

Just in Time

ECB Economy-wide Climate Stress Test *Methodology and Results*

Oct 2021

Executive Summary

The main contribution made by this paper is the development of a centralized (top-down) economy-wide climate stress test that assesses the resilience of NFCs and euro area banks to transition and physical risk, applying a range of assumptions in terms of future climate policies. The stress test presented here comprises three main pillars. First, climate-specific scenarios identify future projections of climate and macroeconomic conditions over the next 30 years. Second, a comprehensive dataset combines climate and financial information for millions of companies worldwide and maps them to banks through granular loan and security holdings. Third, the specific transmission channels of climate risk drivers for firms and banks are captured thanks to a novel set of climate-specific models.



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01

The Methodological Framework

Key Distinctive Features and Main Differences with Climate Stress Tests Already in Place



The Methodological Framework

Key Distinctive Features and Main Differences with Climate Stress Tests Already in Place

The ECB climate risk stress-testing framework offers a comprehensive methodology for evaluating the **impact of alternative climate scenarios on the resilience of NFCs and banks** over a time horizon of 30 years.

The set-up is unique and different from climate stress-test exercises previously performed given that:

It is a Centralized, Top-down Exercise

The proposed framework is **based on data, assumptions and models** that have been developed by ECB staff and that have been **homogenously applied** to all euro area financial institutions.

Climate Specific Scenario

It relies on climate-specific scenarios that allow for the **interactions between transition and physical risks** over a 30-year time horizon. Transition and physical risks are **two sides of the same coin**: greater policy action might increase the impact of transition risks, but at the same time reduce physical risks in later decades.



Counterparty-level Analysis

Unique **dataset** that **includes counterparty-level climate and financial information**. This granularity made it possible to accurately map banks' NFC counterparties together with their carbon footprint, physical-risk score and financial information.

Dedicated Set of Models

It captures the **specific transmission channels** for transition and physical risks: it is assumed that firms would be affected differently by **transition risk** depending on their projected greenhouse gas (GHG) emissions, energy mix and technological innovation. For **physical risk**, firms were assumed to be subject to heterogeneous effects based on their geographical location.

02

Scenarios

Scenario Narrative

Macroeconomic and Climate Projections

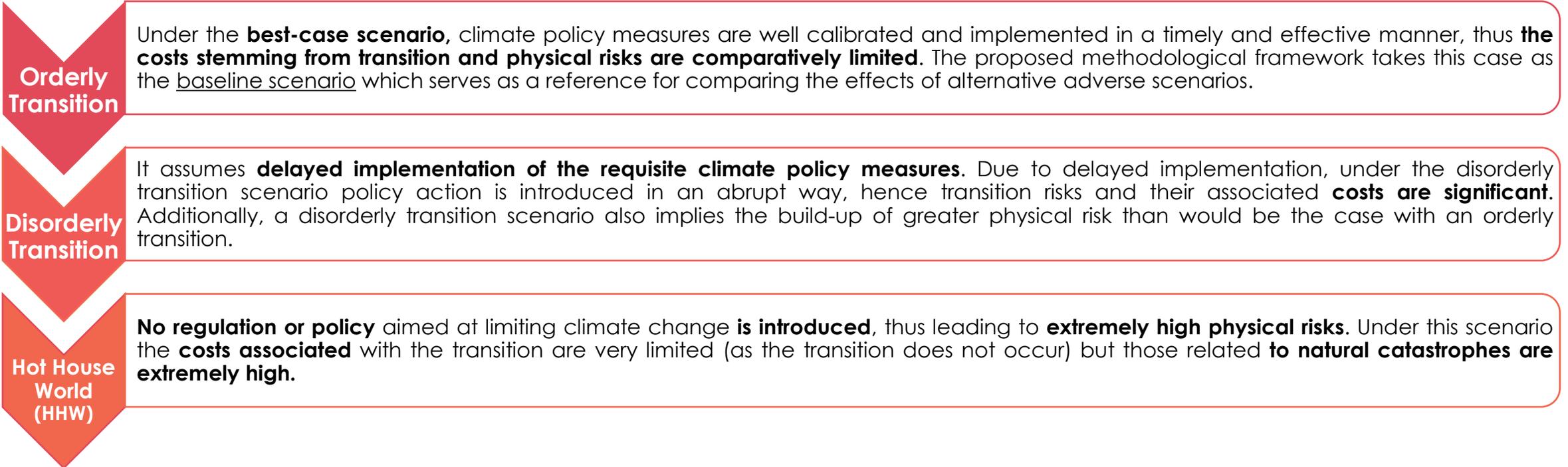


Scenarios 1/3

Scenario Narrative

The climate stress tests exercise aims at **assessing the resilience of banks and NFCs** in a range of climate scenarios. These hypothetical scenarios **combine** plausible representations of **future climatic conditions** with estimates of the macroeconomic **impact on businesses and balance sheets** of policies designed to limit the extent of climate change.

The ECB's economy-wide climate stress test applies **three main scenarios** based on a **30 years time horizon** and on a **static balance sheet** assumption during the same period (while firms' carbon footprint is dynamic):



Scenarios 2/3

Macroeconomic and Climate Projections 1/2

The proposed stress-testing set-up makes it possible to project the changes in the key indicators selected over the specified forecast horizon for each of **the three climate scenarios**.

