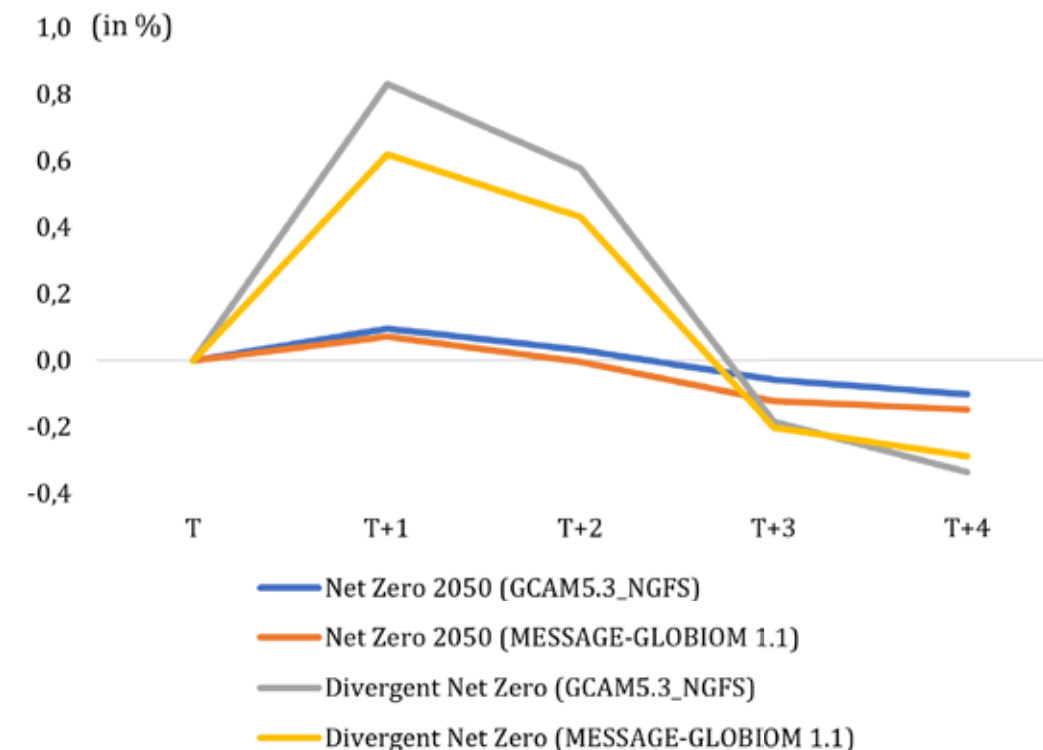
Source: Authors' own calculation, NGFS.
Note: GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

Alternative Scenarios Including Energy Price Increase

- The main driver of the scenarios are ↑ emission costs.

- ↑ energy costs result in a reduction in energy use

- This is mostly offset by improvement in energy efficiency.

- What if: in the short-run, ↑ energy costs ⟶ ↑ energy prices for households if there is a lag in the use of alternative sources.

- Scenarios: energy costs to households ↑ by 20%, 50% or 100% of gas price increase.

Figure 4: Gas price increase compared to the baseline
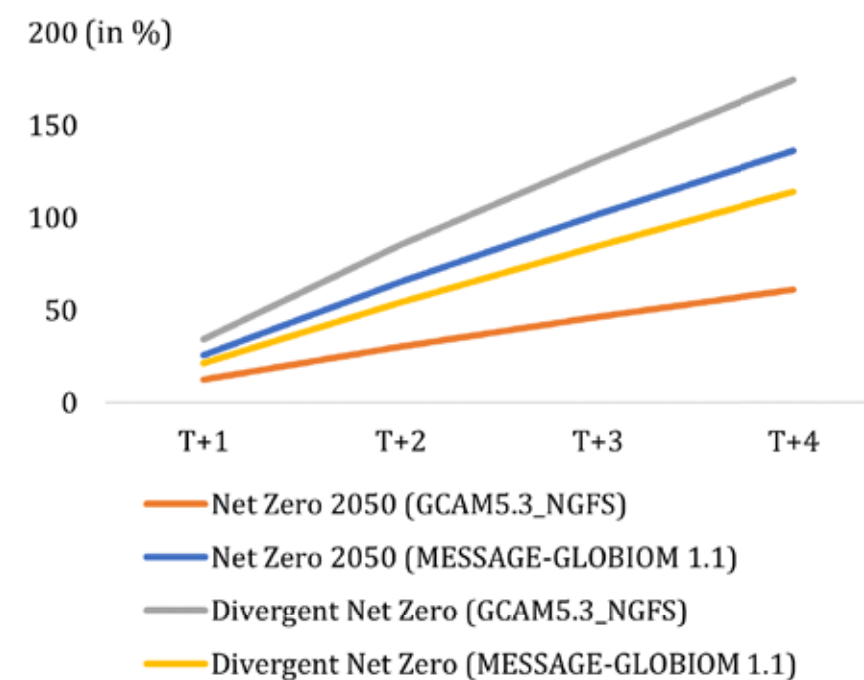
Source: Authors' own calculation, NGFS
Note: GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

