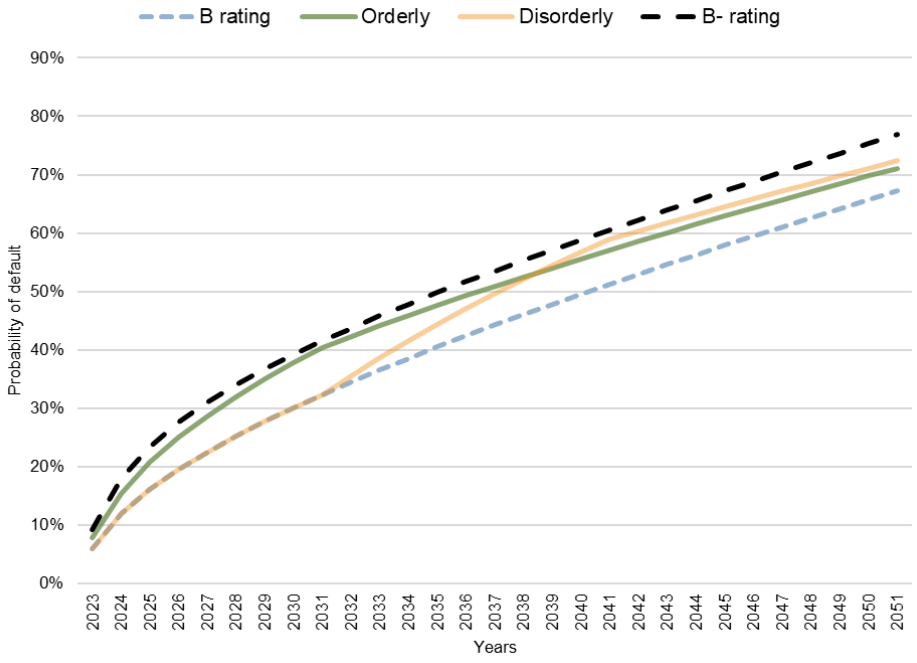
Integrating climate-change risk into structured finance: a stress test-based approach

Integrating ESG factors into credit assessments is far from being standardised and market participants appear uncertain about best practices. In credit analysis, Scope sees climate change as a key area of focus as it strongly affects business activities across different geographies.

This report, the first of a series, lays out a quantitative, consistent, and transparent approach to measuring climate-change risks in structured finance. We start by exploring the impact of the different climate-change scenarios and explain how climate-change risks affect key credit drivers such as probabilities of default and recovery rates. We aim to achieve an approach that is adaptable and flexible and to foster discussions with internal and external stakeholders. Our goal is to provide a roadmap towards better integrating climate-change risks into structured-finance analysis.

Figure 1: Structured finance transactions backed by corporate debt: sensitivity of default rate to climate-change risk under various scenarios



Source: Scope Ratings' calculations, assuming a B rated corporate loan from an obligor located in France in the 'manufacture of coke and refined petroleum products' economic sector (without exposure to acute climate risk)

Taking gross value added (GVA) in a sensitive sector from the ECB's 2022 climate risk stress test scenarios as the explanatory macroeconomic aggregate, Figure 1 shows the sensitivity of credit risk, as measured by the cumulative probability of default to each of the chosen scenarios. We also show our idealised cumulative default probability curve for B and B- ratings.

