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Climate change stress testing for the banking system

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Climate Change Stress Testing for the Banking System



by

EBBE ROGGE*

It is apparent that climate change is creating financial risks. These risks are of such a nature that they can be regarded as systemic: they are exogenous shocks which may simultaneously cause or contribute to the failure of multiple significant financial institutions. As a result, regulatory tools available to monitor and manage systemic risk have recently been deployed in the context of climate change risks. Such tools include stress testing and scenario analysis. This article examines international initiatives, such as those of the Network for Greening the Financial System, as well as specific central bank initiatives including those by the Bank of England. After some initial observations around climate data, stress test design, and central banks' mandate, this paper continues to discuss further possible inclusion in the prudential regulatory framework. In particular, the question is raised if capital requirements should be adjusted and if changes should be made to the risk management and governance framework. This paper argues in favour of the latter, but is more cautious as regards the former.

Table of Contents

ECFR 2023, 717–744

A. Introduction	718
B. Systemic Risk, Stress Testing, and Scenario Analysis	720
I. Systemic Risk Regulation Following the Global Financial Crisis	720
II. Recent Applications	721
C. International Framework for Climate Change-Related Stress Testing	724
I. The Financial Stability Board's Roadmap	724
II. The Network for Greening the Financial System	727
III. The Basel Committee on Banking Supervision	729
D. Implementation by Central Banks	731
I. Bank of England Stress Testing	731
II. European Central Bank Stress Testing	732
III. US Federal Reserve Stress Testing	734

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E. First Observations 735

 I. Data 735

 II. Design 737

 III. Objective and Mandate 738

F. Integration in the Prudential Framework 740

G. Conclusion 744

A. Introduction

Climate change has become a global policy priority.¹ In December 2015, 196 nations adopted the Paris Agreement at the Conference of the Parties (COP) 21, aiming to ‘limit global warming to well below 2 °C, preferably to 1.5 °C, compared to preindustrial levels’.² From a financial stability perspective, climate change has the potential to lead to significant losses due to climate-related financial risks. Building on literature treating climate change risk as a systemic risk, this paper examines the deployment of the ‘usual’ regulatory tools associated with systemic risks, i.e. stress testing, applied to climate change. In particular, this paper will examine both international frameworks for climate-related stress testing as well as the first-ever sets of tests conducted by major central banks within the last two years.

Systemic risk within the financial system includes ‘exogenous shocks which may simultaneously cause or contribute to the failure of multiple significant financial institutions’.³ As argued by for example Steele and Choudhury, climate change should be treated as a systemic risk.⁴ One particular category of risks emerging from climate change are physical risks: a continued increase of severe weather events, such as flooding, heat waves, forest fires, and hurricanes, as well as related environmental disasters, are likely to cause significant

1 For a general introduction to the role of business and finance in climate law, see e.g. *Colin Myers/Jason J. Czarnezki*, “Sustainable Business Law? The Key Role of Corporate Governance and Finance”, *Environmental Law* 51 (2021), 991.

2 United Nations (UNFCCC), “The Paris Agreement” (<https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>, last accessed 27 January 2023); European Commission, “Paris Agreement” (https://ec.europa.eu/clima/policies/international/negotiations/paris_en, last accessed 27 January 2023).

3 *Hal S Scott*, “The Reduction of System Risk in the United States Financial System”, *Harvard Journal Law & Public Policy* 33 (2010), 671, 673.

4 *Graham S. Steele*, “Confronting the ‘Climate Lehman Moment’: The Case for Macroprudential Climate Regulation”, *Cornell Journal of Law & Public Policy* 30 (2020), 109; *Barnali Choudhury*, “Climate Change as Systemic Risk”, *Berkeley Business Law Journal* 18 (2021), 52.

financial losses.⁵ These losses may result in insurance pay-outs, credit losses from both homeowners and businesses, or, generally, the risk of a severe economic recession. Taken together these impacts can become systemic in nature. The other category of risks emerging from climate change are transition risks, which arise from the transition to a carbon neutral economy. Consider for example the impact of the transition away from fossil fuel: this may create significant ‘stranded assets’, writing down investments prematurely, resulting in significant financial losses of systemic size and nature.⁶

Recently, tools deployed in managing the ‘usual’ systemic risks, as observed during the financial crisis, are being used in the field of climate change risk, including stress-testing and scenario analysis.⁷ This paper examines how climate change scenario analysis and stress testing are being applied to the banking system. Note that in the context of climate change the use of backward-looking or historical stress test models are less suited because anticipating the eventual impact of future climate change is so complex.⁸ Instead, the development of forward looking scenarios becomes an integral part of stress testing for the impact of climate change. This paper proceeds as follows. Section B provides an introduction to systemic risk in the financial sector. Section C sets out the international regulatory initiatives on treating climate-change risk as a systemic risk and introduces the international framework for conducting stress testing and scenario analysis. Section D discusses the implementation of this international framework by some of the major central banks. Some first observations are provided in Section E, whilst section F makes suggestions for future prudential policy. Section G concludes.

5 See for example: *Francisco Estrada/W.J. Wouter Botzen/Richard S.J. Tol*, “Economic losses from US hurricanes consistent with an influence from climate change”, *Nature Geoscience* 8 (2015), 880.

6 *Gregor Semieniuk/Philip B. Holden/Jean-Francois Mercure/Pablo Salas/Hector Pollitt/Katharine Jobson/Pim Vercoulen/Unnada Chewpreecha/Neil R. Edwards/Jorge E. Viñuales*, “Stranded fossil-fuel assets translate to major losses for investors in advanced economies”, *Nature Climate Change* 12 (2022), 532.

7 Stress testing is used widely and provides much information: *Rory van Loo*, “Stress Testing Governance”, *Vanderbilt Law Review* 75 (2022), 553; *Jonathan Watson*, “Financial institutions prepare for climate-related stress tests”, *IBA Global Insight* December 2020/January 2021, (<https://www.ibanet.org/article/8BB32971-6BFD-47D9-A323-5BD280DD45E2>, last accessed 27 January 2023).

8 *Patrick Bolton/Morgan Despres/Luiz Awazu Pereira Da Silva/Frédéric Samama/Romain Svartzman*, “The green swan: central banking and financial stability in the age of climate change”, *Bank for International Settlements (BIS)*, January 2020, (<https://www.bis.org/publ/othp31.pdf>, last accessed 27 January 2023).

