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The first ECB bottom-up climate stress test: Dealing with data gaps and methodological challenges

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At a glance

- The ECB's "SSM Climate risk stress test," published in July 2022, provides an important step toward integrating climate change related risks into the banking system. A key aim of this exercise is to take stock of the state of individual bank's climate risk assessment systems. In addition, a bottom-up stress test was conducted, seeking to analyze banks' potential financial losses related to climate risks.
- The ECB's exercise highlighted widespread data limitations that may prevent adequate climate risk assessment by individual banks. There is a strong reliance on proxies and sectoral aggregation to compensate for more granular exposures at counterparty level.
- At the same time, the risk assessment covered only a subset of assets on banks' balance sheets. The assessment of large asset classes, such as government bonds, is still in its infancy and is not part of the picture.
- On the modelling side, we explain limitations stemming from a strong focus on carbon price as the only policy tool and main stressor, as well as the disregard of potential carbon substitution and cost passthrough mechanisms for exposed firms and their balance sheets.
- To overcome these shortcomings, we suggest three ways forward: using a standardized climate neutrality scenario at the firm level; including all relevant assets in the assessment; and filling existing data gaps at counterparty level.

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The European Central Bank (ECB) has identified the "exposure to climate-related and environmental risks" as an emerging risk for its supervisory priorities,[1] which the ECB banking supervision needs to monitor and address. In order to improve the understanding and quantification of these risks, the ECB started a series of activities to identify, measure, and analyze the consequences that these risks might have for the stability of the financial system, as well as for the large banks under its supervision. As part of these activities, in July 2022, the ECB Banking Supervision published the findings of its first bottom-up "SSM climate risk stress test 2022."[2]

Before engaging in the bottom-up exercise, the ECB's Banking Supervision published its first guide for banks on how to deal with climate and environmental risks in 2020.[3] In 2021, the ECB published a macroeconomic top-down climate stress test.[4] The methodology and assumptions used in the ECB stress-testing exercise build on work from other central banks and institutions that have developed stress test methods to capture the impact of climate risks on the financial system.[5] Part of this work, in particular the climate (policy) scenarios, were developed in cooperation with the Network of Greening the Financial System (NGFS).[6]

The ECB stress test is, as a first move, unique in its detail and setting. Several stakeholders discussed the results extensively in July and August 2022.[7] This Policy Brief highlights the challenges that emerged from the ECB's exercise, both in terms of modelling and data reporting. It also suggests ways forward.

1 See the Supervisory priorities 2022-2024 of the ECB banking supervision (available online), accessed on 08.08.2022. This also applies to all other online sources of this report, unless stated otherwise)
2 ECB press release, 27 January 2022: ECB Banking Supervision launches 2022 climate risk stress test (available online).
3 ECB Press Release, 27 November 2020: The Guidance for Banks on Managing Climate and Environmental Risks was published in November 2020 (available online)
4 European Central Bank (2021): ECB economy-wide climate stress test. Occasional Paper Series 281 (available online)
5 The Autorité de Contrôle Prudentiel et de Résolution (ACPR) and Banque de France (BdF) were the first to publish results on a joint bottom-up climate stress test for a group of French banking institutions and insurers in 2020. The Bank of England launched its Climate Biennial Explanatory Scenario (CBES) in 2021. In the same year, also the European Banking Authority (EBA) published its EU-wide climate pilot exercise.
6 See Network for Greening the Financial System (2021) Scenarios in action: a progress report on global supervisory and central bank climate scenario exercises. NGFS Publications. (available online).
7 See analyses from Fitch Ratings (available online), Reuters (available online), CNBC (available online), AFME (available online), EBF (available online), Moodys (available online), Euractiv (available online), and S&P Global (available online).

An overview of the SSM climate risk stress test 2022

The ECB's bottom-up climate stress test consisted of three modules. In module 1, a qualitative questionnaire aimed at checking a bank's climate stress test capabilities. In module 2, banks were asked to build two credit risk metrics, one capturing the sensitivity of bank's income to transition risk, i.e. the risk from a rather abrupt increase in climate policy stringency for its asset valuations, and one capturing the exposure to carbon-intensive industries. Module 3 focused on a constrained bottom-up test, considering short as well as long-term transition and physical risk scenarios.[8]

The focus of this policy brief lies on module 3, which asked banks to implement a bottom-up stress test using the scenarios given by the ECB. As its main result, the combined credit risk losses under the short-term transition risk scenario and two physical risk scenarios amounted to about 70 billion Euro for the 41 banks in the sample. The loss arises purely from climate related risks, as this particular stress test did not assume a simultaneous economic downturn.[9] The losses projected are lower in a scenario assuming an orderly transition to a decarbonized economy than in scenarios where transition policies are phased in late but more rapidly or not at all (see technical explanation in the next section). The highest losses in terms of gross value added in the short-term Disorderly scenario are concentrated in a few sectors: mining, refined petroleum products, electricity and energy, as well as land transportation. The ECB climate stress test allowed a first stock-taking of banks' use and need of climate relevant data. Before addressing the challenges looking forward, we briefly explain the main components of the stress test in section 2.

