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TREND
SUPERVISION

Authorities are using stress tests to assess financial actors' exposure to climate risks

To assess the climate risks financial actors are exposed to, market and other authorities are increasingly experimenting with an extension of a widespread financial practice: stress tests. The first systemic tests yield initial observations as to the exposure of institutions in different parts of the world.

DATA OVERVIEW

Financial institutions are increasingly exposed to climate risks

Financial authorities in charge of supervision around the world are taking an increasing interest in climate-related financial risks (CFR) and in preparing the financial sector to address them. As proposed by Mark Carney, former Governor of the Bank of England, such risks are generally assigned to three categories:

- 'Transition risks', arising from the implementation of a low-carbon economic model on economic actors
- 'Physical risks', resulting from the uncertain economic effects of climate change on our environment
- 'Liability risks', caused by rising litigation against financial players to hold them responsible for climate inaction[1]

The insurance industry is particularly exposed to the 'physical risks' posed by climate change. According to an assessment by Swiss Re, natural catastrophes generated $112 billion worth of insured losses in 2021, the fourth highest annual total on record (**Figure 1**).[2] According to an assessment by the European Insurance and Occupational Pensions Authority (EIOPA), one of the three European System of Financial Supervision (ESFS) supervisory agencies, '*All property-related lines of businesses are expected to be impacted by physical climate change risk.*'[3] In 2020, about 80% of business losses from storms and floods in Europe were due to building damage.

The category of 'transition risks' is currently materialised most visibly through divestment movements, in which financial institutions exit from activities deemed incompatible with the climate objectives of the Paris Agreement, such as exploration/extraction of oil or gas fields and opening coal-fired power plants. The Global Fossil Fuel Divestment Commitments Database currently lists 1,550 institutions committed to some type of fossil fuel divestment (**Figure 2**), for a total value of $40.48 trillion.[4] In October 2021, La Banque Postale was the first financial institution to announce its complete withdrawal from the oil and gas sector by 2030.[5] Back in 2019, the Norwegian Government Pension Fund, which, in addition to being the world's largest sovereign wealth fund ($1.2 trillion in assets), is closely linked to the oil industry, announced what was then the largest ever divestment from fossil fuels, amounting to some $13 billion.[6] For its part, the International Energy Agency recommends, in its roadmap for a carbon-neutral energy sector in 2050, that investments in any new fossil fuel extraction project be halted as of today.[7]

'Liability risks' take two main forms for financial institutions and the non-financial companies they finance. First is the increasing number of climate-related lawsuits against private entities, particularly in the

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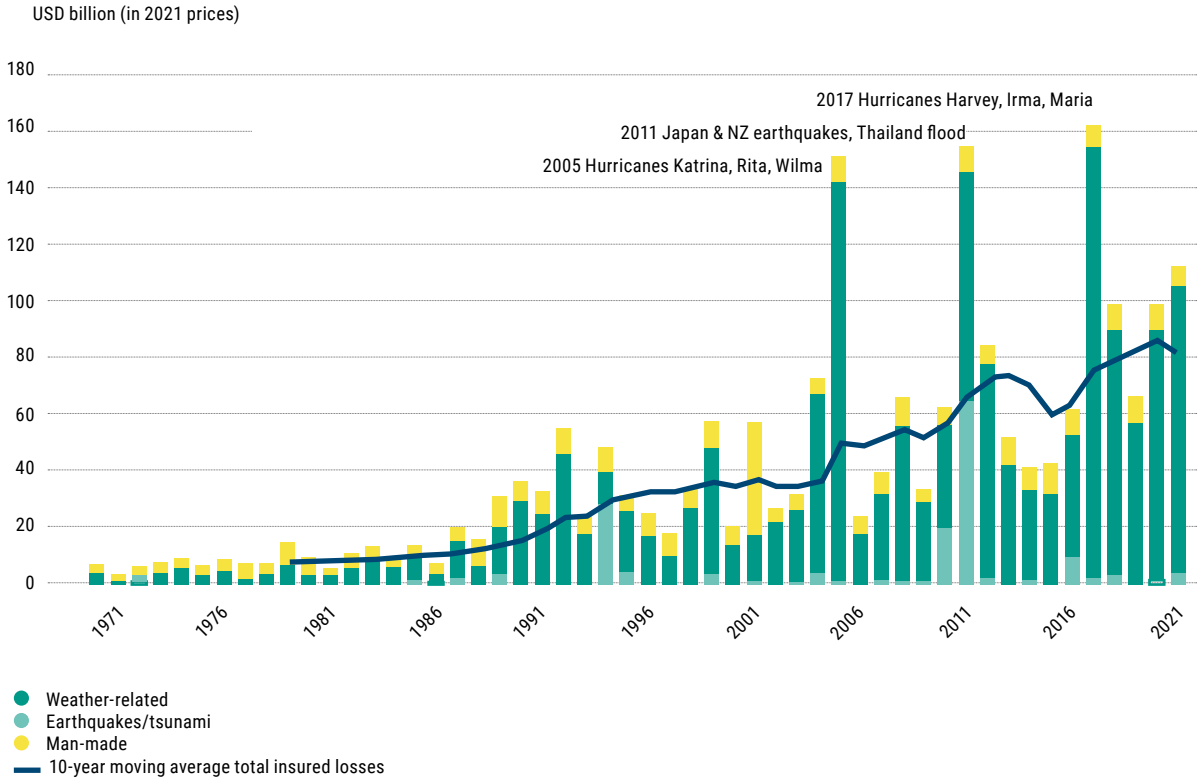
FIGURE 1