Below is reported the projected paths of selected aggregates under the three scenarios in the case of Europe

REAL GDP

- Real GDP could be expected to **grow** under all scenarios **over the next decades**, however the pace at which it is expected to increase would **vary across scenarios**.
- From 2045/50 onwards **the most adverse scenario** from a macroeconomic perspective would be the **HHW** scenario, while the **most beneficial** would be **orderly transition** already from 2030.
- While in the very **short-term real GDP** would **increase more in the HHW** scenario as compared with the baseline scenario, in the **medium to long term** the macroeconomic **costs** associated with physical risk **would become more significant** than those related to transition risk.
- In a disorderly transition, cost would imply the largest negative impact on GDP; this situation however reverses after 2045, when the increased frequency and severity of natural catastrophes starts to prevail.
- The impact of **physical risk on GDP prevails** over the transition costs **under all scenarios** and throughout the projection horizon.
- The impact from transition risk is limited to no more than **2% of European GDP** in the event of a **disorderly transition**, while in a **HHW** scenario it could decrease up to **10% by 2100**.

Scenarios 3/3

Macroeconomic and Climate Projections 2/2

GHG EMISSIONS

- Projected levels of carbon emissions under the HHW scenario are well above those under the baseline scenario over the entire forecast horizon.
- The mentioned above difference does not hold between orderly and disorderly transition scenarios due to differentiated access to and availability of carbon dioxide removal (CDR) technologies between the two cases over time.
- For the purposes of this exercise, **ECB assumed fully available CDR technologies** under the **orderly transition scenario**, and only **limited** CDR technologies under the **disorderly transition** scenario.

ENERGY PRICES

- **Green energy would be produced** relatively **more efficiently under the orderly transition** scenario, which would allow energy prices to swiftly take a downward trend.
- By contrast, in a **disorderly transition** scenario projected **energy prices are comparatively higher** over most of the forecast horizon.
- A timely and efficient use of green technologies would not only exert downward pressure on energy prices through lower energy production costs but also through lower energy consumption.

03

Data

Data Sources and Integration Procedure

Breakdown of European Firms' Exposures to Climate Risk

Breakdown of Euro Area Bank Exposures to Climate Risk

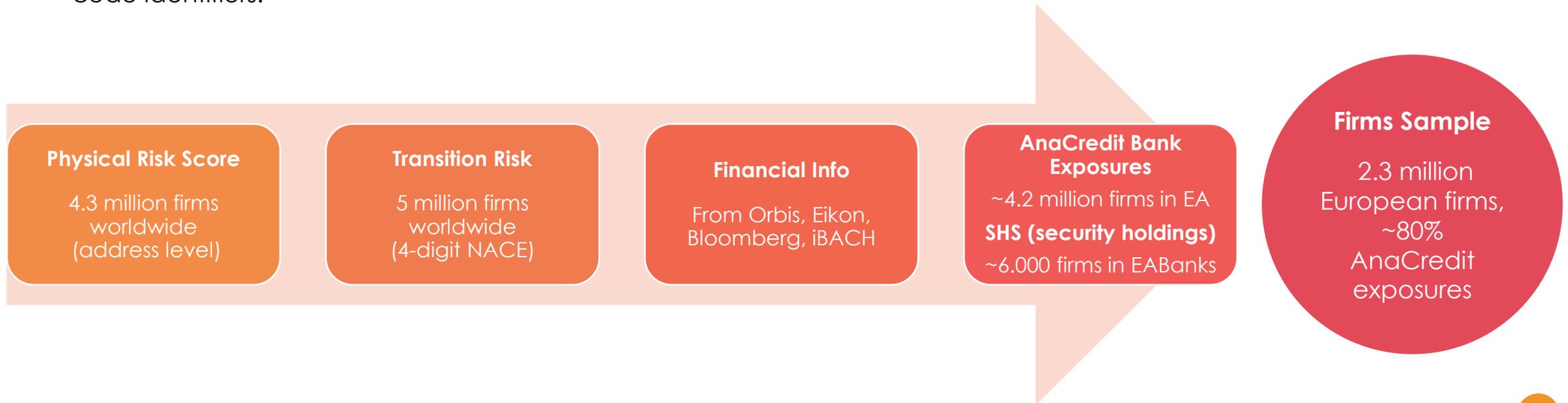


Data 1/3

Data Sources and Integration Procedure

The data used for the climate stress test integrates four main streams of information and combines regulatory and private sources. In particular:

1. Firms are geolocated at address level and are subsequently assigned a **physical-risk score** based on firms' climate information obtain from four twenty seven.
2. Firms are **sectoral classified** via **nace** code, in order to derive **transition risk** via firms' emission carbon data, obtained from urgentem.
3. Firm-level **financial information** are obtained from different **data provider**, such as orbis or bloomberg.
4. Firms are mapped to **bank-level individual exposures** derived from the AnaCredit and SHS-G databases via RIAD and ISIN code identifiers.