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1. Climate risk

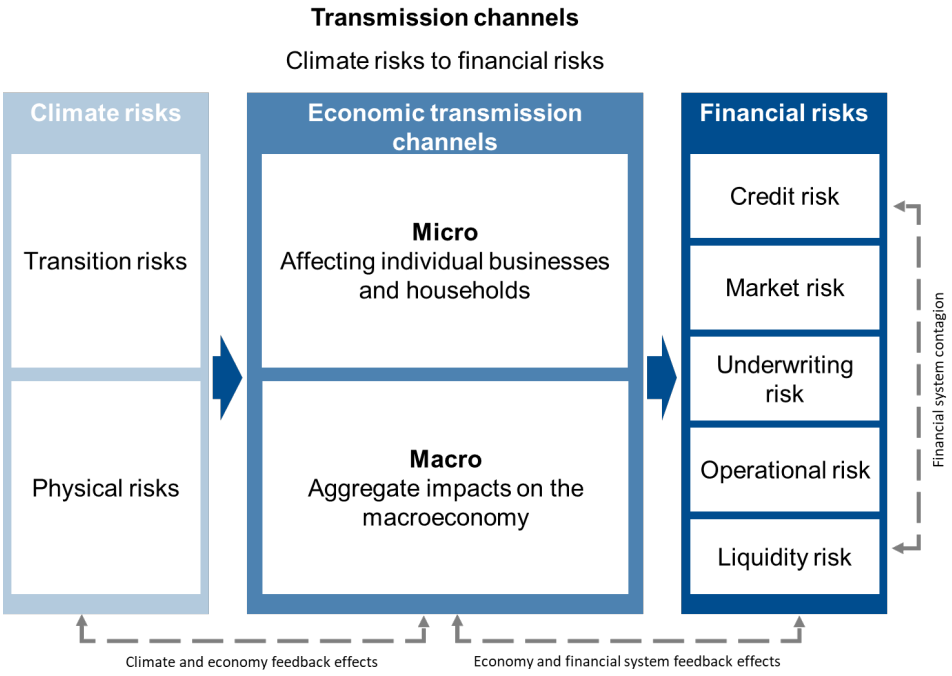
1.1. The transmission channels of climate risk

Developing an approach to incorporate climate components into financial risks has gained the attention of market participants, supervisors, and regulators in recent years. Institutions such as the European Central Bank (ECB), the Bank of England (BoE), and the Bank for International Settlements (BIS) have started to develop methods to assess the impact of climate risks on financial markets. The European Commission has also been active on the topic with its taxonomy of sustainable activities. Markets have also seen a raft of regulation, including the Sustainable Finance Disclosure Regulation (SFDR).

Transition and physical risks: the two types of climate risk

Assessing the potential impact of climate risks on financial markets starts with the process of risk identification. There are two categories of climate risk: transition risk and physical risk. Transition risks relate to actions taken to reduce emissions to reach net zero greenhouse gas emissions. Examples of transition risk drivers include public sector (generally government) policies, legislation and regulation, changes in technology and changes in market and customer sentiment. Physical risks relate to chronic climate impacts driven by rising temperatures and acute climate impacts, represented by natural disasters (floods, landslides, cyclones/storms, water scarcity, extreme heat or wildfire).

Figure 2: From climate change risks to financial risks



Source: Central Banks and Supervisors Network for Greening the Financial System (NGFS), Scope Ratings

Climate risks have micro and macro impacts

Climate risks can affect individual businesses and households (micro-level) or the macroeconomy (see Figure 2). Transmission via microeconomic channels distinguishes between impacts on businesses and households. For businesses, physical risk relates to i) lower productivity from the persistent temperature increase; and ii) property damage and business disruption from factors such as extreme weather events, stranded assets, and additional capital expenditure to satisfy policy requirements.

Transition risk relates to changing consumer preferences and costs, as well as legal costs since companies are legally liable for adjusting to climate-related government policies and regulations[1].

Households, on the other hand, may experience loss of income and wealth due to changing weather, and labour market frictions. Property damage may arise due to extreme weather events. Low-carbon policies may pose additional costs and affect valuations of energy-inefficient housing.

The transmission of climate risks via the macroeconomic channel can be seen in productivity, capital, public and private consumption. Output loss aggregates are prominently used to quantify such transmission.

We focus on how climate risks impact credit risk

Through these economic transmission channels, climate risks ultimately translate to bottom-line financial risks. Credit risk arises from the climate-driven vulnerability of businesses and households and depreciated collateral values. Market risks manifest themselves in the repricing of equities, debt, commodities and other financial instruments traded in the open market. Underwriting risks are amplified too as insured losses and the insurance gap is likely to increase as a rise of climate change. Operational risks are elevated due to supply-chain disruption and the forced closure of facilities. Liquidity risk rises with demand and elevated refinancing risk. **We focus here on the adverse effects of climate change on the credit risk of structured-finance transactions.**

1.2. Climate-change scenarios to assess a range of outcomes

Scenario analysis is a key tool to project climate risks

Increasing emissions of greenhouse gases since the industrial revolution have led to about 1.2 °C of global warming[2]. Many countries have put in place net-zero targets and strategies to reduce their contribution to global warming by 2050. With the outcome of these policies still uncertain, scenario analysis is an efficient tool as it enables an exploration of climate risks and their impact on structured-finance transactions for a range of hypothetical futures. This forward-looking projection of climate risk outcomes starts with defining appropriate scenarios.