8 For the main document of the ECB 2022 climate risk stress test see (available online); For the short press release see (available online).
9 The ECB lists four caveats for its estimates: First, regular stress tests consider an economic down-turn, while this was not the case here. The ECB also states that both data and modelling underlying the banks' projections were at a preliminary stage. Furthermore, no supervisory overlays were applied and the overall captured exposure was very limited.

Transition risk

Transition risks refer to financial losses a bank may incur from stricter regulation of carbon emissions or from sudden shifts in climate policies, technologies, or market conditions e.g., a sharp increase of carbon prices or other regulatory policies.

To capture the **short-term transition risk**, the ECB asked for projections of a "Disorderly scenario" with a time horizon of three years, where suddenly governments decided to increase carbon prices by 100 USD in January 2022.

This stress-test exercise focuses on the current amount of a firm's carbon emissions and then studies the consequences of a sudden increase of the carbon price for the production costs of that firm. It is important to understand that this approach does not consider transition plans of carbon-intensive firms and investments made in order reduce future carbon emissions. Furthermore, the approach does also not consider potential upsides for climate-friendly producers, such as increasing market shares and revenues, leading to potentially lower default probabilities for such firms in such a scenario (e.g. for wind turbine producers or firms engaging in green hydrogen or negative emission technologies).

For **long-term transition risks,** which span from present up to 2050, the ECB asked banks to provide credit risk projections with respect to three different climate policy paths. Again, the ECB distinguishes between orderly and delayed disorderly transition, where carbon emissions are smoothly reduced in the former, and not quickly enough in the latter which triggers increased policy action as of 2030. In the Hot House scenario, no policy action is undertaken, leading to increased physical risks.[10]

Physical risk

Physical risks are captured in the short-term to some extent and only very roughly in the long-term scenario. To capture physical risks in the short-term model (over a one-year time horizon), the ECB considers shocks from two extreme weather events highly relevant for the Euro area: droughts and floods. The drought and heatwave events impact sectoral value-added and labor productivity, respectively. The flood

10 The scenarios come from the Network for Greening the Financial System (available online).

event affects the value of bank's real estate collateral depending on its geographic location. The long-term scenario does not explicitly model any company-specific or bank-specific physical risk, these are instead reflected in a limited and homogenous manner through macroeconomic scenario variables. Physical risk damages consistent with a global warming of 3°C, 2°C, or 1.5°C at the end of the century under the Hot House World, Disorderly transition, or Orderly transition scenario are incorporated in the temporal trajectory of sectoral growth rates, GDP growth rates, commodity prices, and other variables. Consequently, the Hot House World scenario displays negligible transition costs but the highest physical costs, the Disorderly transition scenario displays significant transition costs due to policies being delayed, accompanied by moderate physical costs. Finally, the Orderly transition scenario displays both lower transition and lower physical costs compared to the Disorderly and the Hot House scenario.[11]

Technical explanation: How do climate risks find their way to bank balance sheets?

Climate related risks can affect banks through the credit risk and the market risk channel. The **credit risk** exposures are derived from banks' mortgage and corporate loan holdings. Banks participating in the stress-test were asked to split their corporate loan exposures between 22 industries at the NACE two-digit level, then link these to Scope 1 and 2 emissions (but not Scope 3 emissions).

Banks were then required to forecast credit impairments resulting from the shock and the different scenarios. In practice, this means that bank's credit risk indicators are impacted in two ways: on the one hand, the default probability (PD) of firms, which rely heavily on carbon emissions for their operations, increase with a surge in carbon prices. On the other hand, the loss given default (LGD) captures the deterioration in value of collateral due to physical or transition risks. Overall, the expected losses of a bank are reflected in the loan amount multiplied by the scenario specific LGD and PD.

11 See ECB (2022) Macro-financial scenarios for the 2022 climate risk stress test (available online) Network for Greening the Financial System (2020): NGFS Climate Scenarios for Central Banks and Supervisors. Technical report (available online).