Data 2/3

Breakdown of European Firms' Exposures to Climate Risk

Below is the level of exposures of European companies to climate risk partitioned by firm size, sector and country of origin:



Size

- **Large firms** seem to be **the biggest polluters** given that they contribute almost **90% of the overall emissions**. Due to the fact that they typically rely on a larger supply chain, and they are also typically more inclined to report their emissions than small companies.
- Looking on average emission **relative to revenue**, the **differences are less pronounced** across companies: nonetheless, micro firms are almost half as carbon intense as large firms.



Sector

- **On average**, the **most emission-intensive** sectors are **mining**, followed by electricity and gas and agriculture, while overall, **the biggest contributors** are **manufacturing**, electricity and gas, as well as transport, wholesale and retail activities.
- Firms exposed to **high transition risk** are **concentrated in resource-intensive sectors**, while vulnerability to high physical risk seems to be spread homogeneously across sectors.



Country

- The distribution of **emission** intensities seems to be **homogeneous across countries** with **emerging country** slightly exceeding the European average.
- In terms of **physical risk**, the exposure to climate risk **varies** widely **across countries and types of hazards**; in particular, Southern Regions will be more affected by wildfires, while eastern and central countries will suffer more from flooding risk.

Data 3/3

Breakdown of Euro Area Bank Exposures to Climate Risk

The **sample** is composed by nearly **1600 banks**, covering up to 80% of the bank loans held in the euro area. In this regard, **climate risk affects banks mainly through their loan exposures** to firms which are subject to **physical and transition risks**.

In nearly all countries, **domestic firms** make up at least **50% of bank portfolios** and at euro area level 80% of banks' exposures are to domestic firms. Furthermore, across euro area countries, even if less Significant Institutions (LSIs) make up more than 90% of total banks in the sample, **Significant Institutions (SIs) hold approximately 80%** of the total exposures.

ECB climate stress test focuses on different banks exposures by breaking down the climate risk into Transition risk and Physical risk as follow:



- Most countries have **similar average exposures to transition risk**, comparable with the average euro area results.
- Although transition risk are homogeneous overall across countries, **tail transition risk is concentrated in specific banks and countries**: more precisely, the top 10% most polluting portfolios finance up to 65% of total emissions.



- There are **relevant differences between banks' exposures to physical risk**, which greatly depend on their location.
- It is also **extremely concentrated in specific areas**: 22% of euro area bank exposures are affected by high physical risk, mostly in the Southern European countries.

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Transmission to Firms

Impact of Climate Risk on NFC Financials

Impact on the Median European Firm

Impact on the Highest Emitting Firms

Impact on Firms Highly Exposed to Physical Risk

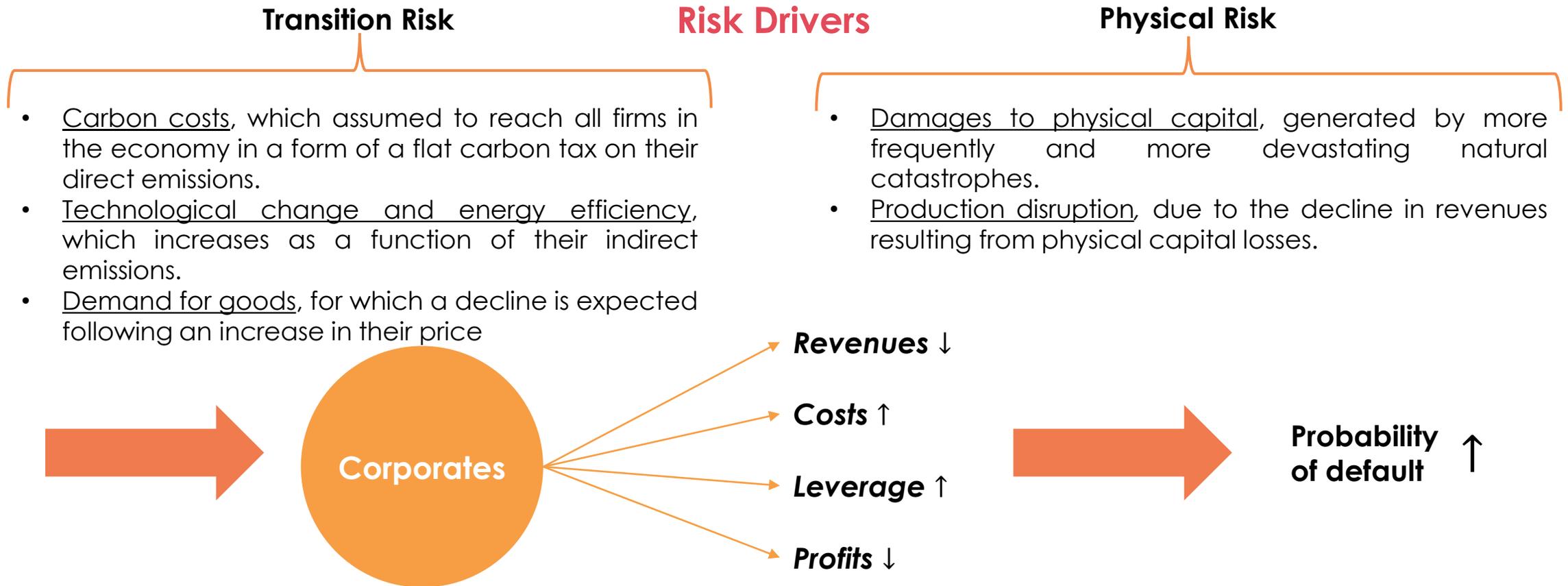
Benefits of a Green Transition



Transmission to Firms 1/6

Impact of Climate Risk on NFC Financials 1/2

The methodology seeks to evaluate how transition and physical risks affect the probability of default (PD) of individual firms through changes in their profitability and leverage.