B. Systemic Risk, Stress Testing, and Scenario Analysis

I. Systemic Risk Regulation Following the Global Financial Crisis

The Global Financial Crisis of 2008 (GFC) confronted the financial system with systemic risks: the problems in the US mortgage market, by way of derivative products such as mortgage backed securities, had spread throughout the global financial system.⁹ Losses had started to accumulate through these products whilst market participants did not know the positions of others. In short, a high level of interconnectedness, combined with various financial firms considered too-big-too-fail, posed new risks which would have to be monitored and managed better in the future. These risks have become known as systemic risk, defined above as an exogenous shock which may result in the failure of several large financial institutions.¹⁰ There have been various regulatory initiatives to improve the understanding, monitoring, and mitigation of systemic risk.¹¹ Even before the GFC, the Basel Committee on Banking Supervision (BCBS) had made significant contributions to banks' stress testing requirements. For example, as part of the internal rating-based approach for measuring credit risk in Basel II, stress testing should be used to identify possible future economic changes with a negative impact on the banks' credit exposures.¹²

9 Kurt Eggert, "The Great Collapse: How Securitization Caused the Subprime Melt-down", *Connecticut Law Review* 41 (2009), 1257; William Poole, "Causes and Consequences of the Financial Crisis of 2007–2009", *Harvard Journal Law & Public Policy* 33 (2010), 421; Patricia A. McCoy/Andrey D. Pavlov/Susan M. Wachter, "Systemic risk through securitization: The result of deregulation and regulatory failure", *Connecticut Law Review* 41 (2008), 1327.

10 Scott, (fn. 3), 673; general introduction see e.g. Kern Alexander/Rahul Dhumale/John Eatwell, *Global governance of financial systems: the international regulation of systemic risk*, 2005; or Rosa María Lastra, "Systemic risk, SIFIs and financial stability", *Capital Markets Law Journal* 6 (2011), 197; Anita I. Anand, "Is Systemic Risk Relevant to Securities Regulation?", *University of Toronto Law Journal* 60 (2010), 941; Steven L. Schwarcz, "Systemic risk", *Georgetown Law Journal* 97 (2008), 193.

11 For critical discussion, see Steven L. Schwarcz, "Systematic Regulation of Systemic Risk", *Wisconsin Law Review*, 2019, 1; John C. Coffee Jr, "Political economy of Dodd-Frank: Why financial reform tends to be frustrated and systemic risk perpetuated", *Cornell Law Review* 97 (2011), 1019; Roberta S. Karmel, "The Controversy Over Systemic Risk Regulation", *Brooklyn Journal of International Law* 35 (2010), 823; Iman Anabtawi/Steven L. Schwarcz, "Regulating systemic risk: towards an analytical framework", *Notre Dame Law Review* 86 (2011), 1349; Kathryn Judge, "Fragmentation nodes: a study in financial innovation, complexity, and systemic risk", *Stanford Law Review* 64 (2012), 657.

12 Basel Committee on Banking Supervision, *International Convergence of Capital Measurement and Capital Standards*, June (<https://www.bis.org/publ/bcbs107.pdf>, last accessed 27 January 2023), 2004, p. 166.

In 2009, shortly after the GFC, the Financial Stability Board (FSB) was created to strengthen further the international financial regulatory system.¹³ Its mandate included, amongst others, reducing interconnectedness, whilst increasing resilience of global financial markets. Around the same time, the BCBS published its principles for sound stress testing practices.¹⁴ It describes stress testing as a useful tool to supplement other risk management practices, with particular added value in amongst others: providing forward looking risk assessments; overcoming limitations of models and historical data; and facilitating risk mitigation and contingency planning.¹⁵ The GFC demonstrated flaws with earlier stress testing models, which should be improved: backward-looking historical information is less useful if it relates to a period of stability or does not include events that one is testing for; and risk characteristics can change rapidly due to feedback loops, market reactions, or system-wide interactions.¹⁶ Likewise, scenarios used in testing before the GFC were typically too short, not severe enough, or did not cover sufficiently changing correlation or system-wide effects.¹⁷ Not surprisingly, the BCBS suggested significant enhancements of the stress-testing framework and scenario design, as well as deeper integration in banks' risk management and decision making process.

II. Recent Applications

Whilst the above highlights the use of stress-testing to identify and manage system-wide financial risks, their usage towards other novel risks is increasing swiftly. A recent example is provided by the Covid-19 pandemic, which typically resulted in economic turmoil and in dramatic government interventions combatting the financial effects of the Corona virus. With many companies in financial distress, the various central banks played a role in supporting economic stability.¹⁸ Within the context of stress-testing, the Covid-19 pandemic

13 G20 Leaders Statement: The Pittsburgh Summit, 24–25 September 2009 (<http://www.g20.utoronto.ca/2009/2009communique0925.html>, last accessed 27 January 2023).

14 Basel Committee on Banking Supervision, Principles for sound stress testing practices and supervision, May (<https://www.bis.org/publ/bcbis155.pdf>, last accessed 27 January 2023), 2009.

15 Basel Committee on Banking Supervision (fn. 14), p. 1.

16 Basel Committee on Banking Supervision (fn. 14), p. 3–4.

17 Basel Committee on Banking Supervision (fn. 14), p. 4.

18 *Christos V. Gortsos*, "The Response of the European Central Bank to the Current Pandemic Crisis: Monetary Policy and Prudential Banking Supervision Decisions", *European Company and Financial Law Review* 17 (2020), 231; *Danny Busch*, "Is the European Union going to help us overcome the COVID-19 crisis?", *Capital Markets Law Journal* 15 (2020), 347.

has presented a different type of crisis scenario for the financial sector. Various major central banks have since ran stress-tests based on the Covid-19 scenario.

The Federal Reserve has conducted scenario testing to measure the impact of the Covid-19 pandemic based on three different scenarios: a sharp V-shape recovery; a slow U-shape recovery; and a double-dip W-style recession and recovery.¹⁹ Especially in the second and third scenario, various banks would approach the minimum amount of required capital. In these scenarios, either (or both) government intervention to stimulate the economy or mitigating actions by the banks would become advisable. In Europe, the ECB conducted a Covid-19 vulnerability analysis.²⁰ The baseline scenario resulted in a reduction of banks' capital although they had enough capital to withstand a short-lived deep recession. A more severe scenario with a delayed economic recovery, however, showed a significant depletion of capital. It suggested that additional support measures (e.g. government intervention to support the wider economy) or mitigating actions by banks themselves would be required. The Bank of England published an interim financial stability report relating to the impact of Covid-19.²¹ The report highlights a significant increase in market volatility and deteriorating liquidity, resulting in a 'dash for cash' by investors – i.e. selling long term safe assets such as government bonds to obtain short-term highly liquid assets.²² This has resulted in significant stress on the financial market infrastructure, although it has shown sufficient resilience to cope with it. The report further showed the banking sector is able to withstand a sharp economic downturn when combined with a relatively swift recovery period, similar to the ECB results.