Household Credit Risk

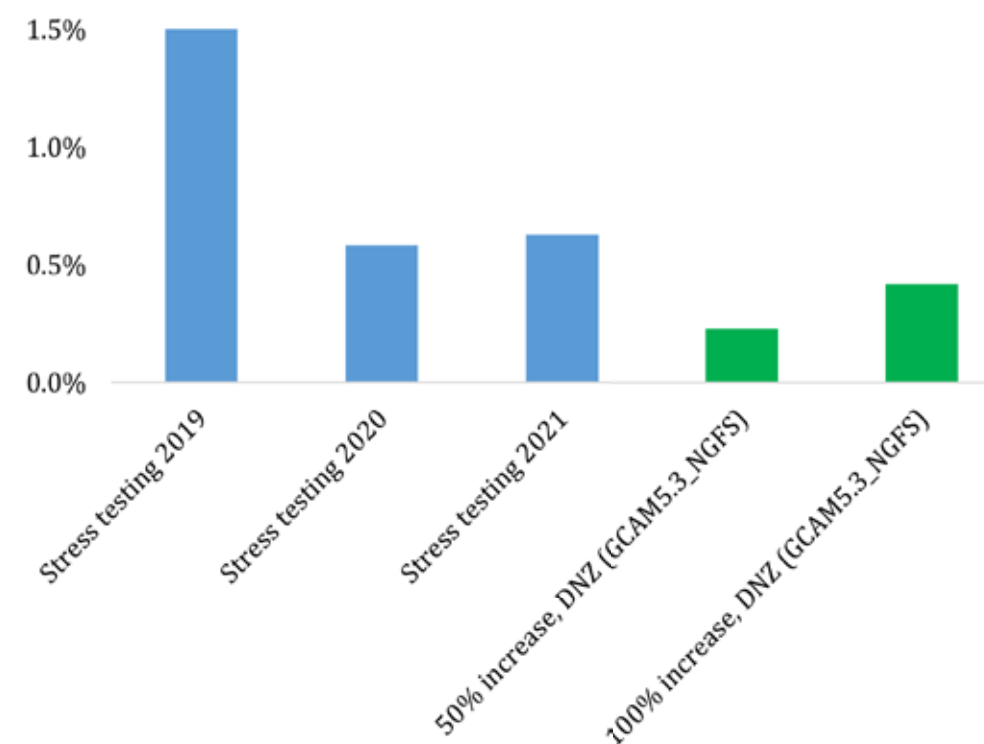**Figure 5:** Results of the Divergent Net Zero scenario compared to conventional stress testing
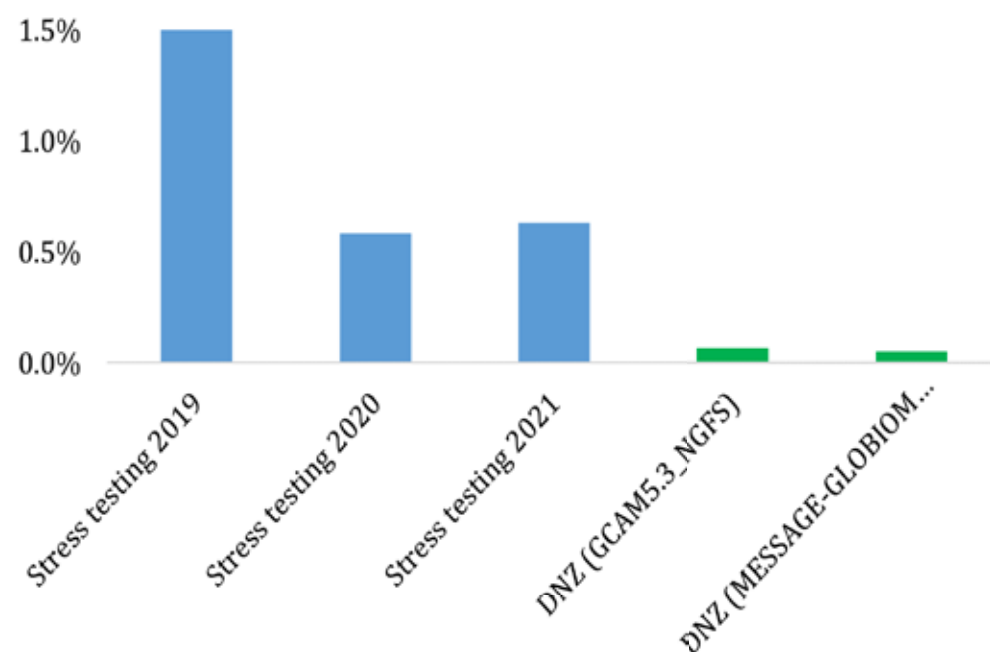
Source: NBS, Authors' own calculation.
Note: All results are provided relative to the baseline, as a percentage of the outstanding amount of loans.
GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