1.2.1. Network for Greening the Financial System's climate scenarios

NGFS climate change scenarios are widely adopted

To assess climate risks, market participants use different climate scenarios over a time horizon of 30 years, i.e. until 2050. The NGFS[3] has developed **six climate scenarios** that can be grouped in **three categories**: orderly, disorderly, and hot house. They aim to provide market participants, including central banks and supervisors, with a common starting point for analysing climate risks under different pathways. The scenarios were produced in partnership with leading climate scientists, leveraging climate-economy models that have been widely used to inform policymakers. These have been used in key reports such as the IPCC Special Report on Global Warming of 1.5 ˚C. The main characteristics of these scenarios are summarised in Figure 3.

[1] We also note that climate change could be a source of opportunities for certain businesses
[2] Source: Network for Greening the Financial System
[3] More information available on https://www.ngfs.net/ngfs-scenarios-portal/

Figure 3: NGFS climate scenarios

	ORDERLY		DISORDERLY		HOT HOUSE WORLD	
	Net Zero 2050	Below 2°C	Divergent Net Zero	Delayed Transition	Nationally Determined Contributions	Current Policies
Global warming in °C	+1.5	+1.7	+1.5	+1.8	+2.5	+3.0
Policy reaction	Immediate and smooth		Immediate but divergent	Delayed	NDCs	None (current policies)
Technology change	Fast	Moderate	Fast	Slow then Fast	Slow	
Use of carbon dioxide removal technologies	Medium		Low		Low	
Regional policy variation	Medium	Low	High	Low	Low	
Transition risk	Medium	Limited	High		Low	
Physical risk	Limited		Limited	Medium	High	

Source: NGFS, Scope Ratings

Orderly scenarios assume mild climate change risks

Orderly scenarios assume an early and gradual transition, where the consequences of both physical and transition risks for the economy are expected to be mild. The "Net Zero 2050" scenario assumes global warming of only 1.5°C due to tight climate policies and innovation. Under this scenario, net zero CO2 emissions will be achieved by 2050. It is the most ambitious scenario and even assumes some developed countries will reach net zero for all Greenhouse Gases (GHGs) by that time. The "Below 2°C" scenario assumes gradually rigidity of climate policies, which gives the chance to limit the global temperature increasing by only 2°C.

Disorderly scenarios emphasise transition risk

Disorderly scenarios assume high transition risk due to more abrupt climate policy changes. The "Divergent Net Zero" scenario achieves net zero by 2050 but transition happens less smoothly due to more sudden policy changes. The "Delayed Transition" scenario expects that GHG emissions will not decrease until 2030. Consequently, strong, and sudden policies are needed to achieve transition to an economy that supports the goal of below 2°C temperature increase by 2050.

Hot house world scenarios assume acute physical risks

Hot house world scenarios reflect low to no efforts in terms of climate policy and a shortfall regarding the net zero goal by 2050. The Nationally Determined Contributions (NDCs) scenario under the 2015 Paris agreement assumes that all policies pledged are implemented, whereas the "Current Policies" scenario assumes currently implemented policies are preserved. Both scenarios lead to high levels of physical risk associated with a global temperature increase of 3°C.

1.2.2. ECB and BoE climate scenarios

ECB and BoE have designed three long-term climate change scenarios

The ECB and BoE have also designed long-term scenarios in the context of recent stress test analyses. For both, three main scenarios are considered: Figure 4 on the next page summarises the main characteristics of the ECB and BoE's scenarios.