Transmission to Firms 2/6

Impact of Climate Risk on NFC Financials 2/2

The calculation of expected losses from physical risk combines direct impact on firms' exposure to extreme weather events with indirect impact, such as the expected damage at the regional level as a share of GDP.

Direct Impact

- Firm level exposure to extreme weather events
- Frequency and intensity of Flooding, Wildfire and Sea Level Rise

Indirect Impact

- Region-level expected damages as a share of GDP
- Chronic changes in temperature, precipitation and crop yields
- Including second and third round effects



Expected Losses to Firms' Physical Capital

- The highest damage due to wildfires are reported on HHW scenario.
- Wildfires are more spread events affecting a wider geographical area within Europe.
- Floods also have significant potential to destroy physical capital



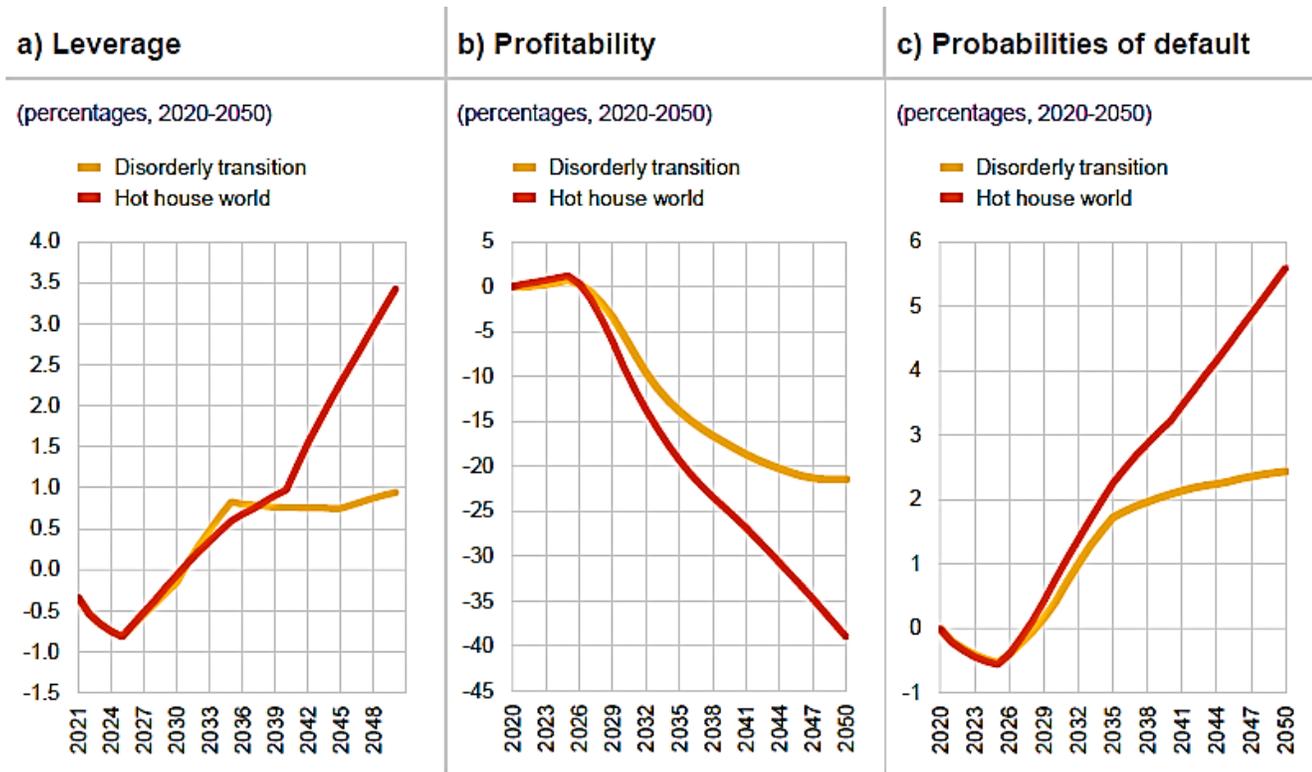
Mitigants: Insurance coverage protects capital from damages

Amplifiers: Insurance costs increase in some vulnerable areas

Transmission to Firms 3/6

Impact on the Median European Firm

Overall, **the median European firm is less indebted, more profitable** and has a lower probability of default at the end of the horizon under the orderly transition scenario as compared with the two adverse scenarios.



- **Leverage** dynamics are primarily driven by implementation of the requisite investment projects in green technologies and by the debt that is incurred to cover physical damage
- **Profitability**: the effects of climate risks on profitability also point to the benefits of early policy action, and show potentially significant impacts under the adverse scenarios, mainly driven by shocks to revenues and operating costs.
- **PD**: the projected PDs combine the results for leverage and profitability and show that the potential impact of no climate action could be detrimental for firms' creditworthiness in the long run.