Figure 6: Increasing energy prices - losses from loans to households
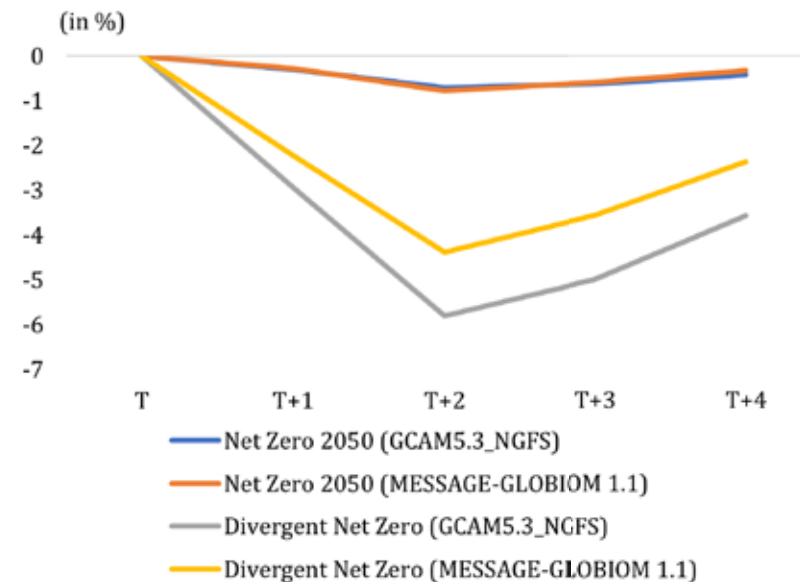

Source: NBS, Authors' own calculation.
Note: All results are provided relative to the baseline, as a percentage of the outstanding amount of loans.
GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

Impact on Non-Financial Corporations Credit Risk

- High-emitting companies/sectors are more affected by the scenarios as the shock to GDP is mainly driven by the emission prices.

- We use a transition vulnerability factor (TVF) for each sector, calculated based on their CO_2 emissions for producing goods and services.

- Then TVF * GDP shock to account for each company/sector's emission production and ownership.

- Companies' revenues are linked to development of GDP.

- The profitability of companies is affected in two ways - an ↑ in costs and a ↓ in revenues.
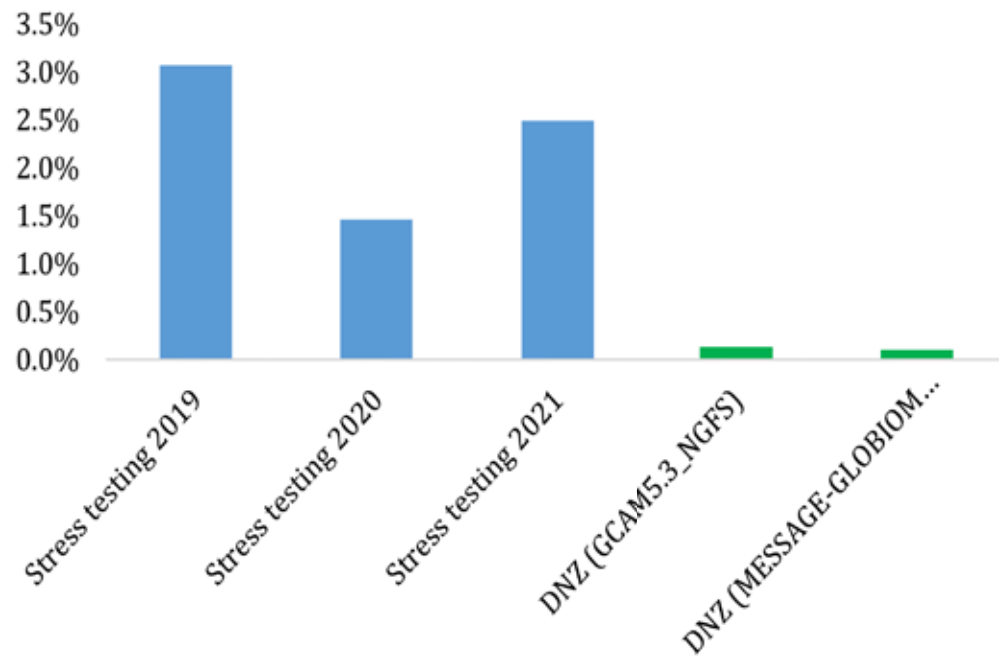
Figure 7: GDP – difference compare to baseline