CAUSES OF INSURED LOSSES SINCE 1970

Source: Swiss Re Institute, 2021



US, Europe and Australia. Of the 193 climate lawsuits filed in 2021, 38 involved private sector defendants, compared to 22 in 2020.[8] A number of these lawsuits have resulted in landmark convictions, such as the ruling against Shell by a Dutch court on 26 May 2021. Shell was asked to increase its climate ambitions, following a complaint filed by seven NGOs and supported by 17,000 signatories. However, another form of 'liability risk' is materialising for private entities: shareholder activism. At ExxonMobil's annual general meeting, activist hedge fund Engine No. 1, with the support of major financial players, succeeded in placing three directors on the oil company's board on the same day as Shell's conviction.[9] Meanwhile, Chevron's shareholders voted 61% in favour of a resolution requiring the company to reduce its emissions.[10] In 2022, 172 environmental resolutions were proposed at general meetings (+39% year-on-year year), including 71 regarding the measurement of GHG emissions, and 14 on ending financing for fossil fuels.[11] These movements affect financial institutions directly when they find themselves the target of such actions, and indirectly when they are invested in the companies involved.

At present, financial authorities appear to be primarily concerned with how these risks affect the financial sector and much less with what role the financial sector plays in increasing them in turn. Consideration for physical and transition risks, known as the 'double materiality principle', is complicated by the highly political nature of transition risks.

This increasingly certain and significant materiality (the simple kind), uncertainty about the shape of events, the irreversibility of climate events (as opposed to most economic events), are all reasons that clamour for better disclosure practices on institutional exposure.[12,13] The report of the Financial Stability Board (FSB) Task Force on Climate-related Financial Disclosures (TCFD) in 2017 was a first practical step in efforts to assess climate risks by financial authorities.[14]

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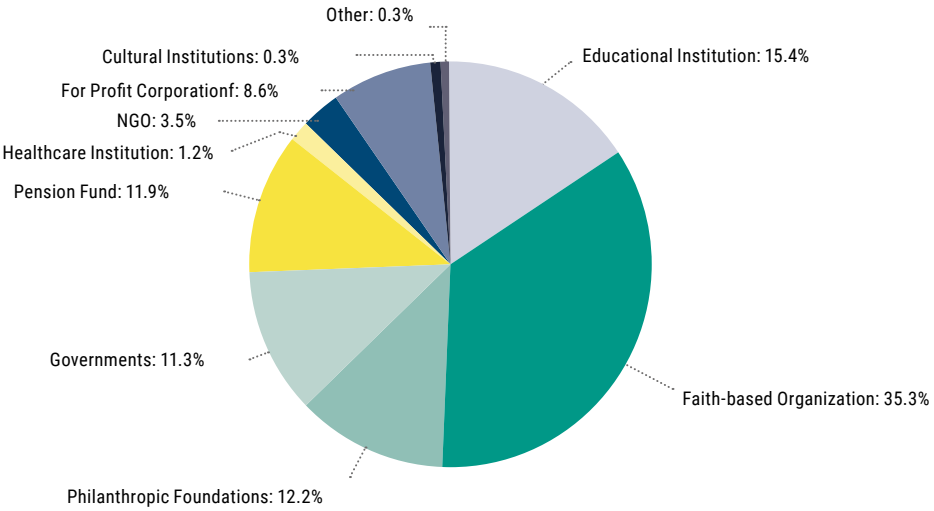
FIGURE 2

TYPOLOGY OF INSTITUTIONS DIVESTING FROM FOSSIL FUELS

Source: Global Fossil Fuel Divestment Commitments Database, 2022



THE OBSERVATORY'S LENS

Climate stress tests on the rise as supervisors test out a new tool

To increase awareness of climate risks, authorities apply the principles of stress testing, taking into account the specificities of climate risks — and most notably their longer time horizons. These exercises are designed to study the impact of external shocks on the solvency of a financial institution ('microprudential' stress tests), and on the financial system as a whole ('macroprudential'). By simulating a future climate scenario, for example, stress tests assess the capacity of a financial institution, considered in isolation or as part of a group, to withstand a shock, a major incident or an anomaly that might transpire in the course of its activities. Pilot climate stress tests have already been carried out in the Netherlands (2018),[15] in France (2020),[16] and at the level of the European Banking Union,[17] as well as in the United Kingdom (2021),[18] Canada[19] and Singapore.[20]

This first round of climate stress tests, whose results are not associated with binding capital requirements for financial institutions, has already made it possible to identify challenges that must be overcome for the exercise to become a fully-fledged supervisory tool in coming years. As such, they are a fundamental proving ground for institutions and supervisors alike.[21] In addition to the need for access to granular and sufficiently recent data— which legislators are gradually addressing through reporting requirements — the modelling constitutes a challenge in and of itself, given the aim of (1) interpreting climate variables, (2) converting this into impact on macroeconomic variables and, (3) disaggregating this impact across sectors to (4) quantify the combined impact on financial firms.[22]

In the remainder of the present analysis, we will first review the climate stress tests carried out to date by central banks and financial authorities in France, the Netherlands and the United Kingdom. These exercises are among the first ambitious climate stress tests and have therefore attracted attention in economic literature. Secondly, we will look more closely at the methodology adopted for the first comprehensive stress test of the banking system by the European Central Bank (ECB) in 2022, whose results were published in July 2022. Although the banks participating in this exercise used estimates rather than actual data from their counterparties,[23] the European climate stress test remains more interesting to discuss at the banking union level than at a national level. We will also consider the preparatory work of the European Insurance and Occupational Pensions Authority (EIOPA) for an insurance stress test at European level.[24] The third and final section will open up a few avenues for further study on how to meet the challenge of modelling in the years to come.