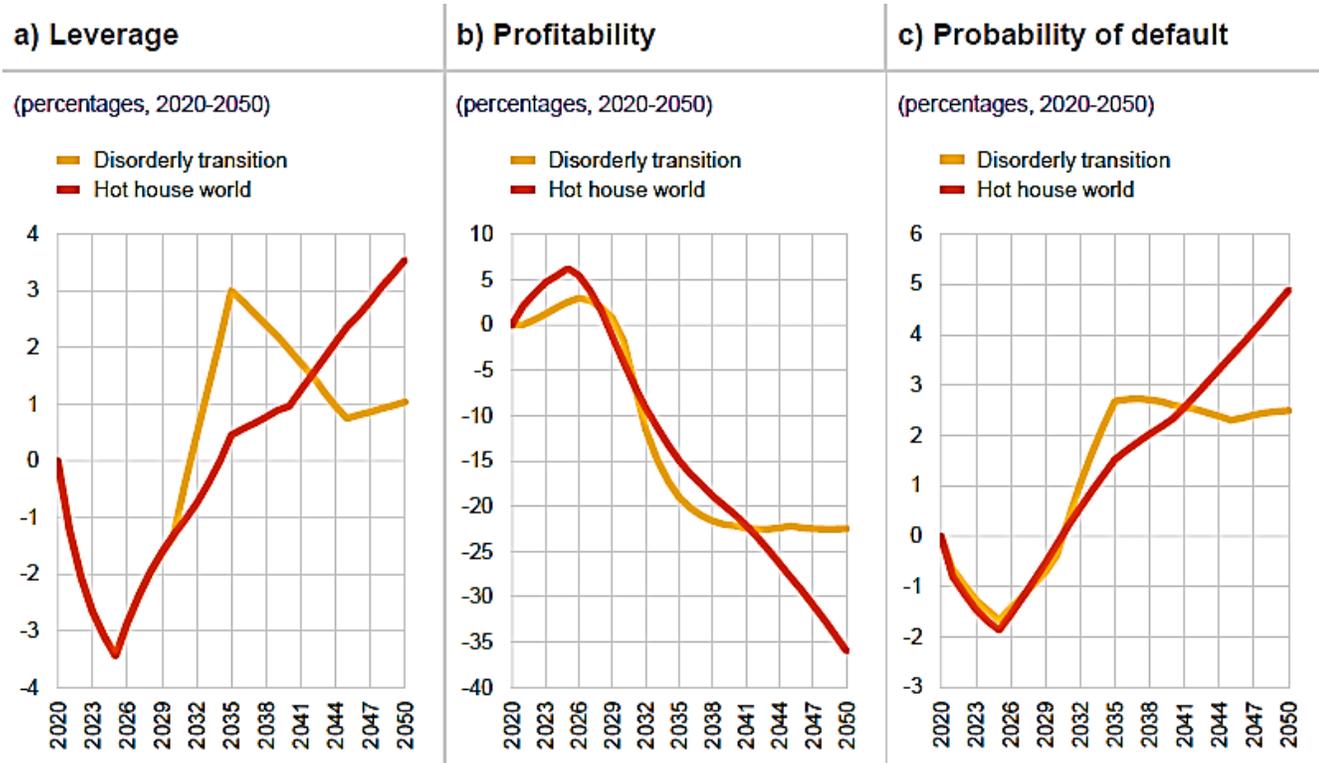
Source: ECB calculations based on NGFS scenarios (2020b), Orbis, iBACH, Urgentem and Four Twenty Seven data (2018).

Note: all charts shown in this section display median percentage changes under the disorderly transition and HHW scenarios relative to baseline scenario.

Transmission to Firms 4/6

Impact on the Highest Emitting Firms

High emitting firms are defined as the top 10% of firms with the highest emissions' intensity. The impact on the highest emitting firms is greater than for median firms and is reflected in higher leverage and more pronounced differences across scenarios.



- **Leverage** dynamic is more prominent than for median firms and reflects the need for high-emitting companies to raise more capital to replace their technologies and reduce emissions.
- **Profitability**: The profitability of high-emitting firms is also significantly impacted in the short run in the case of transition; the latter would, however, have strong long-term benefits.
- **PD**: The increase in PDs with orderly transition at the beginning of the period is higher for high-emitting than for median firms, although it is still offset by the long-term benefits of climate mitigating actions.