Source: Authors' own calculation, NGFS.
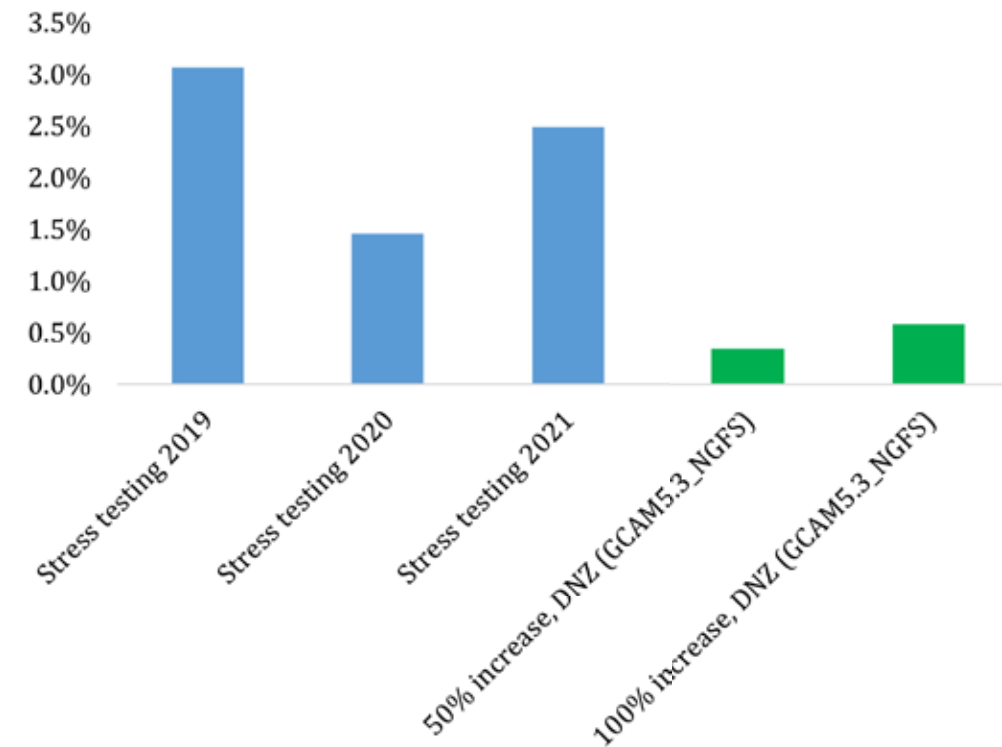Note: GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

Non-Financial Corporations Credit Risk

Figure 8: Results of the Divergent Net Zero scenario compared to conventional stress testing
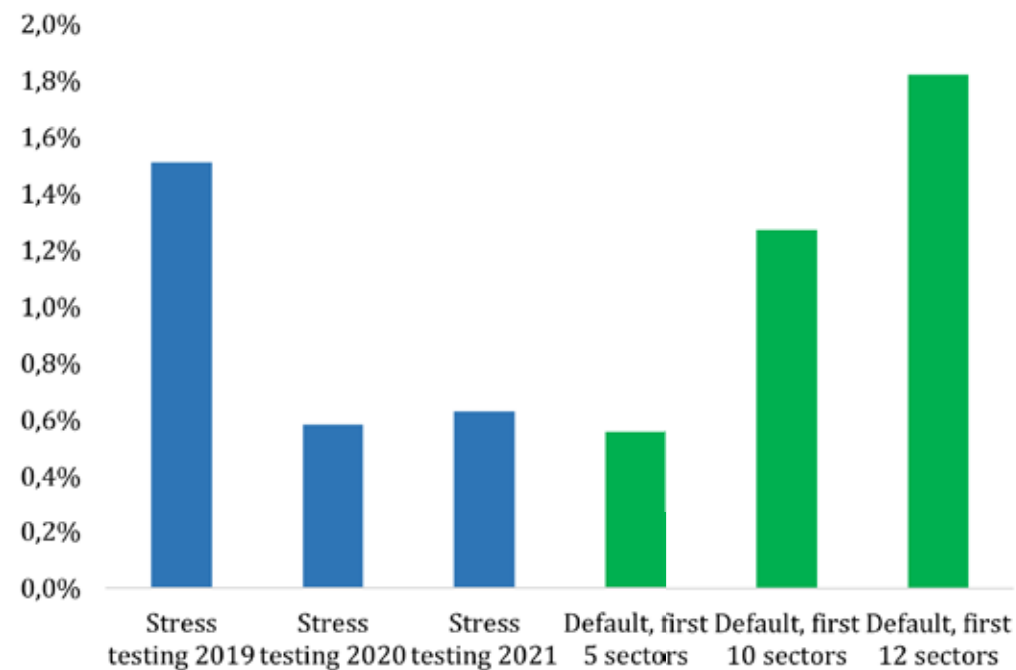