19 Board of Governors of the Federal Reserve System, Federal Reserve Board releases results of stress tests for 2020 and additional sensitivity analyses conducted in light of the coronavirus event, 25 June (<https://www.federalreserve.gov/newsevents/pressreleases/bcreg20200625c.htm>, last accessed 27 January 2023), 2020.

20 European Central Bank, COVID-19 Vulnerability Analysis, Results Overview, 28 July 2020 (https://www.bankingsupervision.europa.eu/press/pr/date/2020/html/ssm.pr200728_annex~d36d893ca2.en.pdf, last accessed 27 January 2023); for more European results, see for example: Banque de France, Bank stress tests: tools for prudential analysis – Episode 1, 22 December 2020 (<https://blocnotesdeleco.banque-france.fr/en/blog-entry/bank-stress-tests-tools-prudential-analysis-episode-1>, last accessed 27 January 2023); and Banque de France, Bank stress-tests at the time of Covid-19- Episode 2, 24 December 2020 (<https://blocnotesdeleco.banque-france.fr/en/blog-entry/bank-stress-tests-time-covid-19-episode-2>, last accessed 27 January 2023).

21 Bank of England, Interim Financial Stability Report, May 2020 (<https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-report/2020/may-2020.pdf>, last accessed 27 January 2023).

22 Bank of England (fn. 21), p. i.

Another recent example of the new usage of scenario analysis and stress testing in the financial sector is managing emerging risks associated with technological innovations including the increased use of blockchain technologies and FinTech generally. It has been suggested that technologies such as blockchain could revolutionize existing market infrastructure.²³ Some commentators argue the risks associated with a rapid rise of financial technology and associated decentralized FinTech markets are different from the risks associated with ‘too-big-to-fail’ institutions.²⁴ After all, the newly emerging markets are far less transparent or regulated at the moment and perhaps more vulnerable to economic shocks. It is even suggested that the tail risks are higher for technology firms than they are for financial firms.²⁵ In other words, there might well be systemic risks but they differ from those observed in the traditional banking sector. Other commentators, however, suggest the opposite, i.e. that FinTech does not contribute greatly to systemic risk as stress in one FinTech firm does not necessarily increase stress at another.²⁶ In any event, the recent bankruptcy of crypto currency exchange FTX demonstrates the need and urgency for managing and mitigating these new risks.²⁷ One could argue that whilst the contagion in crypto markets may not have had a significant impact on traditional financial markets, the situation may well change as the latter become increasingly engaged with crypto assets.²⁸ There already are some regulatory initiatives edging towards this area, for example, the Bank of England has introduced a voluntary cyber stress test, simulating a severe stress in (new) pay-

23 *Ryan Surujnath*, “Off The Chain! A Guide to Blockchain Derivatives Markets and the Implications on Systemic Risk”, *Fordham Journal of Corporate & Financial Law* 22 (2017), 257.

24 *William Magnuson*, “Regulating Fintech”, *Vanderbilt Law Review* 71 (2018), 1167.

25 *Sajid M. Chaudhry/Rizwan Ahmed/Toan Luu Duc Huynh/Chonlakan Benjasak*, “Tail risk and systemic risk of finance and technology (FinTech) firms”, *Technological Forecasting and Social Change* 174 (2022), 121191.

26 *Lavinia Franco/Laura Garcia/Vigor Husetovic/Jessica Lassiter*, “Does Fintech Contribute to Systemic Risk? Evidence from the U.S. And Europe”, ADBI Working Paper 1132, *Macroeconomic Stabilization in the Digital Age*, 2020, (<https://ssrn.com/abstract=3468809>, last accessed 27 January 2023).

27 See e.g. *Thomas Conlon/Shawn Corbet/Yang Hu*, “The Collapse of FTX: The End of Cryptocurrency’s Age of Innocence”, Working paper, December 2022, (<https://ssrn.com/abstract=4283333>, last accessed 27 January 2023); or *Joseph Jasperse*, “FTX: Four Degrees of Fallout”, Working Paper November 2022 (<https://ssrn.com/abstract=4277871>, last accessed 27 January 2023).

28 Financial Stability Board, *Assessment of Risks to Financial Stability from Crypto-assets*, February 2022; *Lieven Hermans/Annalaura Ianiro/Urszula Kochanska/Veli-Matti Törmälehto/Anton van der Kraaij/Josep M. Vendrell Simón*, “Decrypting financial stability risks in crypto-asset markets”, ECB Financial Stability Review, 2022.

ment system technology, which may be more integrated in traditional financial markets than other FinTech firms.²⁹

The above highlights the use of stress testing and scenario design in the financial sector, at first as a response to managing systemic risk in the wake of the GFC, but later on towards emerging risks from the Covid-19 pandemic and technological innovations. The next step, and central to this paper, is to extend the scope of stress testing to monitor and manage the impact of climate change on the financial sector.

C. International Framework for Climate Change-Related Stress Testing

I. The Financial Stability Board's Roadmap

This section will introduce various initiatives on including climate change and mitigation risks into stress testing. This subsection will cover the proposals of international standard-setting organisations. The next subsection will examine their national or regional implementation.³⁰ In 2021 the Financial Stability Board (FSB) published a roadmap for addressing climate change-related financial risk.³¹ The preliminary observation made in the roadmap is that these risks need to be managed by individual firms but at the same time the resilience of the financial system as a whole needs to be considered.³² The FSB notes this effectively creates a direct link between ‘micro-prudential, macro-prudential and economic objectives’, making coordination of different measures a necessity.³³ The roadmap then sets out four different but related areas: 1) firm level

29 Bank of England, Prudential Regulation Authority statement on the 2022 cyber stress test: Retail payment system, December 2021 (<https://www.bankofengland.co.uk/prudential-regulation/publication/2021/december/cyber-stress-test-2022-retail-payment-system>, last accessed 27 January 2023).

30 General approach see: *Ebbe Rogge*, “Transnational Financial Rulemaking: An Application of Comparative Law & Global Legal Pluralism”, *Review of Banking & Financial Law* 39 (2019), 499; *Pierres-Hugues Verdier*, “Transnational Regulatory Networks and Their Limits”, *Yale Journal of International Law* 34 (2009), 113; or *Anne-Marie Slaughter*, “The Real New World Order” *Foreign Affairs* 76 (1997), 183.

31 Financial Stability Board, FSB Roadmap for Addressing Climate-Related Financial Risks, July 2021 (<https://www.fsb.org/wp-content/uploads/P070721-2.pdf>, last accessed 27 January 2023); for progress on this roadmap see: Financial Stability Board, FSB Roadmap for Addressing Climate-Related Financial Risks 2022 Progress Report, July 2022 (<https://www.fsb.org/wp-content/uploads/P140722.pdf>, last accessed 27 January 2023).