To quantify the impact of the carbon price shock on the fair value of **market risk** exposures, banks were asked to classify their bond and stock holdings by the same 22 NACE industries as outlined above. Banks then needed to calculate the decline in net fair value positions of their bond portfolio, subsequently breaking it down by risk driver (equity, credit spread, interest rates, commodities, FX movements, and other).

The ECB bottom-up stress test is unique in its detail and setting. It allowed for a first stocktaking of climate-risk related data availability from the bank's side, as well as a first glance at how to model climate risks. As also highlighted by the ECB, several serious challenges related to data reporting and modelling emerged. We discuss each challenge in detail and suggest ways forward.

Challenges in data reporting

The ECB itself stated the availability of climate-related data as one of the main challenges. The results of the bottom-up stress test exercise reveal a disproportionate use of, and reliance on, data proxies and sectoral aggregations to overcome missing data. Additionally, and somewhat linked to the limited data availability, the exposures are too narrowly defined to be able to capture all climate-related risks on a bank's balance sheet. Both points are major issues that need to be addressed in the future.

Use of proxies and sectoral aggregation

The stress test revealed that most banks use proxy data instead of firm level data for carbon emissions and emission intensity. Proxy data are mainly sector based. However, at the company level, emissions are actually quite heterogeneous. Thus, an aggregated sectoral perspective is not able to identify the actual risks at a more granular level. Previous empirical work finds that even within very narrowly defined six-digit industries, the emission-intensities of firms vary substantially. Using U.S. administrative plant-level data, Lyubich et al., (2018) show that, with one dollar of energy input, a plant at the ninetieth percentile of a typical industry produces 580 percent more output that a plant at the tenth percentile. This variance in energy-intensity obviously also affects the financial risks of climate policy shocks.

Due to this data limitations on the bank's side, the main quantitative analysis is based on participating banks reporting of their corporate volume and income among 22 NACE2 sectors with the highest carbon emissions on average.

In addition, some sectors are aggregated to a relatively high level. For instance, the stress test methodology treats NACE2 sectors C24 and C25, the manufacturing of basic metals, as one aggregated sector, treating the production of basic iron steel and aluminum as similar - but the two industries have a very different climate risk profile in terms of scope 1 emissions. Previous research reveals the importance of sectoral heterogeneities for assessing the sector-specific costs of climate policies (Alexeeva-Talebi et al., 2012).

The stress test results indicated relatively high exposures of banks to these sectors. Therefore, it will be key to understand climate risks with more granularity at the company level.

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1 More data availability at the counterparty level can reduce the use of proxies and overcome problems of sectoral aggregation. As the variance within sectors is substantial, banks need to get a more granular understanding of the specific carbon emissions related to their assets. To deliver more reliable and comparable data at the company level, one way forward is a standardized climate neutrality scenario against which companies will need to report their transition plan.[12]

Missing exposures

Another point raised by the ECB is that the stress test exercise captured only one-third of total exposure, without specifying the gaps. These can stem from two factors. First, missing climate-related data on the counter-party level diminishes the ability to fully estimate the exposure of banks' loan and bond portfolios. With regards to mortgages, the ECB stress test results show that banks were unable to allocate 17 percent of the reported collateral to an Energy Performance Certificate bucket,

12 For a discussion of this proposal, see Policy Brief 5/2022: Standardized stress test scenario can improve climate risk reporting. Sustainable Finance Research Platform (available online).

despite EPCs being mandatory in the EU. As discussed before, the use of proxies is a poor substitute for real counter-party data availability when it comes to emission data and transition plans.

Second, a typical bank's assets side comprises (1) loans to corporations and households; and (2) corporate and government bond holdings and (3) interbank lending. By focusing only on credit and market risk exposure for corporate loans and mortgages, other financial assets and their climate risks are not part of the picture. The most striking example are government bonds: there is increasing empirical evidence that climate-related factors impact sovereign bond yields (Battiston and Monasterolo, 2019). Recent research shows that countries that are more resilient to climate change have lower bond yields relative to countries with greater vulnerabilities (Cevik and Jalles, 2022). Painter (2020) documents an increased pricing of sea-level rise risk in U.S. municipal bond markets. In similar terms, better ESG ratings significantly decrease government bond spreads (Crifo et al, 2017).

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2 As a way forward, comprehensive climate risk management should aim to include exposures to all relevant assets, including, for example government bonds. Additionally, data gaps, especially with respect to buildings and mortgages, must be closed.

Challenges in modelling of transition risks

It is in the nature of stress tests that the methodology relies on various assumptions when establishing stress information at the level of the individual bank. We discuss the most relevant assumptions and their effects in turn.