Source: NBS, Authors' own calculation.
Note: All results are provided relative to the baseline, as a percentage of the outstanding amount of loans.
GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

Figure 9: Increasing energy prices - losses from loans to NFCs

Source: NBS, Authors' own calculation.
Note: All results are provided relative to the baseline, as a percentage of the outstanding amount of loans.
GCAM5.3_NGFS and MESSAGE-GLOBIOM 1.1 are IAM models.

# Default of High-Emission Intensive NFCs

- Sectors are ranked in descending order based on TVF, and we assess the impact of default on five, ten, and twelve sectors.

Figure 10: Default of emission intense sectors - losses from loans to households

Source: NBS, Authors' own calculation.
Note: All results are provided relative to the baseline, as a percentage of the outstanding amount of loans.

Figure 11: Default of emission intense sectors - losses from loans to NFCs
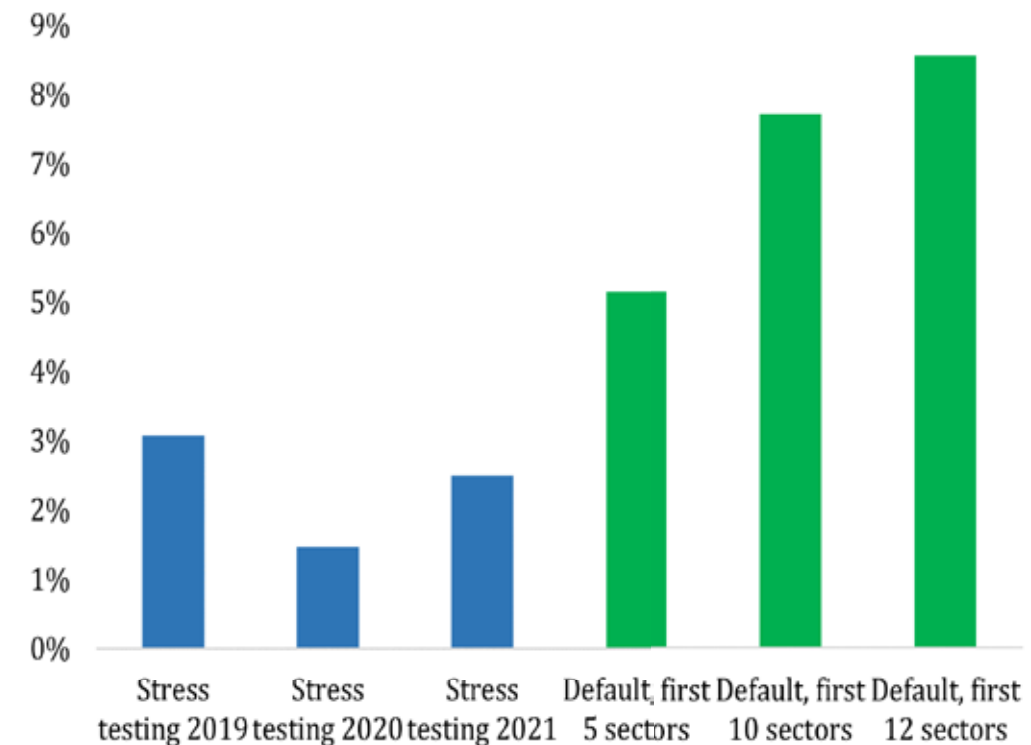
Source: NBS, Authors' own calculation.
Note: All results are provided relative to the baseline, as a percentage of the outstanding amount of loans.

Conclusions

- We assessed the indirect impact of transition risks on the banking sector using NGFS scenarios over a four-year horizon.

- A relatively smooth substitution – *Net Zero 2050* – of emission-intensive sectors results in relatively low indirect costs for banks,

- while an uneven transition – *Divergent Net Zero* – generates significantly higher losses that occasionally exceed adverse scenario outcomes of conventional stress testing.

- Increased energy prices in the short-run may have a significant impact on households' credit risk if there is not enough alternative energy supply.