32 Financial Stability Board (fn. 31), p. 1.

33 Financial Stability Board (fn. 31), p. 1.

disclosures; 2) data; 3) vulnerability analysis; and 4) regulatory supervisory and practice tools.³⁴

The first of the four areas covered by the FSB road map is ‘disclosure’. Companies should make public disclosures as regards their (financial) risks emanating from climate change, in this case for the purpose of informing banks, lenders, investors, and other financial market participants. For the purpose of conducting stress tests, these disclosures would provide insights into the behaviour of e.g. a loan portfolio in different stress scenarios. Of course, any standardization of said disclosures would be beneficial: it would result in data which is easily compared or aggregated. With this in mind, the FSB created the Task Force on Climate Disclosures (TCFD), which has made several recommendations laying down a basic standardized and international framework.³⁵ This is being adopted widely in various national and regional standards, for example in the EU and the UK.³⁶ A related initiative is the development of the International Financial Reporting Standards (IFRS) global sustainability disclosure standards.³⁷ The IFRS in 2021 created a new standard setting board to this extent: the International Sustainability Standards Board (ISSB).³⁸ Examples of initiatives taken by the ISSB include drafting requirements for the disclosure of ‘sustainability-related financial information’³⁹ and of ‘climate-re-

34 Financial Stability Board (fn. 31), p. 2.

35 See generally: Task Force on Climate-related Financial Disclosures, About (<https://www.fsb-tcfd.org/about/>, last accessed 27 January 2023), 2023.

36 *Lara Ohnesorge/Ebbe Rogge*, “Europe’s Green Policy: Towards a Climate Neutral Economy by Way of Investors’ Choice”, *European Company Law* 18 (2021), 34; UK Government, UK to enshrine mandatory climate disclosures for largest companies in law, Press Release, October 2022 (<https://www.gov.uk/government/news/uk-to-enshrine-mandatory-climate-disclosures-for-largest-companies-in-law>, last accessed 27 January 2023); and HM Treasury, Mansion House Update February 2022 (<https://www.gov.uk/government/collections/mansion-house-update-february-2022>, last accessed 27 January 2023), 2022.

37 Generally, see: International Financial Reporting Standards, General Sustainability-related Disclosures, (<https://www.ifrs.org/projects/work-plan/general-sustainability-related-disclosures/#about>, last accessed 27 January 2023), 2023.

38 International Financial Reporting Standards, International Sustainability Standards Board, (<https://www.ifrs.org/groups/international-sustainability-standards-board/>, last accessed 27 January 2023), 2023.

39 International Financial Reporting Standards, [Draft] IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information, March 2022 (<https://www.ifrs.org/content/dam/ifrs/project/general-sustainability-related-disclosures/exposure-draft-ifrs-s1-general-requirements-for-disclosure-of-sustainability-related-financial-information.pdf>, last accessed 27 January 2023).

lated disclosures’.⁴⁰ These include recommendations made by the TFCD and thus directly support the work done by the TFCD (and FSB) in this area.⁴¹

The second area of the FSB roadmap covers ‘data’: climate data needs to be available in order to make any impact assessment of any climate related risks. It is needed to be able to assess the vulnerabilities, exposures, and possible consequences for companies and financial services providers. Although this will be partially covered in the corporate disclosures as indicated above, availability of climate data should assist in obtaining better understanding of e.g. cross-sectoral effects and future developments as well as ensuring (international) consistency.⁴²

The third area of the roadmap is the assessment of vulnerabilities and their impact on financial stability. It requires the development of a framework for monitoring (and assessment) of such vulnerabilities, for example through scenario analysis. These include for example the Network for the Greening of the Financial System (NGFS) scenarios discussed in the next subsection. It should be noted already that such scenarios should not be static: with increasing knowledge and insights, these can be improved upon continuously. The fourth and final part of the roadmap is the development of necessary regulatory and supervisory practices and tools. These are mostly tools to be developed by the NGFS, as discussed in the next subsection, and by the BCBS, as discussed in the subsection thereafter.

Clearly these four strands are closely related and interconnected as all four will build on each other.⁴³ Importantly, progress on one of these should lead to improvements on the other strands as well. The 2022 FSB Progress Report, for example, provides an update on the roadmap: essentially, progress is claimed in all four areas.⁴⁴ In particular, it is noted that the ISSB has published two drafts for climate- and sustainability related disclosures, as highlighted previously. On data, progress is made by way of cooperation with e.g. OECD for One Planet Data Hub: a global open data platform through which consolidated and

40 International Financial Reporting Standards, [Draft] IFRS S2 Climate-related Disclosures, March (<https://www.ifrs.org/content/dam/ifrs/project/climate-related-disclosures/issb-exposure-draft-2022-2-climate-related-disclosures.pdf>, last accessed 27 January 2023), 2022.

41 International Financial Reporting Standards (fn. 39), p. 6; and International Financial Reporting Standards (fn. 40), p. 6.

42 Financial Stability Board (fn. 31), p. 6.

43 Financial Stability Board (fn. 31), p. 8.

44 Financial Stability Board, FSB Roadmap for Addressing Financial Risks from Climate Change – 2022 Progress Report, July (<https://www.fsb.org/wp-content/uploads/P140722.pdf>, last accessed 27 January 2023), 2022.

standardized firm-level information is available. Developments by the NGFS on scenarios will be discussed next.

II. The Network for Greening the Financial System

The previous subsection already briefly mentioned the Network for the Greening of the Financial System (NGFS). As the name suggests, it is a network with a membership of over a hundred central banks and other financial supervisory authorities.⁴⁵ Currently hosted by the Banque de France, the French Central Bank, the NGFS' central aim is to 'help strengthening the global response required to meet the goals of the Paris agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development'.⁴⁶ Whilst there are various workstreams ongoing in the NGFS⁴⁷, two are of particular interest in the current context: scenario design and analysis; and supervision.

The workstream for scenario design is most important for the central theme in this paper: its objective 'is to help NGFS members in their development of climate scenario analysis and promote its use within the financial system more broadly'.⁴⁸ The workstream seeks to improve scenario design constantly, for example by improving the 'modelling of acute and chronic physical risks' as well as 'macro-economic modelling'.⁴⁹ This will hopefully provide for more accurate, detailed, and realistic scenarios. At the same time, the workstream will seek to expand the scenarios to include more sectors, geographies, and

45 Network for Greening the Financial System, Membership (<https://www.ngfs.net/en/about-us/membership>, last accessed 27 January 2023).

46 Network for Greening the Financial System, General Information (<https://www.ngfs.net/en/about-us/governance/origin-and-purpose>, last accessed 27 January 2023); and Network for Greening the Financial System, NGFS Glasgow Declaration – Committed to Action, Nov (<https://www.ngfs.net/sites/default/files/ngfsglasgowdeclaration.pdf>, last accessed 27 January 2023), 2021.