Figure 4: ECB and BoE climate scenarios[4]

ECB	ORDERLY TRANSITION	DISORDERLY TRANSITION	HOT HOUSE WORLD
Global warming in °C	+1.5	Below 2	By more than 3
Policy reaction	introduced early and gradually become more stringent	Late (not introduced until 2030)	No new climate policies
Transition risk	Relatively low	High	Relatively low
Physical risk	Relatively low	Relatively low	Increase until the end of the century

BoE	EARLY ACTION	LATE ACTION	NO ADDITIONAL ACTION
Global warming in °C	+1.8	+1.8	+3.3
Policy reaction	Early and orderly	Late and disorderly	Only policies in place before 2021
Transition risk	Medium	High	Limited
Physical risk	Limited	Limited	High

Source: European Central Bank, Bank of England, Scope Ratings

ECB, BoE and NGFS scenarios are comparable

The ECB (orderly transition, disorderly transition, hot house world) and BoE (early action, late action, no additional action) scenarios take the NGFS's Net Zero 2050, Delayed Transition and Current Policies scenarios as a starting point, respectively. Although not identical, the ECB, BoE scenarios and the three NGFS scenarios are consistent across many aggregates.

In addition, the ECB has designed three short-term scenarios that focus on significant increase in energy costs and impact of extreme weather events. They reflect the risks of an immediate disorderly transition, with sharp increases in carbon prices and the crystallisation of acute physical risks (including flood risk, drought and heat risk).

The ECB and BoE have also determined how a set of macroeconomic aggregates depend on the underlining climate pathway. Aggregates derived by the ECB and BoE include GDP, GVA, unemployment rate, energy prices, inflation, financial market indicators (interest rates, equity prices, credit spreads, FX rates), and real-estate prices.

1.2.3. Scope's climate scenarios

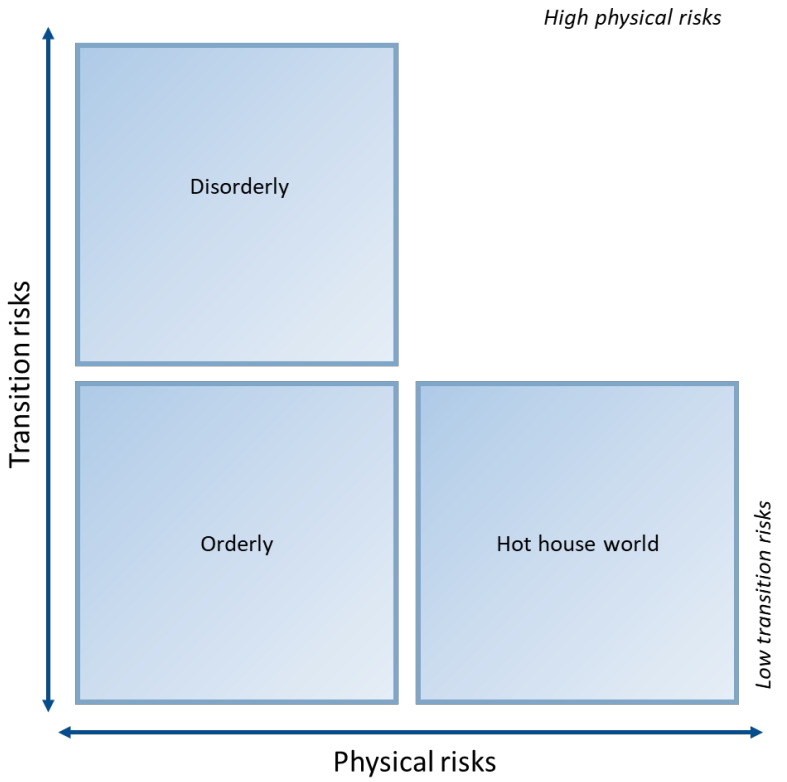
NGFS, ECB and BoE scenarios are relatively consistent and well accepted by market participants. Scenarios of the three main types (orderly, disorderly and hot house world) as highlighted by Figure 5 offer a wide range of outcomes for the crystallisation of transition and physical risks that can be used for further analysis. Figure 6 illustrate the different levels of transition and physical risks for each type.

Figure 5: Used scenarios within the main types

ORDERLY	DISORDERLY	HOT HOUSE WORLD
Net zero 2050 (NGFS)	Delayed transition (NGFS)	Current policies (NGFS)
Orderly transition (ECB)	Disorderly transition (ECB)	Hot house world (ECB)
Early action (BoE)	Late action (BoE)	No additional action (BoE)

[4] More details on ECB'S 2022 climate risk stress test can be found here. More details of BoE's 2021 Biennial Exploratory Scenario can be found here.