- Similarly, if companies cannot adjust sales prices, increased energy prices may significantly affect the credit risk of non-financial corporations.

Thank you for your attention!

Appendix 1

Figure 12: Outline of NBS stress test framework
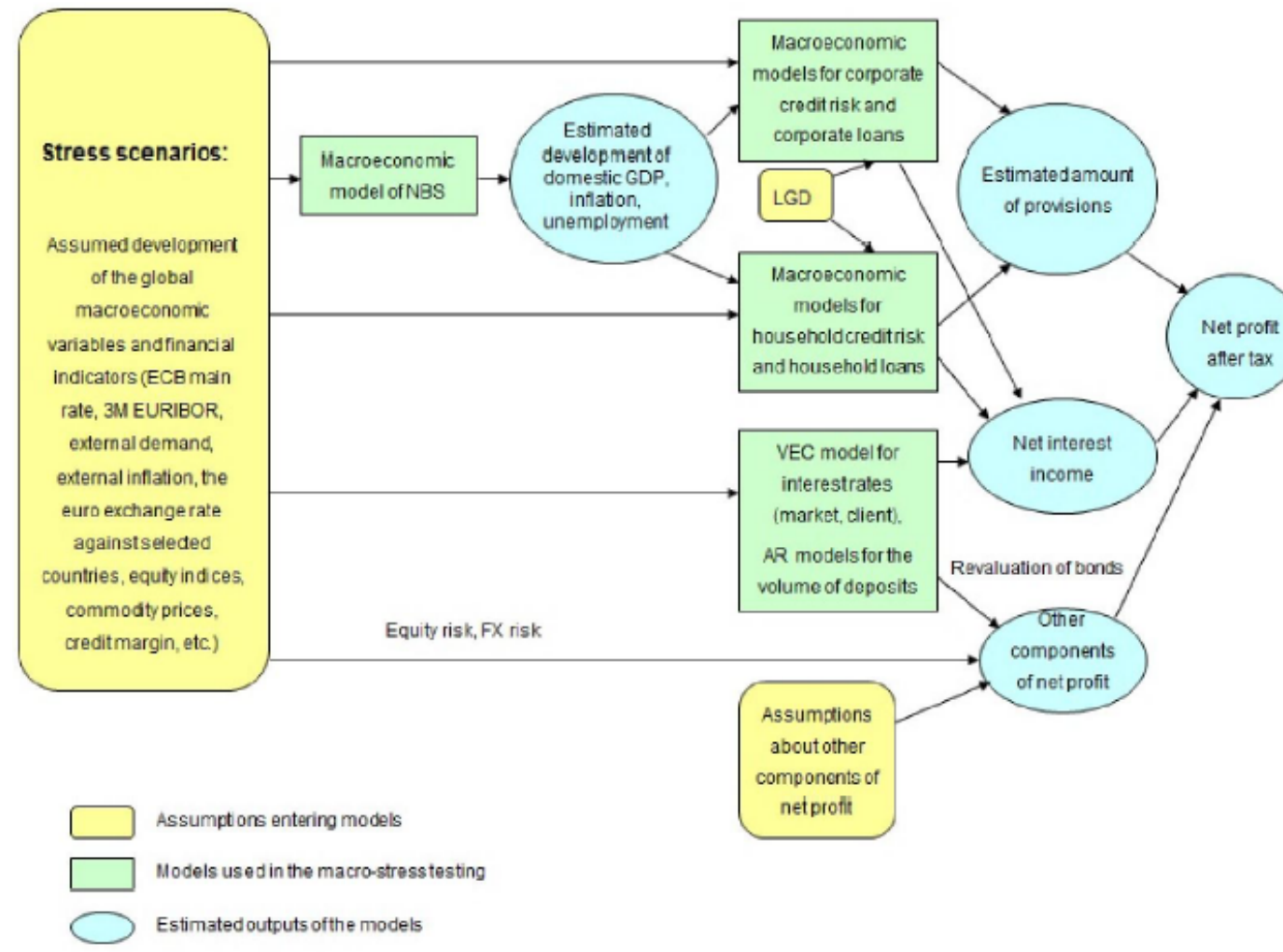
Source: NBS

Appendix 2

Table 1: Estimated Transition vulnerability factor for first fifteen Slovak sectors