47 Network for Greening the Financial System, General Information (<https://www.ngfs.net/en/about-us/governance/general-information>, last accessed 27 January 2023); and for the charter see: Network for Greening the Financial System, Charter of the Central Banks and Supervisors Network for Greening the Financial System, July (https://www.ngfs.net/sites/default/files/media/2020/09/03/ngfs_charter_final.pdf, last accessed 27 January 2023), 2021.

48 Network for Greening the Financial System, Workstream 'Scenario Design and Analysis' Mandate – April 2022/April 2024 (https://www.ngfs.net/sites/default/files/workstream_scenario_design_and_analysis_mandate.pdf, last accessed 27 January 2023), 1.

49 Network for Greening the Financial System (fn. 48), p. 1–2.

financial variables. These expansions would enhance the scenarios' usability across different (emerging) economies and across new potential users.⁵⁰ Another key element for this particular workstream is to provide methodological guidance, i.e. discussing which methodological approaches, types of analysis, and in- and outputs could be used.⁵¹ Finally, this workstream seeks to promote the use of NGFS scenarios within the financial sector.⁵² This ties in to the second workstream on supervision.⁵³ This second stream contributes towards integrating climate-related risks into financial monitoring and prudential supervision, which will be revisited later in this paper.⁵⁴

The NGFS has published updated scenarios in 2021 and a third iteration in 2022.⁵⁵ Both explore six scenarios, which together cover three dimensions: 'orderly'; 'disorderly'; and 'hot house world'.⁵⁶ In orderly scenarios, climate change policies are adapted early on limiting both physical and transition risks. In disorderly scenarios, climate change policies are delayed or divergent between countries and regions, resulting in substantial transition risks. Finally, in the hot house world, global efforts are insufficient, perhaps despite national or regional policies, causing severe and irreversible physical risks and events. These scenarios are explored with granularity and level of detail improving in each iteration. One of its observations is that, although transition risks (e.g. from eliminating greenhouse gas emissions) may be substantial, they appear to be far less impactful than physical risks emerging from both the acute impact (e.g. extreme weather events) and the chronical impact (e.g. rising sea levels)

50 Network for Greening the Financial System (fn. 48), p. 2.

51 Network for Greening the Financial System (fn. 48), p. 2.

52 Network for Greening the Financial System (fn. 48), p. 2–3.

53 Network for Greening the Financial System, Workstream 'Supervision' Mandate – April 2022/April 2024 (https://www.ngfs.net/sites/default/files/workstream_supervision_mandate.pdf, last accessed 27 January 2023).

54 See also: Network for the Greening of the Financial System, Guide for Supervisors – Integrating climate-related risks into prudential supervision, May 2020 (https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_for_supervisors.pdf, last accessed 27 January 2023).

55 Network for Greening the Financial System, NGFS Climate Scenarios for central banks and supervisors, June 2021 (https://www.ngfs.net/sites/default/files/media/2021/08/27/ngfs_climate_scenarios_phase2_june2021.pdf, last accessed 27 January 2023); and Network for Greening the Financial System, NGFS Climate Scenarios for central banks and supervisors, September 2022 (https://www.ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_for_central_banks_and_supervisors_.pdf.pdf, last accessed 27 January 2023).

56 Network for Greening the Financial System (fn. 55), p. 7.

due to climate change.⁵⁷ These different scenarios will not only provide insights for policy makers, but should be used as input by (financial) firms to examine the potential impact and as a risk management tool.⁵⁸

III. The Basel Committee on Banking Supervision

One of the most important international bodies setting out prudential regulation and risk management expectations for the banking sector is the Basel Committee on Banking Supervision (BCBS), mentioned earlier in the context of systemic risks generally. The BCBS is best known for its frameworks for the prudential requirements for banks, known as the Basel Accords, including for example Basel I in 1988⁵⁹, Basel II in 2004⁶⁰ and Basel III in 2011 following the GFC.⁶¹ The BCBS has also drawn up high level principles on corporate governance at banks⁶². Recently, the BCBS has adopted a similar approach of setting out high level principles on the effective management and supervision of climate-related financial risks.⁶³ These principles have been drafted by BCBS' Task Force on Climate Related Financial Risk (TCFR), which commenced their work in 2020. Before drafting any principles, the TCFR did a stock take⁶⁴ and set out the preliminary analytical groundwork culminating in two separate

57 Network for Greening the Financial System (fn. 55), p. 7–14.

58 Network for Greening the Financial System (fn. 55), p. 42.

59 Basel Committee on Banking Supervision, International Convergence of Capital Measurement and Capital Standards, July 1988 (<http://www.bis.org/publ/bcbs04a.pdf>, last accessed 27 January 2023).

60 Basel Committee on Banking Supervision, International Convergence of Capital Measurement and Capital Standards: a Revised Framework, June 2004 (<http://www.bis.org/publ/bcbs107.pdf>, last accessed 27 January 2023).

61 Basel Committee on Banking Supervision, Basel III: A Global Regulatory Framework for More Resilient Banks and Banking System, June 2011 (<http://www.bis.org/publ/bcbs189.pdf>, last accessed 27 January 2023); Basel Committee on Banking Supervision, Basel III: International Framework for Liquidity Risk Management, Standards and Monitoring, December 2011 (<http://www.bis.org/publ/bcbs188.pdf>, last accessed 27 January 2023).

62 Basel Committee on Banking Supervision, Corporate Governance Principles for Banks, July 2015 (<https://www.bis.org/bcbs/publ/d328.pdf>, last accessed 27 January 2023).

63 Basel Committee on Banking Supervision, Principles for the Effective Management and Supervision of Climate-Related Financial Risks, June 2022 (<https://www.bis.org/bcbs/publ/d532.pdf>, last accessed 27 January 2023).

64 Basel Committee on Banking Supervision, Climate-related financial risks: a survey on current initiatives, April 2020 (<https://www.bis.org/bcbs/publ/d502.pdf>, last accessed 27 January 2023).

reports: ‘Climate-related risk drivers and their transmission channels’,⁶⁵ and ‘Climate-related financial risks – measurement methodologies’.⁶⁶

The first report on climate-related risk drivers ‘explores how climate-related financial risks can arise and impact both banks and the banking system’.⁶⁷ Two distinct types of risk drivers are identified: first, costs and losses resulting from physical climate risk drivers, such as floods or heatwaves. Second, transition risk drivers related to the reduction in green house gas emissions, such as net zero policies or a shift towards electric cars – which may result in losses from stranded assets and early write downs. Although these climate drivers may affect all risk categories identified in the Basel Accords, credit risk is particularly likely to be increased (both household as well as corporate and sovereign), and to a lesser extent market risk (e.g. asset valuation).