Figure 6: Levels of transition and physical risks for each type of scenario



Source: NGFS, Scope Ratings

2. Incorporating climate impact in the assessment of credit risk: Scope's approach

Stress testing sensitivity allows, based on the discussed climate scenarios, incorporation of climate-related transition and physical risk into the assessment of credit risk of structured finance transactions.

2.1. Stress testing as primary tool

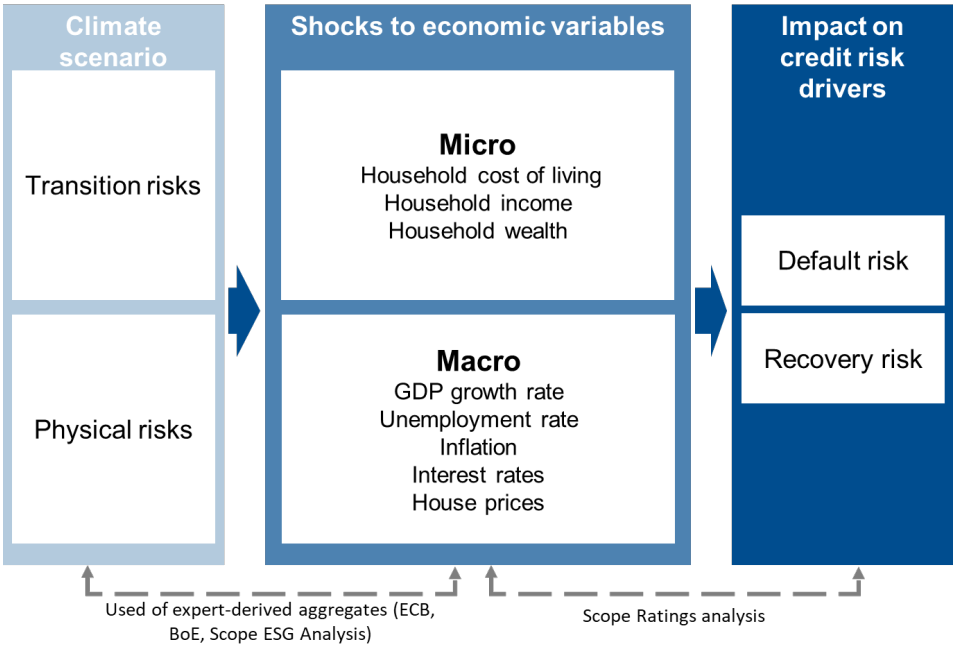
Stress tests are frequently used by financial regulators

Stress tests have become an increasingly valuable tool for macroprudential policymakers and microprudential supervisors. This development was reinforced by the Global Financial Crisis, which resulted in substantial losses for banks and created general uncertainty about the banking sector's loss-bearing capacity. Supervisors' stress tests are used to quantify financial-stability assessments, to challenge calculations that supervised entities provide in supervisory stress tests and to reinforce the link between macro risk assessment and microprudential actions.

Shocks to economic aggregates impact credit risk drivers

In a similar fashion, we use stress tests in structured finance to assess the resilience of a transaction to shocks regarding certain risk drivers. With regard to climate risks, we seek to understand how, in a particular climate change scenario, key economic aggregates (at macro and microeconomic levels) are affected over time. Variations in key credit-risk drivers are then derived as a result of the stressed environment.

Figure 7: Stress testing: from climate risk to credit risk



Scope's MSCT provide GDP output gaps shocks

In a given climate-change scenario, the intensity of the shocks to economic aggregates are derived via established models, including ECB and BoE models as well as the Macroeconomic Climate Stress Test (MCST) developed by Scope ESG Analysis. Considering the three NGFS scenarios, the MCST models the flows of intermediate and final goods and their associated GHG emissions in a global country-sector-based value chain model. MCST provides two risk-associated KPIs (physical and transition risks for country-sector combinations in terms of output gap) and two climate-associated KPIs (implied temperature rise and GHG in CO2-equivalent).

The transmission of these shocks to credit-risk drivers demands further analysis as described below.

2.2. Bottom-up and top-down approaches

The set of economic aggregates to stress and the method of transmission to credit risk drivers depends on the structured-finance transaction. We can distinguish two main types of approaches: top-down and bottom-up.