Sector	TVF
Manufacturing and basic metals	7.52
Manufacture other non-metallic mineral products	4.52
Manufacture of fabricated metal products, except machinery and equipment	3.54
Electricity, gas, steam and air conditioning supply	3.47
Manufacture of chemicals and chemical products	3.38
Manufacture of coke and refined petroleum products	2.41
Land transport and transport via pipeline	2.38
Manufacture of electrical equipment	2.37
Postal and courier activities	2.23
Construction	2.07
Manufacture of machinery and equipment n.e.c.	1.95
Manufacture of rubber and plastic products	1.91
Manufacture of other transport equipment	1.83
Air transport	1.79
Manufacture of motor vehicles, trailers and semi-trailers	1.70

Source: Authors' own calculation based on Vermeulen et al. 2018

Data Challenges in Climate Change Stress Testing

May 2023

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Addressing data challenges

- Primary data

  – Dissemination by firms

  – Questionnaires

    - Firms

    - Households

  – Collected by banks

    - Questionnaires for loan evaluation

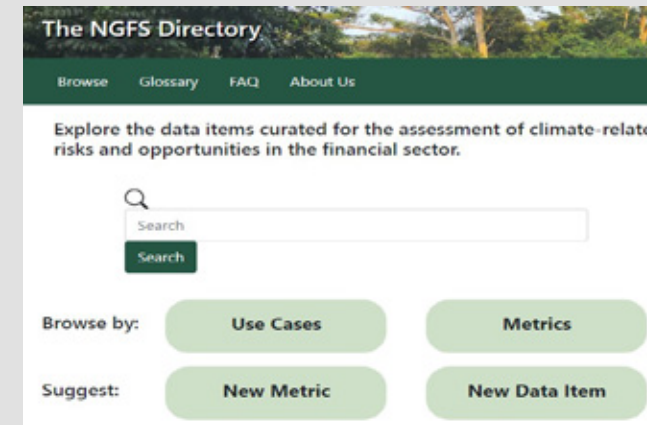 – Common platform

    - e.g., Austrian banks' project

Addressing data challenges

- Secondary data

  – Average by sector

  – Average by region

  – Scaling up from sub-sample

    - Can indicate range

  – Data from other countries

    - Can indicate range

  – Environment-enhanced input-output tables

  – Non-economic databases

    - e.g., on weather events

Some secondary sources

- NGFS Directory
  - https://www.ngfs.net/sites/default/files/medias/documents/final_report_on_bridging_data_gaps.pdf
  - https://ngfs.dev.masdkp.io

- NBR survey October 2022
  - https://www.bnr.ro/PublicationDocuments.aspx?icid=16645

- CDP
  - https://www.cdp.net/en/data

- Greenhouse Gas Protocol inventory of Life Cycle Databases
  - https://ghgprotocol.org/life-cycle-databases

- European Platform on LCA | EPLCA
  - https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

- EU Building Stock Observatory
  - https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/eu-building-stock-observatory_en

ECB

'The Macroprudential Challenge of Climate Change' and Annex, July 2022

'Climate-related risk and financial stability,' July 2021

- Use gap between firm emissions and allowance under the European Emissions Trading System. For covered firms, shows exposure to carbon tax increase

- Base exposure on estimated average sectoral CO2E

- Use external EU taxonomy alignments estimated at NACE four-digit sector level

ECB

- Correlate common variables in the national household budget survey and mortgage loan-level monitoring database to estimate energy expenditure and emissions by household and property characteristic

- Use input-output tables to estimate effect of a large reduction in hydrocarbon supply and/or a reduction in demand

- Estimate flood risk for location of firm headquarters based on information from geographic survey and available depth-damage curves

ECB

a) Loan-weighted Scope 1 emission intensity by sector and country

(y-axis: kg of CO2e per euro of GVA, 2020)