Climate policy and carbon price

First, it is assumed that a carbon price is the only available policy instrument to reach the targets of the Paris Agreement. However, in reality, the policy portfolio is much broader and offers many instruments with different distributional consequences. Other climate policies include, for example, minimum standards (e.g. the minimum

efficiency standard for buildings discussed at the European level) or phase-out decisions (such as a coal phase-out or the planned phase out of combustion engines in the EU).[13] Furthermore, carbon pricing schemes come in a variety of designs with substantially different impacts on company's balance sheets. Even today, the EU Emission Trading System (EU ETS), which is the EU's most important policy instrument to reduce carbon emissions, covering 41 percent of EU's total emissions, still gives firms in those sectors deemed under carbon leakage risk most of their emissions permits for free. An increase in carbon prices in such a system obviously has a different impact on balance sheets than a pure carbon tax where tax revenues are used for different purposes.

The assumed 100 USD carbon price shock is also not particularly severe for most firm's balance sheets. In recent history, the price of carbon emission allowances in the EU ETS increased by 80 EUR (80 USD) between March 2020 and February 2022 without creating the environment necessary for a transition to climate neutrality; further banks and the financial system did not experience severe stress.

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3 An increase of the carbon price by 100 Euro is insufficient to reach the 1.5° climate target and, hence, to simulate a transition scenario. Instead, an extreme, but plausible, transition scenario could be one that assumes climate neutrality for all companies and all economic activities within a certain year. In this case, companies cannot use any bridge technologies but need to implement climate-neutral technologies immediately.[14]

Carbon substitution and cost pass through

Firms can react to an increase in carbon costs by trying to pass it on to consumers or by substituting carbon-intensive inputs in production processes. The stress test methodology assumes that, despite a significant carbon price shock, the carbon emission of counterparties remain constant and input substitution is impossible.

13 For a discussion of different policy packages see Grubb, M., Hourcade, J. C., & Neuhoff, K. (2014). Planetary Economics. Taylor Francis.
14 For a discussion of a plausible transition scenario see Policy Brief 5/2022: Standardized stress test scenario can improve climate risk reporting. Sustainable Finance Research Platform (available online).

This is not in accordance with empirical evidence showing that firms respond to higher carbon prices (Martin et al., 2020). In the electricity sector, for example, Hintermann et al. (2016) explain that generators can switch fuels to abate emissions, even in the short run, which often does not require any additional investment. Mitigating emissions obviously would reduce the profitability risks from higher carbon prices.

A key determinant of a subsequent financial stress of a company due to climate policy is the carbon cost pass-through rate. If companies are able to pass-through the additional cost from climate policy to consumers, balance sheets remain relatively unaffected. Although challenging to estimate, the literature finds substantial pass-through rates in many industries (Cludius et al., 2020).

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4 Understanding the incidence of climate policies is non-trivial but essential for any assessment of the effects on balance sheets and asset valuations. More research is necessary to improve the modelling of the complex interactions between market power, climate policy instruments, and carbon mitigation investment decisions.

Conclusion

The ECB's "SSM Climate risk stress test 2022" forms an important contribution to the efforts on comprehensively integrating climate change related risks into the banking system.

The stress test highlights several challenges and limitations: From a stock-taking perspective, the results show a widespread use of proxies and sectoral aggregation by the participating banks and a lack of relevant exposures on the bank (firm) level. Additionally, due a lack of data and methodologies, so far exposures are quite narrowly defined. In terms of a first modeling approach of climate risks, the stress test focuses on the rather limited and abstract carbon price shock, which might not reflect the most severe scenario. Furthermore, both potential carbon substitution and cost pass through mechanisms are so far missing from the picture.

Looking forward, we suggest:

- to use a standardized climate neutrality scenario against which companies need to report their transition plans;
- to include all relevant assets in the assessment, including government bonds, and to fill existing data gaps at counterparty level; and
- to improve the modelling of complex climate and economic interactions.

Moreover, a complete understanding of the impact of climate change on financial risk inevitably has to include the systemic perspective, which is addressed through parallel efforts (e.g., the macroprudential view presented by the European Systemic Risk Board (ESRB)).

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About the project

The Sustainable Finance Research Platform is a joint project between five German research institutions conducting research on different aspects of Sustainable Finance, e.g. sustainable investments, sustainability risks and chances, and sustainability reporting. With their independent research, the project partners aim to support stakeholders in politics, the financial sector, and the real economy in understanding and shaping the central role of capital markets in achieving a net-zero economy. The researchers involved answer social, political, and business-related questions, provide established and new research findings, and participate in political and public debate. They also want to establish sustainable finance as a topic in the German research landscape and secure connections with international institutes and processes.

More information can be found on the project's website wpsf.de/en/.

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