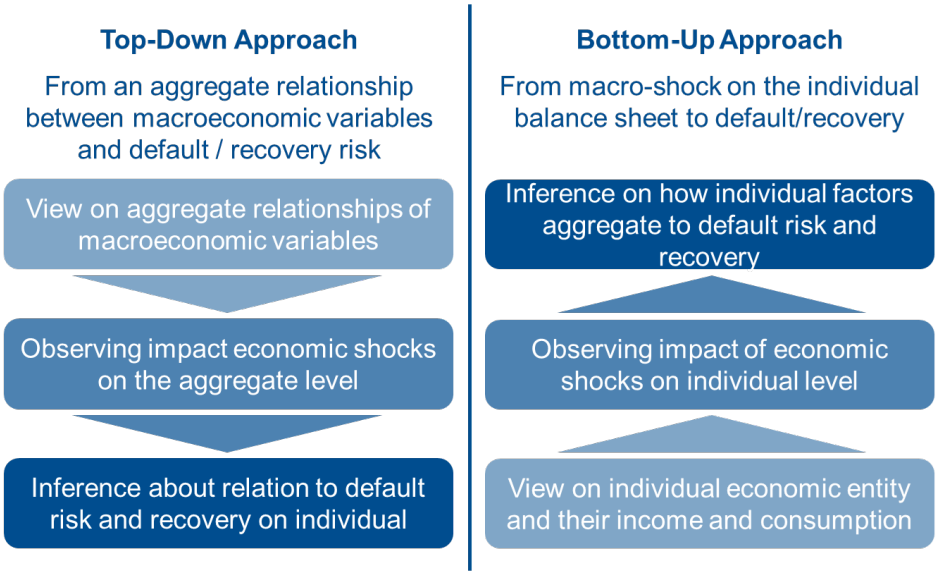
Top-down approach infers individual impact from shocks applied to the global economy

The top-down approach is similar to macro stress tests performed by central banks to assess bank solvency. Via scenarios, the impact of shocks on macroeconomic aggregates is observed over time. The impact on individual obligors is inferred and allows to derive stresses on their credit-risk metrics. This approach is appropriate when assessing climate risk for a transaction backed by corporate loans. Each scenario leads to output gap at the level of country-sector which translates into a revised probability of default at the level of each obligor.

Bottom-up approach infers global impact from shocks applied to individual obligors

The bottom-up approach starts with the details of individual obligors. Scenario modelling allows an assessment of how shocks to the global economy impact each household. The overall effect can then be inferred on a portfolio basis. This approach is pertinent when assessing climate risk for transactions backed by residential mortgages or consumer loans. Each scenario leads to a shock on household finances (income and wealth), based on the geographical location, affecting the credit risk metrics.

Figure 8: Top-down and bottom-up approaches to apply shocks



2.3. Defining the sensitivity of key credit drivers to climate change

2.3.1. Main framework

Integrating climate-change risks into a credit assessment will focus only on the impact of the climate-change scenarios on typical key credit risk drivers, including default probabilities and recovery-rate assumptions. Each scenario will yield a different expected financial loss and expected weighted average life for the instrument in consideration. These metrics will help determine how each climate-change scenario impacts the instrument's credit risk.

Figure 9 outlines the main approach and aggregates used for two illustrative types of transaction.

Figure 9: Case of transactions backed corporate debt and household debt

	Corporate debt	Household debt
Approach	Top-Down	Bottom-up
Economic aggregate used	GDP / GVA	Financial margin, leverage
Key credit risk driver	Probability of default, recovery rates	Probability of default, recovery rates