The first climate stress tests: The Netherlands, France, the United Kingdom

The three stress tests carried out in the Netherlands, France and the UK are viewed as exploratory and preliminary. Like the latest ECB exercise (**see below**), their purpose was to gain knowledge and help build the

capacity of financial firms to identify their exposure to climate risk, gather information and assess the strategic outlook of banks. While the methodologies used by the three supervisory authorities differ, the scenarios used in the exercise are fairly comparable and based on the four scenarios contained in the Network for Greening the Financial System (NGFS)[25] recommendations:

- The 'business as usual' aka 'worst case' scenario focuses on physical risks and assesses the extent to which their impact can damage the economy and the financial system.

- The 'orderly transition' aka 'best case' scenario outlines the preferred transition for mitigating physical risks without generating excessive transition risks.

- Two intermediate scenarios exploring various alternatives to assess the trade-offs between best- and worst-case scenarios.

The approaches are also often described in terms of their 'top down' and 'bottom up' components. A top-down approach signifies that the exercise is overseen a single authority, which provides the scenario, the key assumptions, and directs the analyses. A bottom-up approach is one in which companies produce the results through their own modelling and may include their own assumptions (especially as these better reflect their individual situations), while basing themselves on a shared scenario. Naturally, these concepts make sense only in the context of micro-prudential stress tests, as banks cannot work up systemic simulations on their own.

1. The stress test process

The climate stress test conducted by the Banque de France (BdF) and Autorité de Contrôle Prudentiel et de Résolution (ACPR) is acknowledged to have been the first truly comprehensive and demanding climate change risk assessment exercise.[26] It was completed between July 2020 and April 2021, with the voluntary participation of nine banking groups representing 85% of the combined French banking balance sheet and fifteen insurance groups representing 75% of French insurers' cumulative balance sheets.[27] In the UK, the Bank of England (BoE) and the Prudential Regulation Authority (PRA) conducted their climate stress test from January through June 2021, with the voluntary participation of the country's seven largest banking groups and five largest (re)insurers.[28, 29]

In both cases, responsibility for conducting the stress test was shared across the various parties. In France, the ACPR oversaw the exercise using an analytical framework provided by the BdF, but banks and insurers were involved by participating in the various working groups. In the UK, the BoE designed the exercise, with contributions from its Financial Stability Department and the PRA via the relevant BoE committees. Banks, insurers and a large reinsurance company also participated, using their internal models to estimate the impact scenarios would have. In both cases, a methodological guide was published to help participating institutions frame the exercise and to clarify expectations.[30, 31] Authorities in both countries also conducted a further 'reconciliation' exercise to ensure consistency between the sum of all individual submissions and the systemic impact of climate stress on banks and insurance companies.

Both the French and English exercises employed three of the four scenarios from the NGFS recommendations, extended to a 30-year horizon. These were: orderly transition, disorderly transition and late transition (equivalent to 'business as usual' with an average temperature increase > 4°C by 2100). For the latter scenario, the BdF discounted measures taken in the 2020 through 2050 period as having a limited impact on physical risks, which are determined by the concentration of greenhouse gases (GHGs) accumulated in the atmosphere over the prior 20-25 years. The BoE/PRA made a different choice by assuming that, absent a rapid transition, certain financially significant physical risks would start to emerge well before 2050. It therefore anticipates risks that are generally expected post 2050 in conventional scenarios.

A stress test was also conducted by De Nederlandsche Bank (DNB), the Netherlands' central bank, in 2018, with the voluntary participation of 3 banking groups, 50 pension funds and 29 insurance companies.[32] DNB conducted this truly pioneering exercise without involving private sector participants, taking a purely top-down approach, although it did use data it received concerning exposure to various sectors.[33] DNB did not include physical climate risks in its exercise. It employs two scenarios with short-term horizons (two years), adjusted for two dimensions that reflect key aspects of transition risk—policy and technology—that come close to the intermediate scenarios proposed by the NGFS:

A 'political shock' scenario that is essentially the same as the NGFS's disorderly transition scenario, and assumes late political action

A 'confidence shock' scenario, in which firms and households postpone investment and consumption due to uncertainties about public policy and

technology. This scenario presents parallels with the NGFS 'business as usual' scenario

However, the stress test's two additional scenarios differ fundamentally from those proposed by the NGFS. They are:

- The 'technology shock' scenario, which assumes that the share of renewable energy doubles in five years

- The 'double whammy' scenario, in which a technological breakthrough is combined with a delayed policy response

2. Designing Models: from climate scenario to financial impact

All three exercises base their calculations on the National Institute Global Econometric Model (NiGEM), a large-scale structural macro-econometric model of the world economy that NIESR[a] has been developing since 1987.[34] This framework includes separate models for each OECD country as well as for several large emerging countries (like India, Brazil and South Africa). Other countries are covered by regional blocks. Based on NiGEM, the economic impacts of climate scenarios are translated into macroeconomic impacts (GDP, interest, inflation, and unemployment rates, etc.).