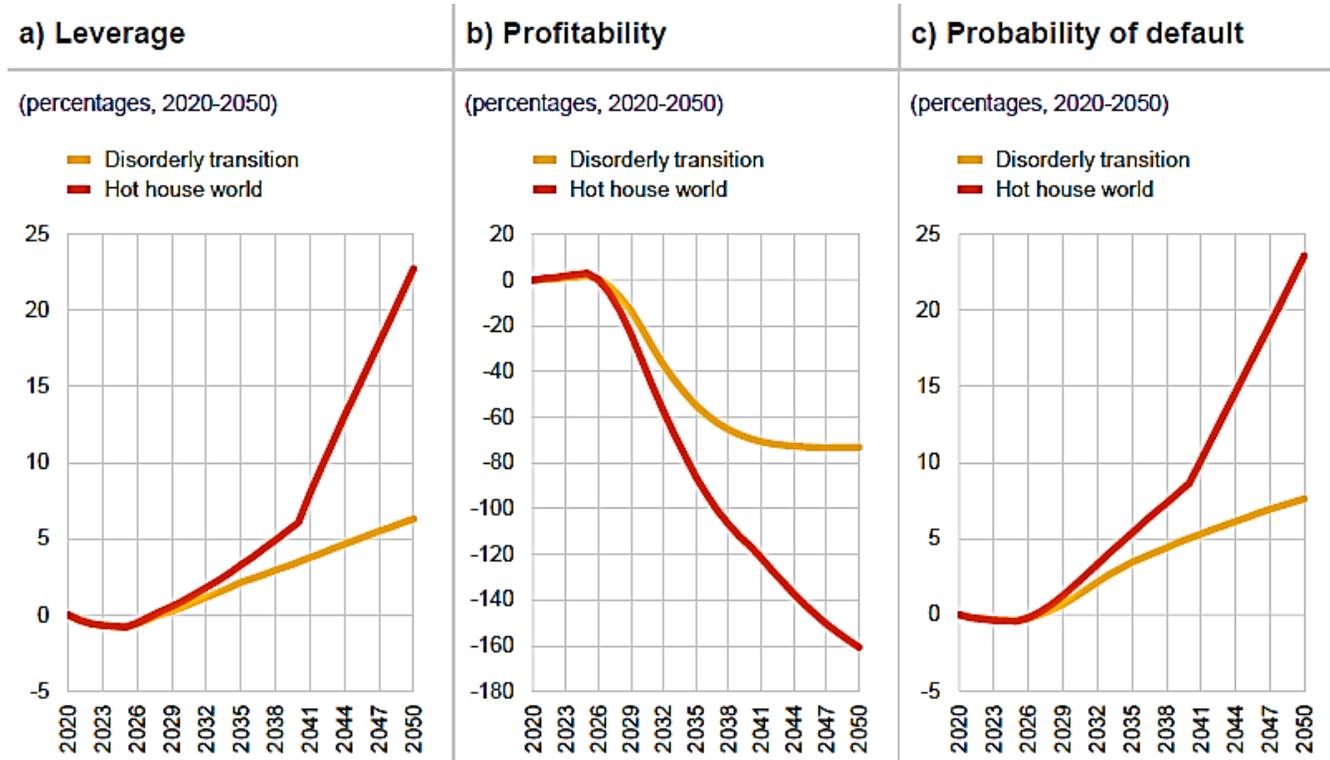
The highest emitting sector is mining, coal mining: the increase in leverage and probability of default is extreme and would likely lead either to the default of such businesses or to their complete reconversion to different sectors.

Source: ECB calculations based on NGFS scenarios (2020b), Orbis, iBACH, Urgentem and Four Twenty Seven data (2018).

Transmission to Firms 5/6

Impact on Firms Highly Exposed to Physical Risk

The firms most vulnerable to physical risk would benefit strongly from an orderly transition given that the consequences of more frequent and severe natural disasters if no policy action was taken would significantly affect their financial performance..



- **Leverage** Firms highly exposed to physical risk would suffer from a strong increase in leverage over the medium-to-long run, due to increased damages from natural catastrophes should climate change not be mitigated.
- **Profitability:** High-physical-risk firms would also experience the largest drop in profitability as compared with other firm samples in the event that no policy action is taken.
- **PD:** The probability of default of high-physical risk firms is projected to increase by 2050 by almost 25% under the hot house world scenario, a figure that is five times larger than what is observed for median and high-emitting firms.

Source: ECB calculations based on NGFS scenarios (2020b), Orbis, iBACH, Urgentem and Four Twenty Seven data (2018).