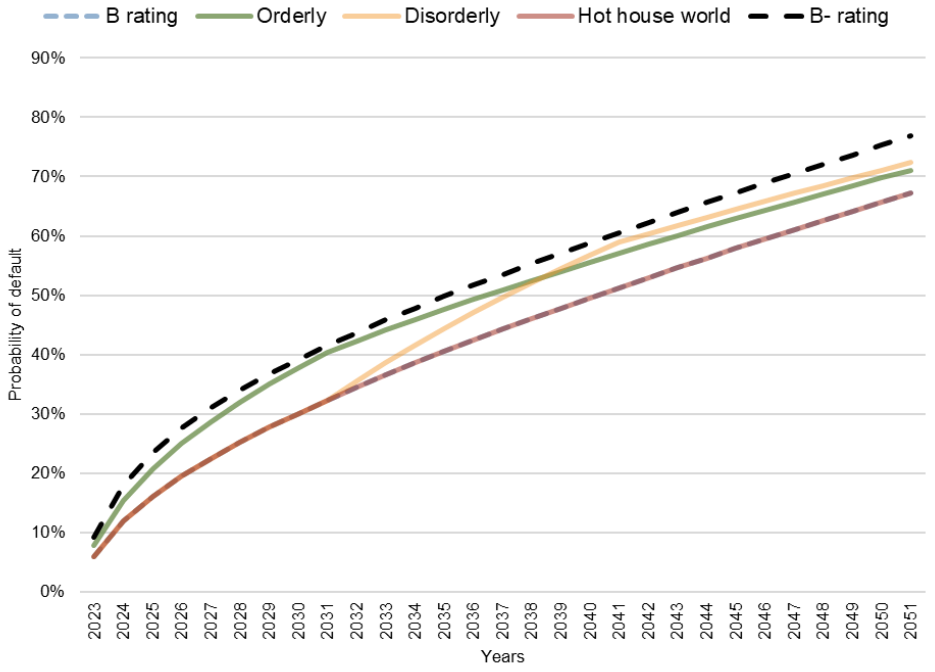
In the case of corporate debt, the segmentation is done at country and business sector level, as each climate-change scenario implies different shifts in business activity and energy prices. A credit-damage function allows us to translate the shock in GVA into a stress on the marginal default probability. In the context of a stress test, positive climate change impacts are considered as neutral.

Regarding household debt, a credit-damage function allows us to translate the shock in households' financial margins and leverage into a stress on default probabilities and recovery rates. Changes in prices or interest rates will impact financial margins whereas house prices will impact leverage, among other things.

2.3.2. Case of study

We illustrate below the framework in a simplified example of a B rated corporate loan from an obligor located in France in the 'manufacture of coke and refined petroleum products' economic sector[5]. Taking the sectoral value added from ECB's 2022 climate risk stress test scenarios as the explanatory macroeconomic aggregate, the sensitivity of credit risk is measured by the cumulative probability of default. The portfolio is particularly negatively impacted in the orderly and disorderly transition scenarios, due to the effects of transition risk on the considered sector, through advances in technology, new energy policies, and evolving consumer preferences.

Figure 10: Sensitivity of default rate under ECB scenarios



Source: Scope Ratings

3. Summary and next steps

Quantitative approach as core of the analysis

A stress-testing approach offers a **quantitative** solution to assessing climate-change risk. By quantifying the variation in selected credit risk drivers, the impact of climate-change risks on structure-finance transactions can be assessed.

The approach can be applied consistently across all types of transactions

The transmission of climate risks into credit risk can be applied **consistently** to all types of structured-finance transactions, using (i) the economic aggregates subject to shocks in each climate scenario, and (ii) the transaction's key credit risk drivers. The core of the approach is the quantification of the transmission of shocks to (i) into (ii). Using the same set of climate scenarios enables comparability within and across asset classes.

All steps of the analysis are transparent

The approach is **transparent** and can be explained step-by-step. The transmission from climate risks to economic aggregate shocks can be performed via Scope ESG Analysis' MCST or via publicly available information (e.g. published by the ECB or BoE). How these economic shocks impact credit risk drivers is derived via internal models, calibrated using publicly available data sources. Follow-on reports will describe how such models are derived for certain types of structured-finance transactions.