To link GHG emissions, carbon prices and economic trajectories for each sector in each scenario, the BoF/ACPR and BoE/PRA pilot tests used Integrated Assessment Models (IAMs). The IAMs integrate economic and climate modelling and the most advanced of them even take into account estimates regarding changing energy systems, as well as shifts in agriculture, technology, infrastructure and health. In the French exercise, sector interdependencies were accounted for in the economic conversion of climate scenarios, notably by considering substitution effects resulting from rising carbon prices (emergence of a new technology, for instance). In addition to adjusting for carbon prices, the BoE/PRA incorporated economic impact from legislative requirements governing the energy efficiency of buildings and vehicles.

For its part, the DNB developed sector-specific 'transition vulnerability factors' (TVFs), with an average TVF assigned to the economy (weighted per the value-added of each sector) set at 1. Based on the DNB's energy transition scenarios, sectors were assigned to the macroeconomic models based on only their direct GHG emissions and thus based on the impact of carbon pricing (through a carbon tax). After adjustments to reflect the risk factors identified for each scenario, sector TVFs are multiplied by the stock prices yielded by the macroeconomic model, permitting an estimate of losses by sector.

Once these economic models established, the economic impacts were converted to financial impact. The French and British exercises also attempted to complement the sectoral approach with a more granular approach:

In France, financial impacts were extrapolated from economic assumptions based on four models: (1) the BdF's internal rating model for calculating default probability (DP) and models of stock price elasticity as a function of carbon pricing, (2) a scenario-based dividend stream discounting model, (3) a discounting model for damages paid out by insurers, and (4) a model estimating credit spreads.

In the UK, the financial impact of economic developments was assessed by the financial institutions themselves. Certain assumptions and variables were imposed by the BoE, which institutions were asked to apply with in conjuncture with their respective exposures to governments, businesses and households.

For the DNB exercise in the Netherlands, financial impact was estimated for each institution on the basis of losses due to exposures and changing spreads according to the type of financial product and sector.

The BoE/PRA and BoF/ACPR stress tests furthermore included elements of what is known in the literature as the 'dynamic balance sheet' i.e., the possibility that institutions may conduct a sectoral reallocation of their portfolios during the test period.

3. Conclusion

Due to the high levels of uncertainty associated with their results, it seems unlikely that the outcomes of these stress tests will be used to set capital requirements. No information has been published regarding the individual exposure of any particular institution—a condition of their volunteering to participate in the three exercises. The aggregate results, however, have been disclosed and provide observers with an initial assessment of the risks, exposures and vulnerabilities of the financial system. Internally, the results of the stress test may have

a The National Institute of Economic and Social Research (NIESR) is the oldest independent economic research institute in Britain.

helped banks to rebalance their exposures and adjust their risk management. Notwithstanding the methodological uncertainties and approximations already mentioned, several observations can be drawn from these exercises. Geographically, half of the exposure to climate risk is in France and a quarter in other European countries. France and Europe are particularly sensitive to transition risk but are overall less exposed to physical risk. In France, however, specific climatic events (droughts and floods in metropolitan France and cyclones in the French Caribbean) could cause insurance claims to increase by a factor of five or six by 2050. In terms of transition risk, credit costs could triple for the seven most sensitive NACE sectors/groups identified. Nonetheless, this estimate excludes an economic recession induced by the climate crisis prior to 2050.

ECB: a first climate stress test in 2022

The European Central Bank's climate stress test was conducted on 104 'significant' financial institutions in 2022, taking over from the stress tests previously conducted on a macro-prudential basis only ('Economy-wide climate stress tests').[35] It consists of three modules, within which financial institutions provided information on their own **climate stress simulation capabilities**, their **dependence on carbon-emitting sectors**, and finally, on their **performance under different scenarios and over several time horizons.**[36] This third module was limited to 41 banks amongst those directly overseen by the ECB.

1. General overview of conclusions

The framework built under the European System of Financial Supervision (ESFS) in the aftermath of the 2008 financial crisis is based on a collaboration between national supervisors and European institutions, specifically the ECB and the European Banking Authority (EBA). While the ECB is at the centre of the exercise, the conclusions drawn are in fact those of a cooperative of national and European actors.

Internal stress testing capacity: More than 60% of banks have no stress testing framework for climate risk, and only 20% consider climate risk in their loan process. Nevertheless, institutions seem to have made progress in establishing climate stress testing frameworks. Most also indicate that they will invest in staffing to improve their climate risk stress testing capabilities.

Scenario performance: The scenario analysis confirms that physical risk has a heterogeneous impact on European banks, as it depends on sectoral activities and location.

Exposure to carbon-emitting sectors: Nearly two-thirds of banks' revenues from non-financial companies are derived from greenhouse gas-intensive industries. This exposure comes from a small number of large counterparties. However, the different institutions exhibit significant variations, especially in terms of financial dependence: custodians and asset managers, as well as global systemically important banks (G-SIBs), are found to be less dependent on revenues from emissions-intensive sectors, compared to development banks/promotional lenders, investment banks and domestic retail banks. Furthermore, the sector breakdown of emissions reveals that the relative share of revenue from GHG-emitting sectors is high overall, but the largest shares of revenue are attributable to sectors with relatively low intensity, such as construction, wholesale and retail trade, and real estate activities.

This sectoral breakdown can be complemented by carbon-intensity estimates broken down by scope:

The report also highlights the importance for institutions of collecting actual Scope 3 emissions data or developing robust estimation techniques, given the extensive use of indirect estimates.