Transmission to Firms 6/6

Benefits of a Green Transition

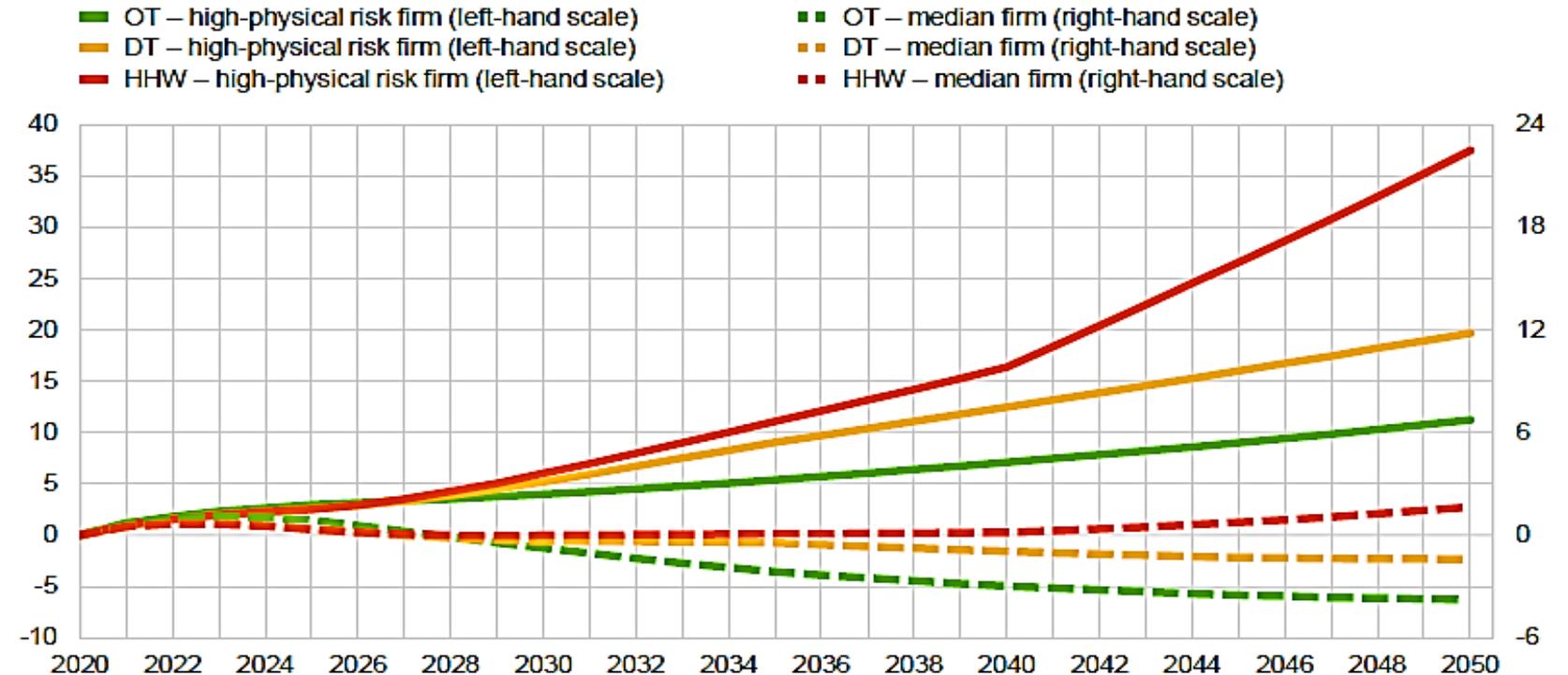
Overall, **the medium-to-long-term benefits of a green transition outweigh the short-term costs**, especially for the firms most vulnerable to physical risks.

Changes in firms' default probabilities for median and high-risk firms.

The results also show that, on average, **orderly transition to a greener economy brings benefits in terms of default probabilities** that are reduced from the current values.

Finally, the disruptive potential of a lack of transition in the medium to long term is significant for firms that are highly exposed to physical risk.

(percentages, 2020-2050)



Source: ECB calculations based on NGFS scenarios (2020b), Orbis, iBACH, Urgentem and Four Twenty Seven data (2018).

05

Transmission to Banks

Credit Risk Channel

Overview of the Market Risk Channel

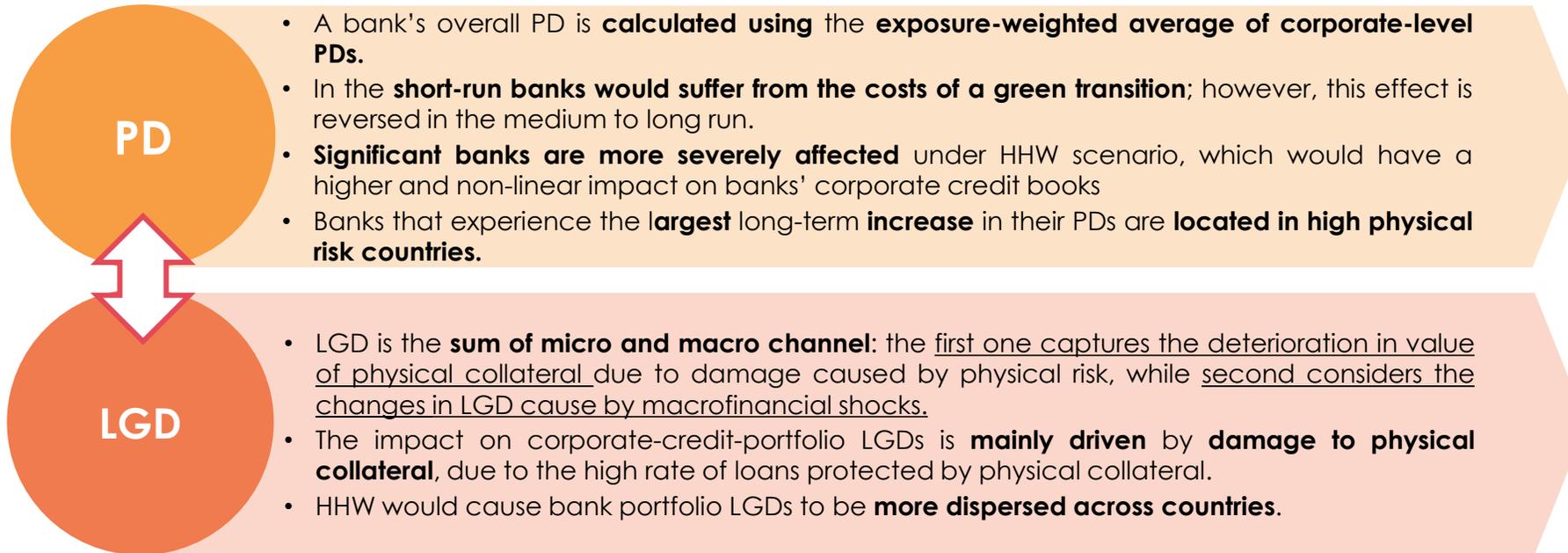


Transmission to Banks 1/2

Credit Risk Channel

The second part of the ECB stress-testing exercise evaluates the **impact of climate risk on the euro area banking** system through the **credit and market-risk channels**.