[5] NACE Code: C19

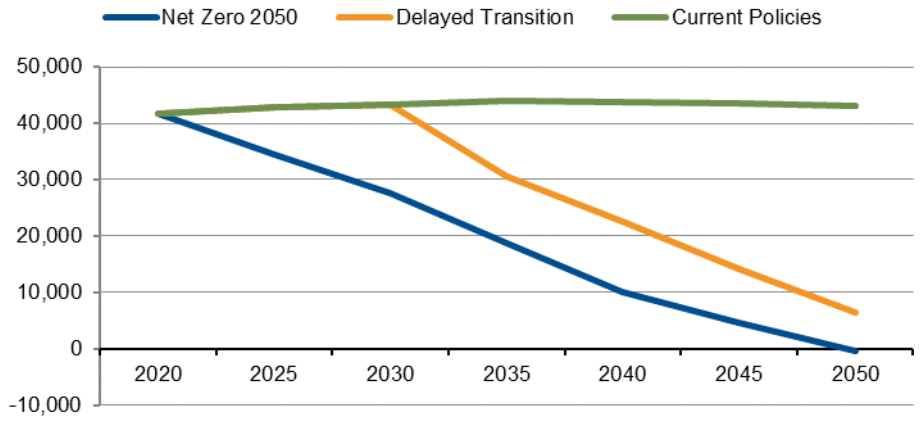
The approach accommodates to various types of inputs

The approach is **flexible** as it offers an ability to use various climate-change scenarios, allowing the incorporation of potential refinements in the definition of those scenarios, and the use of different macro or microeconomic aggregates, most relevant to the asset class under analysis. It is **adaptable** and subject to **further developments** so that it aligns with upcoming future regulatory standards.

Future articles will apply the principles described in this report for selected types of structured-finance transactions. After an academic literature review, we will present the credit-damage function used to translate stress in selected economic aggregates into change of relevant credit-risk drivers and we will apply the results to a practical example for illustration purposes.

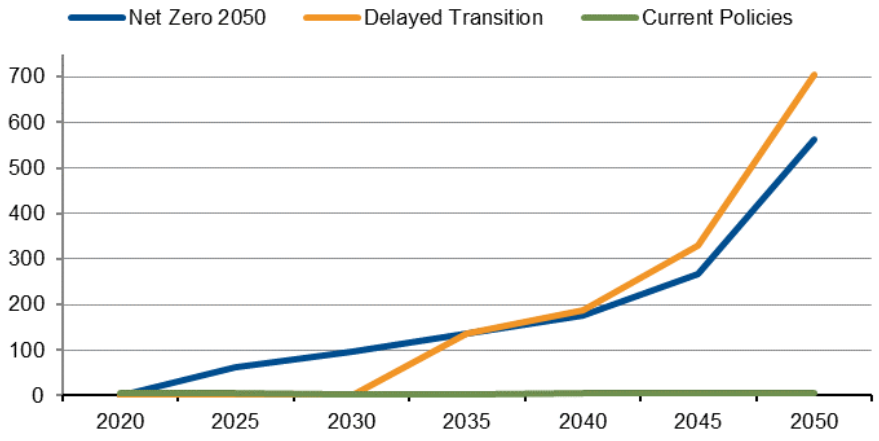
I. CO2 emissions, carbon price and global mean temperatures increase under the three selected NGFS climate scenarios

Figure 11: CO2 emissions (in Mt per year)



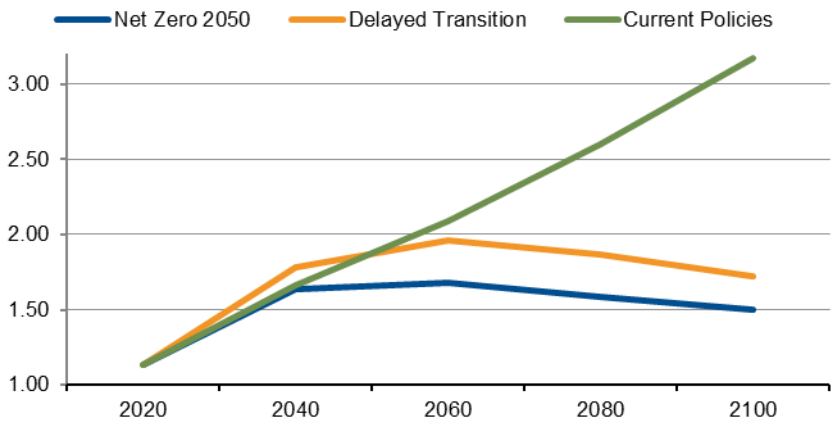
Source: NGFS, Scope Ratings

Figure 12: Carbon price (US$2010/t CO2)



Source: NGFS, Scope Ratings

Figure 13: Global mean temperature increase (°C)



Source: NGFS, Scope Ratings

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