According to the ECB's analysis, the most emissions-intensive sectors (mining and quarrying as well as coke manufacturing in particular) tend to be dominated by large companies. This could explain why systemically important banks, universal banks and investment banks are more exposed to GHG emitting sectors.

The conclusions of this first ECB climate stress test should be taken with a grain of salt, however, given the considerable simplifications that are inevitable at this stage of climate stress tests' development: the exercise is currently aimed primarily at methodological learning.

2. Methodology

The documents published in October 2021 by the ECB for the benefit of banks detail the stress test methodology.

Internal stress testing capabilities are addressed via a questionnaire consisting of 78 closed questions (drop-down type) aimed at obtaining an overview of banks' climate risk stress testing capabilities. The questions cover governance, integration of climate risk stress test results into strategic decisions, methodology and scenario design, data availability and use, the Internal Capital Adequacy Assessment

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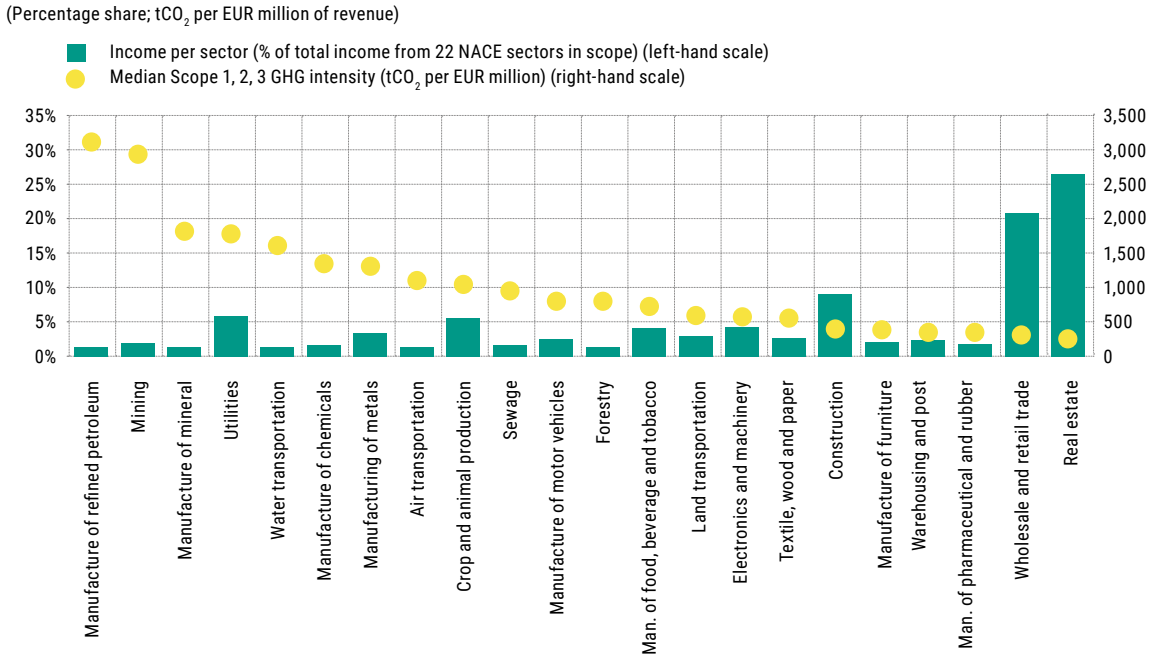
FIGURE 3

INTEREST, FEE AND COMMISSION INCOME PER SECTOR FROM 22 CARBON-INTENSIVE INDUSTRIES, AND MEDIAN OF SCOPES 1, 2 AND 3 GHG INTENSITY[b]

Source: ECB, 2022



Process (ICAAP),[c] future plans and internal audit procedures. This module is essential in light of the freedom the ECB offers banks in terms of the methodology to be followed, according to its own bottom-up logic.[37] The topics of the questionnaire are based on the four themes structuring the climate stress test since 2020: business model and strategy, governance and appetite for risk, risk management and disclosure. In addition to the qualitative results yielded by this section, the approach allows the ECB to compare banks, thanks to a rating system assessing their individual level of preparation compared to peers.[38]

Exposure to carbon-intensive sectors is assessed through a set of metrics calculated by the banks to evaluate their exposure and the sensitivity of their business strategies. This module is more binding and standardises the banks' disclosures, allowing for subsequent comparison of results. It comprises two sets of metrics. The first focuses on the sectoral and geographic distribution of revenues (interest and fees, together with the amounts associated with such revenues), limited to 22 non-financial sectors (based on the NACE classification). It is permitted at this stage to exclude revenues from certain countries, provided that 80% of total revenues are disclosed, or at least five countries (including the home country) are considered if the first criterion cannot be met. The second set of metrics involves the carbon 'intensity' variables for each counterparty. In simplified terms, it gives the ratio of emissions to the average annual revenues of business partners, and weights this against the bank's exposure. Again, only non-financial companies are considered, and SMEs are excluded. The institution must select the fifteen largest counterparties for each sector in terms of exposure.