The second report ‘provides an overview of conceptual issues related to climate-related financial risk measurement and methodologies, as well as practical implementation by banks and supervisors’.⁶⁸ In order to identify strengths and weakness in such measurement and methodologies, the TCFR tried to identify a series of issues upfront, including in relation to forward looking technologies, and tested these against methodologies and measurements already developed by various banks and supervisors. The report presents several key findings, for example, at present most focus by far has been on credit risk modelling, and far less on e.g. liquidity, operational, or reputational risk. It should also be noted that the TCFR indicates many banks use NGFS scenarios.

These reports resulted in the adoption of the aforementioned ‘high level principles on the effective management and supervision of climate-related financial risks’.⁶⁹ The TCFR notes that although the existing principles would have been broad enough to cover this field as well, it was considered helpful to draft specific principles: eighteen in total. Twelve of those are intended to provide guidance to banks on effective management of climate-related risk, the remaining six are to provide guidance to supervisory authorities. Quite a few of these relate to the internal governance and controls of the bank, which will be revisited later in this paper.

65 Basel Committee on Banking Supervision, Climate-related risk drivers and their transmission channels, April 2021 (<https://www.bis.org/bcbs/publ/d517.pdf>, last accessed 27 January 2023).

66 Basel Committee on Banking Supervision, Climate-related financial risks – measurement methodologies, April 2021 (<https://www.bis.org/bcbs/publ/d518.pdf>, last accessed 27 January 2023).

67 Basel Committee on Banking Supervision (fn. 65), p. 1.

68 Basel Committee on Banking Supervision (fn. 66), p. 1.

69 Basel Committee on Banking Supervision (fn. 63).

D. Implementation by Central Banks

I. Bank of England Stress Testing

The initiatives taken by international organizations, as described in the previous section, are implemented in practice nationally. The Bank of England is the United Kingdom's (UK) central bank and it is a member of the FSB, the NGFS, and the BCBS. The Bank of England has taken a two-pronged approach to financial risks emerging from climate change: it is engaging actively with banks directly on current risks, and it is seeking to enhance the resilience of the financial system in light of the transition.⁷⁰ With regard to the latter, the Bank of England published a discussion paper in 2019 setting out its views on the Biennial Exploratory Scenario (BES) for climate change.⁷¹ It would complement the stress testing performed annually by the UK banks, with a focus on climate change and transition risk. In particular, the BES would seek to gain insight into: the banks' exposure; the impact on the banks' business models; and risk management of the climate-related financial risks. The assertion was that over seventy percent of the banks' capital was allocated to loans towards fossil fuel and related industries, prompting serious concerns for the longer term.

The scenarios presented in the BES are closely aligned with the international initiatives. The first part of the BES consists of testing the banks' business model over a period of thirty years for three different scenarios. These scenarios are those designed by the NGFS as discussed previously: early policy action; 10-year delayed policy action (late policy action); and no policy action. The Bank of England provides data input for each scenario, which banks have to adapt to their own situation and balance sheet. The second part of the BES consists of banks setting out mitigating actions. The results of the 2021 BES⁷²

70 *Matthew Scott/Julia van Huizen/Carsten Jung*, "The Bank's Response to Climate Change", Bank of England Quarterly Bulletin, June 2017 (<https://ssrn.com/abstract=3004461>, last accessed 27 January 2023).

71 Bank of England, The 2021 biennial exploratory scenario on the financial risks from climate change – discussion paper, Dec 2019 (<https://www.bankofengland.co.uk/-/media/boe/files/paper/2019/the-2021-biennial-exploratory-scenario-on-the-financial-risks-from-climate-change.pdf>, last accessed 27 January 2023).

72 Bank of England, Bank of England publishes results of the 2021 Biennial Exploratory Scenario: Financial risks from climate change, May 2022 (<https://www.bankofengland.co.uk/news/2022/may/boe-publishes-results-of-the-2021-biennial-exploratory-scenario-financial-risks-from-climate-change>, last accessed 27 January 2023); and Bank of England, Results of the 2021 Climate Biennial Exploratory Scenario (CBES), May 2022 (<https://www.bankofengland.co.uk/stress-testing/2022/results-of-the-2021-climate-biennial-exploratory-scenario>, last accessed 27 January 2023).

were perhaps not surprising: although progress is made, banks still have a lot of work to do to address their climate change risks. Whilst costs appear to be manageable, they become substantially higher in late or no policy scenarios.⁷³ Any need for change in capital requirements, i.e. additions to deal with climate change risks, is currently being assessed and consulted.⁷⁴

II. European Central Bank Stress Testing

Within the Eurozone, the European Central Bank (ECB) is taking a variety of initiatives in relation to climate change. In its monetary policy role, the ECB investigates the macroeconomic impacts of climate change, including potential shocks, as well as related policies aimed at climate risk mitigation and adaptation.⁷⁵ In particular, any potential impact on interest rate- and other monetary policies is considered. Within the context of this paper, and following international initiatives discussed previously, the ECB carried out a climate change stress test as part of its annual stress testing program.⁷⁶ Climate risk transparency and disclosure has in fact become a supervisory priority in its supervisory agenda for 2022–2024.⁷⁷ The ECB places the tests very much within the wider supervisory expectations.⁷⁸

73 Bank of England, Climate capital – speech by Sam Woods, May 2022 (<https://www.bankofengland.co.uk/speech/2022/may/sam-woods-speech-on-the-results-of-the-climate-bes-exercise-on-financial-risks-from-climate-change>, last accessed 27 January 2023).

74 Bank of England, Climate and capital conference, October 2022 (<https://www.bankofengland.co.uk/events/2022/october/climate-and-capital-conference>, last accessed 27 January 2023).

75 European Central Bank, Climate change and monetary policy in the euro area, September 2021 (<https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op271~36775d43c8.en.pdf>, last accessed 27 January 2023).

76 European Central Bank, 2022 Climate Risk Stress Tests, July 2022 (https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.climate_stress_test_report-20220708~2e3cc0999f.en.pdf, last accessed 27 January 2023).

77 European Central Bank, Supervisory assessment of institutions' climate-related and environmental risks disclosures ECB report on banks' progress towards transparent disclosure of their climate-related and environmental risk profiles, March 2022 (https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.ECB_Report_on_climate_and_environmental_disclosures_202203~4ae33f2a70.en.pdf, last accessed 27 January 2023).

78 European Central Bank, Guide on climate-related and environmental risks Supervisory expectations relating to risk management and disclosure, Nov 2020 (<https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202011finalguideonclimate-relatedandenvironmentalrisks~58213f6564.en.pdf>, last accessed 27 January 2023).