Data Challenges

May 2023
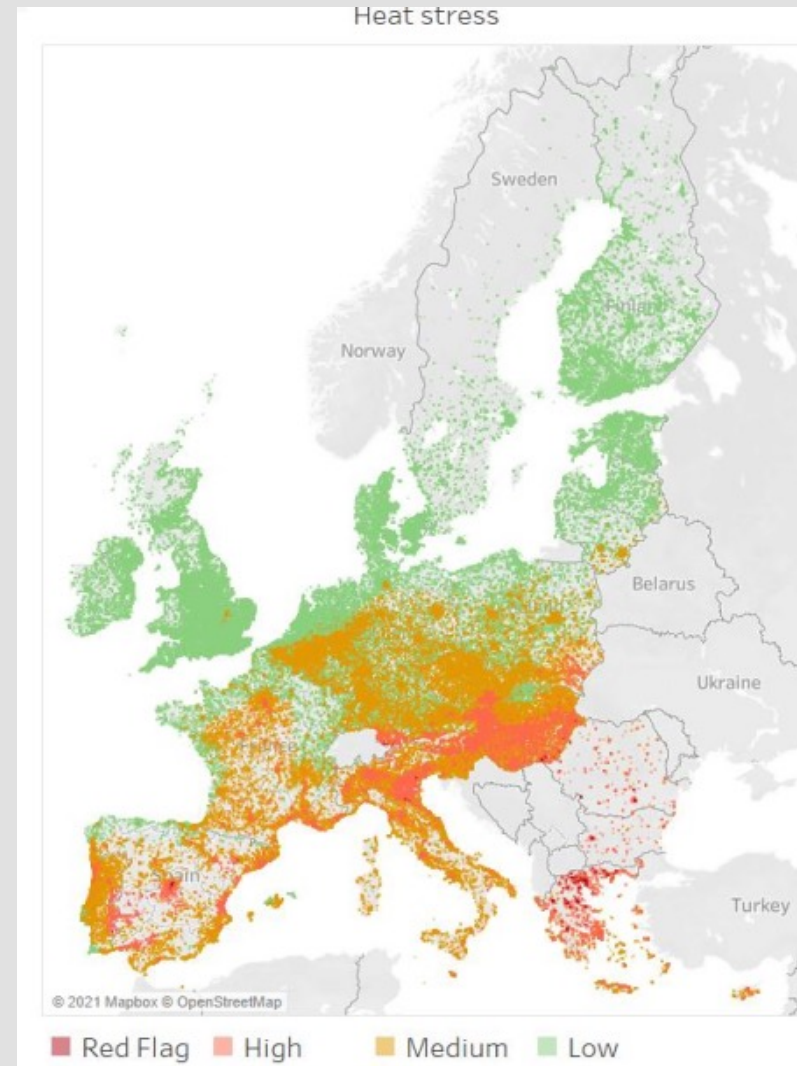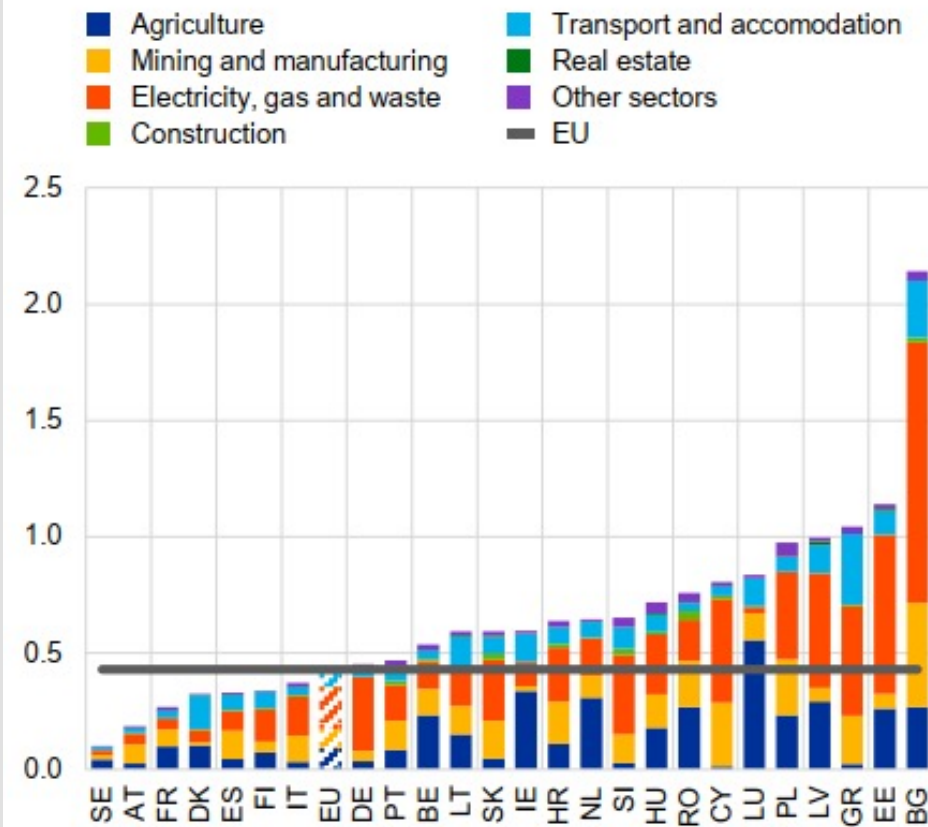
Take aways

- Data challenges severe but not insurmountable

  – Physical risks especially challenging

  – 'Tail' of distribution of impacts especially challenging

- Data availability improving

  – Authorities and banks can take action

- Need to combine data from several sources

- Need to acknowledge uncertainties and gaps

- Judgement

  – Use 'heroic assumptions' to capture major risk factors

  – Start with near-term, measurable risks