The **performance of banks under various scenarios** is assessed on the basis of projections made by the banks using different risk parameters. The scenarios employed are based on those proposed by the Network for Greening the Financial System (NGFS) in late 2021.[39] There are two scenarios for assessing transition climate risk:

A short-term scenario (three-year horizon) assesses a bank's response to an unexpected and sudden

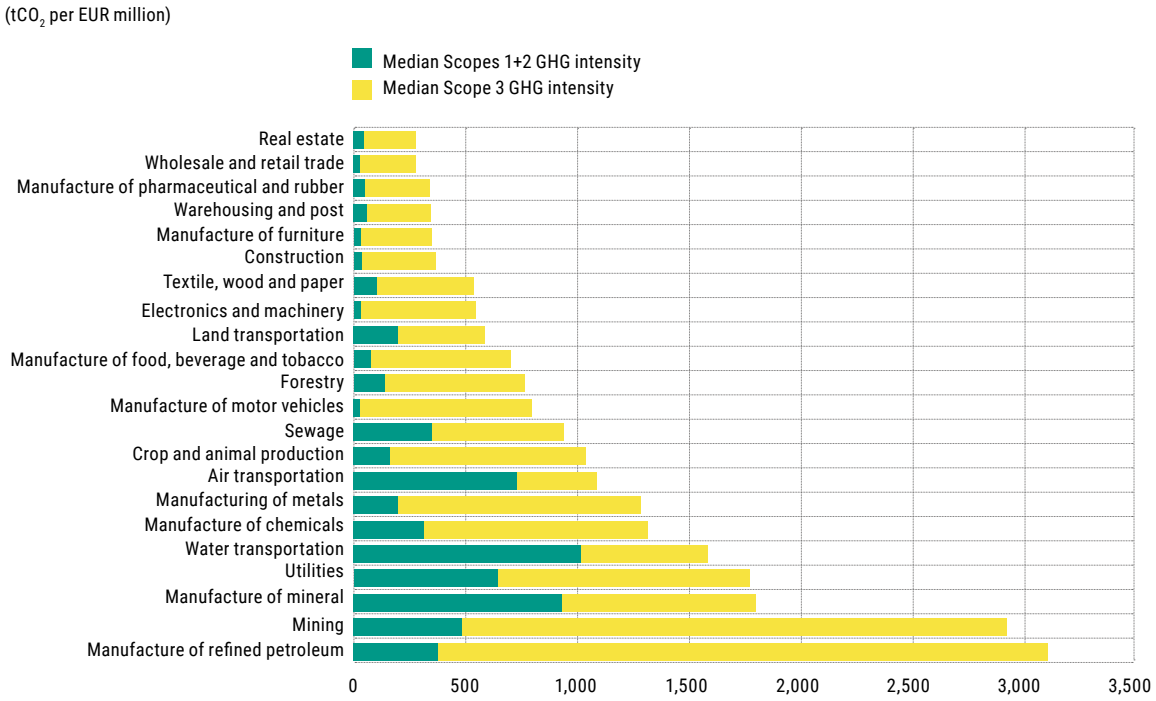
b Currently the vast majority are approximations due to lack of data.

c The Internal Capital Adequacy Assessment Process (ICAAP) is an exercise for self-assessment of financial risks by banks to ensure that they possess sufficient capital.

FIGURE 4

MEDIAN SCOPES 1+2 AND 3 EMISSIONS INTENSITY PER SECTOR[b]

Source: ECB, 2022



carbon price shock, both in terms of credit risk (risk of default by borrowers) and market risk (risk of losses resulting from market price movements).

A long-term scenario (30 years) is divided into three assumptions, corresponding to the scenarios recommended by the NGFS: (1) an orderly transition; (2) a delayed and disorderly transition; and (3) a 'hot world' (no action scenario). The stress test team made assumptions about the evolution of each bank's balance sheet and questions their vulnerability based on the adaptability of the business strategy. The dynamic evolution of the balance sheet in the long-term scenario analysis is a differentiating element compared to the approach recommended in European Banking Authority (EBA) studies. As market risk is much more difficult to estimate in the long term, the second scenario is limited to the analysis of credit risk.

Physical climate risk is also assessed through two scenarios, each with a one-year time horizon: one for drought and heat, the other for flood risk.[40] The scope of the physical scenarios covers exposures not secured by real estate (drought risk) and corporate and mortgage loans secured by real estate (flood risk). In the case of flood risk, the ECB provided the key data for the projection: geographical maps of flood risk levels and house price shocks for each of the regions on the map.

In its *Climate Risk stress test methodology*, published in October 2021,[41] the ECB provides some methodological expectations on credit risk estimation in the chapter 'Expected credit loss projections'. However, these expectations remain generic; no guidance is given on how the bank should relate the variables provided to credit risk parameters, and institutions may make their own assumptions, e.g., as regards customers' ability to withstand transition costs, reputational risk, etc. This flexibility allows institutions to extrapolate by aggregating similar risk exposures across multiple counterparties.

Beyond scenario analysis and in order to gain insight into current and future plans for financing the green transition, the participating institutions provided qualitative and quantitative information on their strategies: (1) their quantitative criteria for selecting counterparties to support the transition, (2) the assets under management related to the provision of green financing instruments and (3) the key performance or risk indicators developed to monitor progress towards alignment with the transition requirements.