The scenarios and results of the ECB's stress tests are not too dissimilar to those carried out by the Bank of England: in short, progress has been made, but much work remains to be done, revealing deficiencies, data-gaps, and inconsistencies between banks.⁷⁹ Nearly two thirds of the interest income for banks comes from greenhouse-gas emitting industries, which creates a significant dependency for the banks on the transition plans of their customers. Moreover, banks are directly exposed to acute physical risk, such as drought, heat, and floods, depending on the geographical location of their lending activities. As a result, the scenarios with early policy action leads to less losses than those with delayed or no action.

The ECB is not alone in the EU in examining the impact of climate change on banks' resilience, as various national central banks such as the Dutch Central Bank (DNB) and Banque de France are taking action as well. The DNB has set out its expectations on integrating climate change risks into the banks' risk management and governance.⁸⁰ This includes developing climate change scenarios, which may include a flood stress scenario in certain areas of the Netherlands or transition risks in sectors linked to fossil fuel.⁸¹ Likewise the Banque de France conducted climate stress tests in 2020 as a pilot exercise.⁸² In summary, it showed that although the financial impact on French banks from transition risks, such as migration from fossil fuels is limited, the potential losses from physical risks are far from negligible. In particular drought and flooding, as well as the increasing risks of cyclones in French overseas territories are significant. Outside the Eurozone, the Danish Central Bank for example has been an early adopter of climate change stress tests: in 2020, it published the results of climate change stress test highlighting the transition risks (only) in the banking sector.⁸³ Although the results showed the sector is generally well-positioned, problems are likely to arise in case of a more drastic transition rather than a gradual one.

79 European Central Bank (fn. 76), p. 5.

80 De Nederlandsche Bank, Good Practice: Integration of Climate-related Risk Considerations into Banks' Risk Management, November 2019 (<https://www.dnb.nl/media/a4gdcovq/consultation-document-good-practice-integration-of-climate-related-risk-considerations-into-banks-risk-management-nov-2019.pdf>, last accessed 27 January 2023).

81 De Nederlandsche Bank (fn. 80), p. 11.

82 Banque de France, A first assessment of financial risks stemming from climate change: The main results of the 2020 climate pilot exercise (https://acpr.banque-france.fr/sites/default/files/medias/documents/20210602_as_exercice_pilote_english.pdf, last accessed 27 January 2023).

83 Danmarks Nationalbank, A gradual green transition supports financial stability (<https://www.nationalbanken.dk/media/2hbdoyht/analysis-no21-a-gradual-green-transition-supports-financial-stability.pdf>, last accessed 3 November 2023), 2020.

III. US Federal Reserve Stress Testing

The main actor in the US as regards the implementation of climate change stress testing is the Federal Reserve. This is based on the Dodd Frank Act, which was enacted following the Global Financial Crisis.⁸⁴ It includes enhanced supervision and prudential standards for non-bank financial companies supervised by the board of governors and bank holdings above a certain threshold. In Section 165 (a)(1) it states as purpose: ‘to prevent or mitigate risks to the financial stability of the United States that could arise from the material financial distress or failure, or ongoing activities, of large, interconnected financial institutions’. It further provides the Federal Reserve with the mandate to conduct stress tests to engage with systemic risk in the financial sector. For example, the Federal Reserve prescribes a series of Supervisory Severely Adverse Scenarios (SSAS), for example in 2022 a severe global recession and heightened stress in real estate and corporate debt markets.⁸⁵

In September 2022, the Federal Reserve announced that six of the largest banks would participate in a pilot climate scenario analysis exercise.⁸⁶ It is said to be for information gathering at the moment, exploratory in nature and for the moment it will not impact capital requirements. In January 2023, the Federal Reserve provided further detail on these scenarios: for example, one such forward-looking scenario explores the impact of a major hurricane in the North-east region of the US, together with associated floodings and storm surges, on residential and commercial real estate.⁸⁷ An earlier report by New York Federal

84 Dodd-Frank Wall Street Reform and Consumer Protection Act, Public Law 111–203 — 21 July 2010 (<https://www.govinfo.gov/content/pkg/PLAW-111publ203/pdf/PLAW-111publ203.pdf>, last accessed 27 January 2023).

85 Board of Governors of the Federal Reserve System, 2022 Stress Test Scenarios, February 2022 (<https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20220210a1.pdf>, last accessed 27 January 2023).

86 Board of Governors of the Federal Reserve System, Federal Reserve Board announces that six of the nation’s largest banks will participate in a pilot climate scenario analysis exercise designed to enhance the ability of supervisors and firms to measure and manage climate-related financial risks, September 2022 (<https://www.federalreserve.gov/newsevents/pressreleases/other20220929a.htm>, last accessed 27 January 2023); and *Pete Schroeder*, “Fed to kick off climate scenario analysis in 2023 with six large banks”, Reuters, September 2022 (<https://www.reuters.com/business/sustainable-business/fed-kick-off-climate-scenario-analysis-2023-with-six-large-banks-2022-09-29/>, last accessed 27 January 2023); and *David Clarke*, “Powell Confirms Climate Stress Tests on the Way”, Green Central Banking, November 2022 (<https://greencentralbanking.com/2022/01/12/powell-climate-stress-tests/>, last accessed 27 January 2023).

87 Board of Governors of the Federal Reserve System, Pilot Climate Scenario Analysis Exercise Participant Instructions, January 2023 (<https://www.federalreserve.gov/public/>

Reserve gives some indication of where regulatory policy might be heading: the study finds that climate transition risks materialising by way of a collapse in fossil fuel prices may result in capital shortfalls.⁸⁸ Note that this work by the US Federal Reserve and New York Federal Reserve is supported by other regulatory initiatives. For example, the US Securities and Exchange Commission (SEC), as highlighted previously, is looking to increase significantly the scope of standardized climate-related disclosures for publicly traded companies.

E. First Observations

I. Data

Data remains a key element for any progress on integrating climate-related risks into risk management or business decisions, including conducting stress tests. In particular, availability and usability are the first crucial elements, including identifying exactly which data is needed and obtaining access to it.⁸⁹ How comprehensive and standardized is climate change data at the moment, and what could be improved? As the FSB progress report states, IOSCO support for ISSB disclosure standards could assist towards further improvement in uniform reporting standards.⁹⁰ Assurance of reporting data by the International Auditing and Assurance Standards Board (IAASB) and by the International Ethics Standards Board for Accountants (IESBA) may also provide improvements.⁹¹ Furthermore, any improvements on the availability and accessibility of the data would be welcome, for example through repositories with open access to the data.⁹² In Europe, for example, the European Single Access Point (ESAP) initiative could assist by creating one place where data is readily available.

cations/files/csa-instructions-20230117.pdf, last accessed 6 November 2023), p. 13 discussing a major hurricane.