With respect to banks' credit risk, the quantification is based on the change of **probability of default (PD)** and **loss given default (LGD)** of banks' loans book under different climate scenarios. These projections are combined to estimate the **expected losses on banks' corporate credit portfolios** at the end of the time horizon.



Expected losses

- It is calculated by **multiplying** the loan amount with their scenario-specific **LGD and PD**
- It is **minimal in the event of an orderly transition** towards a greener economy, while it would be 8% higher in the HHW scenario
- The **strongest driver** for the expected losses is **physical risk**, thus becoming more relevant for Southern countries

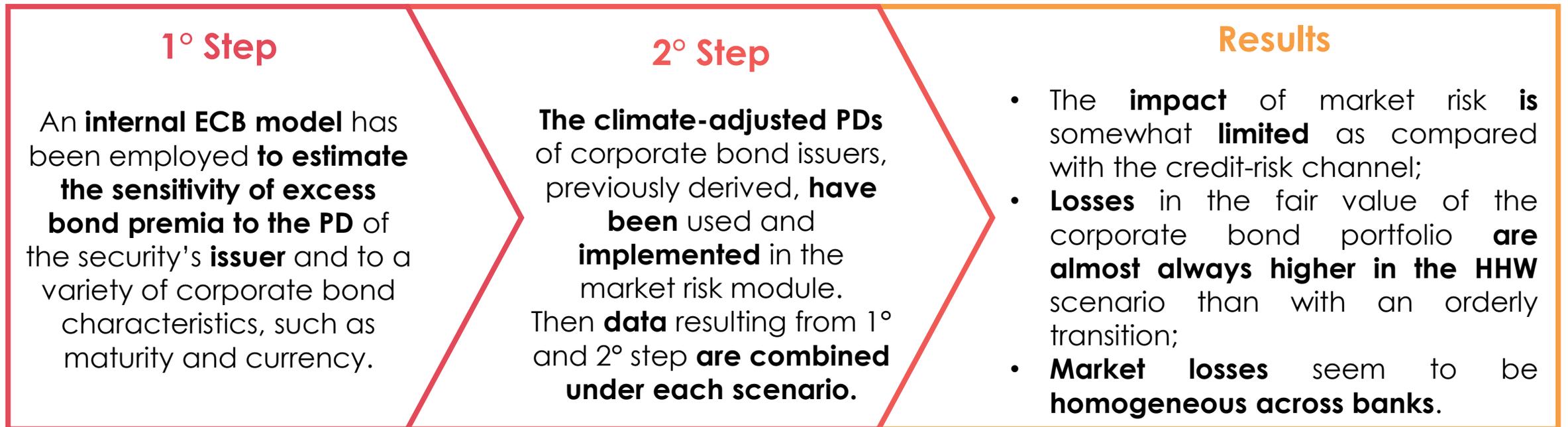
Transmission to Banks 2/2

Overview of the Market Risk Channel

The impact of climate change on banks' corporate bond portfolios is captured through the **sensitivity of the price of securities to movements in market-risk factors** due to climate risks.

In order to **simulate market-risk shocks** driven by climate change dynamics that could be used to reprice corporate bonds, different **market factors**, such as equities and long-term interest rates, **must be available**.

To overcome the lack of credit spreads factor and in order to exercise the test, the following steps has been followed.



06

Future Extensions



Future Extensions

The future extension to the methodological framework aims at relaxing the assumptions underlying the ECB comprehensive climate stress-testing framework, leading to a new extended operational framework.

In particular, **five directives** has been identified:

1. The assumption that banks' balance sheets are static will be relaxed in order to **account for second-round effects** and establish a **feedback loop between banks and the real economy**.
2. The **new scenarios** combine NGFS Integrated Assessment Models with the National Institute Global Econometric Model (NiGEM) **to enrich the macroeconomic dynamics**
3. The climate stress-test **exercise** proposed in this note will be **extended to other financial intermediaries and portfolios**, such as asset manager and insurance.
4. The current **feedback loop will be enriched** with a further layer of bank exposure classifications, based not only on a firm's sector but also on its carbon footprint and exposure to physical risk.
5. The methodological set-up could be extended to **incorporate** the effects of transition and physical risks on **banks' retail portfolios**.

Sources and Literature

- [01] **European Central Bank.** [ECB economy-wide climate stress test.](#)
Occasional Paper Series, September 2021.
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Company Profile

Iason is an international firm that consults Financial Institutions on Risk Management. Iason integrates deep industry knowledge with specialised expertise in Market, Liquidity, Funding, Credit and Counterparty Risk, in Organisational Set-Up and in Strategic Planning.

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This document was prepared in collaboration with Gianmarco Antognetti, who at the time was working for Iason Consulting.

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