3. Towards the design of climate stress tests for insurers

In April 2021, EIOPA issued an opinion[42] based on a consultation regarding the use of climate change financial risk scenarios in the Own Risk and Solvency Assessment (ORSA),[d] to promote convergence and consistency in the consideration of these issues. The document provides general information on assessing materiality and climate change scenarios, based on fictitious practical cases. The document provides insight into EIOPA's position on climate stress tests in the insurance sector:

Regarding the **analysis of materiality**, EIOPA presents a qualitative analysis of two fictitious insurance companies (life and non-life) on the basis of their portfolios (assets/liabilities), by establishing the business context as well as the climate risks faced by the company and identifying precisely over what time horizons and in which ways the business will be impacted. Next, a quantitative analysis identifies/situates all the company's exposures, seeking out and quantifying the possible impacts of climate change on these exposures. EIOPA provides tools and methodologies to quantify the impact of climate change.

In terms of **scenario analysis**, EIOPA presents three methods for analysing physical risks: (1) using the NGFS Climate Impact Explorer,[43] which shows the evolving severity of climate change in different countries and regions and for different scenarios; (2) using the results of the *Peseta IV* study,[44] which offers an understanding of the effects of climate change on Europe, and the sectors that affect climate change; (3) using available climate change scenarios, such as those provided by the NGFS

No proposals have been made to date for scenario analysis around transition risk.

In January 2022, EIOPA published a third version of its *Methodological principles of insurance stress testing,*[45] which it describes as a methodological toolkit for creating and calibrating EIOPA's future climate stress tests as part of its role in overseeing the insurance sector. In April 2022, EIOPA also launched a climate stress test for the European occupational pensions sector,[46] in coordination with the European Systemic Risk Board (ESRB) and the ECB. This involves completing a questionnaire on exposure to carbon price inflation, a questionnaire on the ESG performance of institutions, and a scenario analysis. Results are due to be published in December 2022.

KEY TAKEAWAYS

Given the learning objectives of the pilot tests and their limitations in terms of data and methodology, none of the prudential climate tests conducted to date will be used to set minimum capital requirements ('Pillar I').[e] With its 2022 climate stress test, the ECB stands out as the authority that has taken the exercise furthest. The institution will take under consideration the qualitative results of its stress test, together with its ongoing review of how banks integrate climate and environmental risks into their strategies, governance and risk management, in conducting its 2022 Supervisory Review and Evaluation Process (SREP).[47] These reflections could feed into Pillar II requirements emerging from bilateral dialogue with banks, an outcome most likely to impact those institutions with persistent deficiencies. However, there are still several major areas where considerable work remains before climate stress tests become a full-fledged supervisory tool:

1) Engaging in strategic thinking about climate risk: The results of climate stress tests can be used from a strategic perspective, as they provide a long-term view of the institution's vulnerabilities to climate risk and can help to strengthen financial stability in the short term.[48]

2) Accessing and managing data: Climate stress tests are constrained by uneven data availability/coverage, poor quality, low granularity, limited comparability and standardisation as well as poor integration with financial processes.[49] These bottlenecks persist in the absence of legislative disclosure requirements, but institutions need to develop their capacity to manage and meet such demands in the future, by engaging in dialogue with their stakeholders (companies, data providers) and enhancing their internal capabilities.

3) Providing human and financial resources to carry out these exercises within institutions: The acquisition of key climate-specific knowledge and skills within institutions is essential to effective exercise design and execution. Such skills are also highly strategic

d ORSA is an internal process of risk and solvency assessment by the organisation.

e Under Basel III, so-called 'Pillar 2' requirements are capital requirements defined for each bank, which apply in addition to the minimum capital requirements ('Pillar 1'), to cover risks that the minimum requirements have underestimated or fail to cover.

for financial institutions in the long term. Developing them goes hand in hand with establishing policies to anchor this new function within institutions, and to make data integration central to the business so that a dedicated stress test team does not operate in isolation.

4) Developing scenario analysis capacity: The ECB's 'bottom-up' approach, which requires institutions to analyse the impact of a scenario based on an internal model of their own and in coordination with authorities, appears to be the preferred solution for stress tests going forward.[50] Institutions will therefore need to develop methodologies for selecting variables, modelling and quantifying risks. Filling the gaps in current in-house models, systematising coordination with external modellers and academics to expand scenarios and improve understanding of the various models is a research and development challenge that must be taken up.[51] For example, there is still a great deal of uncertainty concerning 'second round' effects when it comes to assessing the impact of market participants' actions on equilibrium prices and behaviour. Research in this area is still highly theoretical and far from ready for practical applications.[52]

REFERENCES

RETURN TO PREVIOUS PAGE

1 Nicol, M., Hubert, R., Cochran, I., Leguet, B. (2017).). Gérer les risques de transition de son portefeuille: de la théorie à la pratique. *I4CE*

2 Swiss Re (14/12/2021). Global insured catastrophe losses rise to USD 112 billion in 2021, the fourth highest on record, Swiss Re Institute estimates.

3 EIOPA (2022). Discussion paper on physical climate change risks. *European Insurance and Occupational Pensions Authority*

4 Global Fossil Fuel Divestment Commitments Database (n.d.). The database of fossil fuel divestment commitments made by institutions worldwide. *divestmentdatabase.org* (accessed 13/09/2022).

5 Reuters (14/10/2021). French lender Banque Postale commits to exit oil and gas by 2030. *Reuters*

6 Ambrose, J. (12/06/2019). World's biggest sovereign wealth fund to ditch fossil fuels. *The Guardian*

7 IEA (2021). Net Zero by 2050. A Roadmap for the Global Energy Sector. *International Energy Agency*

8 Higham, C., Kerry, H. (03/05/2022). Taking companies to court over climate change: who is being targeted? *London School of Economics and Political Sciences, Grantham Research Institute on Climate Change and the Environment*

9 Brower, D. (26/05/2021). ExxonMobil shareholders hand board seats to activist nominees. *Financial Times*

10 Reuters (26/05/2021). Chevron investors back proposal for more emissions cuts. *Reuters*

11 Orowitz, H., Kumar, R., Hagel, L.A. (07/06/2022). An Early Look at the 2022 Proxy Season. *Harvard Law School Forum on Corporate Governance*

12 Brunetti, C., Dennis, B., Gates, D. et al (19/03/2021). Climate Change and Financial Stability. *Federal Reserve*

13 Emambakhsh, T., Giuzio, M., Mingarelli, L. et al. (2022). Climate-related risks to financial stability. *Financial Stability* Review

14 TCFD (2017). Recommendations of the Task Force on Climate-related Financial Disclosures.

15 Vermeulen; R., Schets, E., Lohuis, M. et al. (2018). An energy transition risk stress test for the financial system of the Netherlands. *De Nederlandsche Bank*

16 Clerc, L., Bontemps-Chanel, A.-L., Diot, S. et al. (2021). A first assessment of financial risks stemming from climate change: The main results of the 2020 climate pilot exercise. *ACPR Banque de France*

17 ECB (2022). 2022 climate risk stress test. *European Central Bank*

18 Bank of England (24/05/2022). Results of the 2021 Climate Biennial Exploratory Scenario (CBES). *Bank of England*

19 *Ibid.*

20 Baudino, P., Svoronos, J.-P. (2021). Stress-testing banks for climate change - a comparison of practices. *Financial Stability Institute, Bank for International Settlements*

21 ECB (08/07/2022). Banks must sharpen their focus on climate risk, ECB supervisory stress test shows. *European Central Bank*

22 UNEP-FI (2021). UNEP FI's Comprehensive Good Practice Guide to Climate Stress Testing. *United Nations Environment Programme - Finance Initiative*

23 Ecofi (11/07/2022). Le stress-test climatique de la Banque centrale européenne. *Funds360*

24 EIOPA (27/01/2022). EIOPA publishes third paper on methodological principles of insurance stress testing climate risks. *European Insurance and Occupational Pensions Authority*

25 NGFS (2021). NGFS Climate Scenarios for central banks and supervisors. *Network for Greening the Financial System*

26 Chassin, C., Seghouani, I., de Jenlis, N. (n.d.). Mesure de la vulnérabilité des assureurs aux risques physique et de transition liés aux changements climatiques. *Deloitte*

27 *Clerc, L., Bontemps-Chanel, A.-L., Diot, S. et al. (2021). A first assessment of financial risks, op. cit.*

28 Thanawalla, R., Grnac, J. (08/06/2021). The 2021 Bank of England Climate Stress Test: Motor your way through with our 4x4. *Deloitte*

29 *Bank of England (24/05/2022). Key elements (...), op. cit.*

30 Fitch Ratings (23/05/2022). What to Expect from the Bank of England Climate Stress Test. *Fitch Ratings*

31 https://www.bankofengland.co.uk/stress-testing

32 *Vermeulen; R., Schets, E., Lohuis, M. et al. (2018). An energy transition risk stress (...), op. cit.*

33 *Ibid.*

34 National Institute of Economic and Social Research (n.d.). National Institute Global Econometric Model. *niesr.ac.uk*

35 Alogoskoufis, S., Dunz, N., Emambakhsh, T. et al. (2021). Occasional Paper Series. ECB Economy-wide climate stress test. Methodology and results. *European Central* Bank

36 *ECB (2022). 2022 climate risk stress test (...), op. cit.*

37 Allemand, N. (15/12/2021). Climat: La BCE est-elle vraiment stressée ? *BSI* Economics

38 Phaure, H., Feron, S. (2022). Les stress tests climatiques 2022 de la BCE. *Deloitte*

39 NGFS (2021). Scenarios in Action. A progress report on global supervisory and central bank climate scenario exercises. *Network for Greening the Financial System*

40 *ECB (2022). 2022 climate risk stress test (...), op. cit.*

41 *Ibid.*

42 EIOPA (2021). Opinion on the supervision of the use of climate change risk scenarios in ORSA. *European Insurance and Occupational Pensions* Authority

43 NGFS Scenarios Portal. *Network for Greening the Financial* System

44 JRC PESETA IV. *Joint Research Centre*

45 EIOPA (27/01/2022). Methodological Principles of Insurance Stress Testing - Climate Change Component. *European Insurance and Occupational Pensions Authority*

46 EIOPA (04/04/2022). EIOPA launches climate stress test for the European occupational pension sector. *European Insurance and Occupational Pensions* Authority

47 Fitch Ratings (13/07/2022). ECB Climate Stress Test Highlights Challenges for Banks. *Fitch Ratings*

48 Beau, D. (07/06/2021). Building an appropriate climate stress testing framework for capital markets. *Banque de France*

49 Covas, F. (19/10/2020). Challenges in Stress Testing and Climate Change. *BPI*

50 Falloon, P., Challinor, A. J., Dessai, S., Hoang, L. (2014). Ensembles and uncertainty in climate change impacts. *Frontiers in Environmental Science,* 2

51 Allen, T., Dees, S., Boissinot, J. et al. (2020). Climate-Related Scenarios for Financial Stability Assessment: an Application to France. *Banque de France*

52 *Covas, F. (19/10/2020). Challenges in Stress Testing and Climate Change, op. cit.*