88 *Hyeyoon Jung/Robert Engle/Richard Berner*, Climate Stress Testing – Federal Reserve Bank of New York Staff Reports no. 977, June 2022 (https://www.newyorkfed.org/medialibrary/media/research/staff_reports/sr977.pdf, last accessed 27 January 2023); and: Reuters, New York Fed researchers develop climate stress test for banks, 24 September 2021 (<https://www.reuters.com/business/sustainable-business/new-york-fed-researchers-develop-climate-stress-test-banks-2021-09-24/>, last accessed 27 January 2023).

89 Center for Climate Aligned Finance, Identification, Access, and Use of Transition-Relevant Data and Metrics, September 2022 (https://climatealignment.org/wp-content/uploads/dlm_uploads/2022/09/finance_transition_data_insight_brief.pdf, last accessed 27 January 2023).

90 Financial Stability Board (fn. 31), p. 5.

91 Financial Stability Board (fn. 31), p. 6.

92 Financial Stability Board (fn. 31), p. 7.

That said, the data position is likely to improve further. The EU Green Deal, in order to redirect the flow of investments, includes various legislative initiatives aimed at disclosure of green credentials, generating much more insights into the non-financial side of companies.⁹³ These regulatory initiatives include, for example, the Corporate Sustainability Reporting Directive (CSRD) requiring larger companies to disclose non-financial information relating to social and environmental performance,⁹⁴ and the Taxonomy Regulation classifying what is sustainable.⁹⁵ The UK has a similar framework in place which requires companies to disclose climate-related financial information, which may serve to inform those making investment decisions.⁹⁶ The US Securities and Exchange Commission (SEC) is currently setting out its expectations on climate-related disclosures.⁹⁷ In other words, in the not too distant future this side of the input data will be improving, hopefully benefitting from aforementioned improvements on assurance, availability, and accessibility.

Whilst there are various policy initiatives underway to improve non-financial reporting specifically to address this, one may never have an ideal and complete data position. Perhaps the real question ought to be how much of a hindrance the lack of data is at the moment for the purpose of conducting stress tests or performing scenario analysis. One could argue that any commercial decisions taken may also be based on imperfect or incomplete information: lending-, business- and other investment decisions are based on incomplete- or mod-

93 *Ohnesorge/Rogge* (fn. 36); *Trude Myklebust*, “Climate-related financial risks: considering an emerging framework for assessment and disclosure in a regulatory perspective”, *European Business Law Review* 33 (2022), 443.

94 Proposal for a Directive of the European Parliament and of the Council amending Directive 2013/34/EU, Directive 2004/109/EC, Directive 2006/43/EC and Regulation (EU) No 537/2014, as regards corporate sustainability reporting, COM(2021) 189 final.

95 Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088.

96 The Companies (Strategic Report) (Climate-related Financial Disclosure) Regulations 2022; and The Limited Liability Partnerships (Climate-related Financial Disclosure) Regulations 2022; and Department for Business, Energy & Industrial Strategy, Mandatory climate-related financial disclosures by publicly quoted companies, large private companies and LLPs – Non-binding guidance, February 2022 (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1056085/mandatory-climate-related-financial-disclosures-publicly-quoted-private-cos-llps.pdf), last accessed 27 January 2023).

97 Federal Register, The Enhancement and Standardization of Climate-Related Disclosures for Investors: a Proposed Rule by the Securities and Exchange Commission, 4 November 2022 (<https://www.federalregister.gov/documents/2022/04/11/2022-06342/the-enhancement-and-standardization-of-climate-related-disclosures-for-investors>), last accessed 27 January 2023).

elled data and by their very nature are not risk-free. Another argument, however, might be that not only is climate-related data less developed than (other) financial data, there is substantially less historical data and experience with crystalized risks and losses. Whilst credit losses, for example, are frequently experienced, well understood and modelled, realization of climate change risks are less well understood and require more assumptions and judgement calls. Of course, these arguments lead back to its current purpose: conducting of stress tests and performing scenario analysis, not to make forecasts, but to explore the potential impact under severe but plausible future circumstances. And for that purpose, it may well be possible to start forming a good picture of the possible impacts of climate change-related financial risks.

II. Design

Data, however, is only the input to the models used to conduct stress tests and simulate scenarios. This remains valid, even if the scenarios are not intended to be forecasts, but merely plausible yet stressful potential future outcomes. The Federal Reserve identified various challenges specifically in modelling and assessing climate-related financial stability risks.⁹⁸ These include: 1) taking into account uncertainty associated with the modelling of the climate system; 2) adapting to time horizons significantly longer than the usual five year horizon; 3) embedding homogeneity, i.e. the differences in portfolio and exposure for each market participant; 4) incorporating technological change, both those resulting in stranded assets and those needed for mitigation and transition; and 5) modeling the damage or impact to the economy due to tangible and intangible effects from climate change on e.g. labour market, welfare, etc.⁹⁹ The suggestion is that, at least so far, there simply is no modelling approach capable of dealing sufficiently with all of these challenges simultaneously. Running a combination of various distinct sets of models may provide relief and insights into the risks associated with the choice of model.

One could also apply lessons learned from modelling other systemic risks. Based on observations during the Covid period, it has been suggested that there are generic shortcomings in the stress tests and scenarios used by the Federal Reserve: the Covid related tests are said to have been ‘tailored’ for Wall

98 Celso Brunetti/John Caramichael/Matteo Crosignani/Benjamin Dennis/Gurubala Kotta/Don Morgan/Chaehee Shin/Ilknur Zer, “Climate-related Financial Stability Risks for the United States: Methods and Applications,” Finance and Economics Discussion Series 2022-043 (<https://www.federalreserve.gov/econres/feds/files/2022043pap.pdf>, last accessed 27 January 2023), 2022.

99 Brunetti/Caramichael et al. (fn. 98), p. 3, 8–9.

Street firms.¹⁰⁰ In other words, the tests were said to be designed to fit the risk- and capital profile of the major banks, therefore showing only a limited impact. Such a ‘tailoring’ to suit existing risk- and capital profiles would effectively amount to a form of regulatory capture, whilst a more precautionary approach might be needed instead: objectively designed scenarios may have yielded a more severe impact. These observations should of course be kept in mind when designing climate related stress tests.

A preliminary response might be to make a comparison between authorities.¹⁰¹ Despite most of the tests being based on the NGFS scenarios, differences between authorities remain and further harmonisation of regulatory practices is possible. For example, as transition risks and physical risks are usually modelled separately and covered by different scenarios, some central banks use either rather than both.¹⁰² Whilst the impact of climate change may vary regionally, some form of harmonization and uniformity in assessing both transition risks and physical risks may be desirable from both a financial stability and a regulatory arbitrage point of view.

III. Objective and Mandate

Over the last few years, central banks have become increasingly active in the climate change debate, which the stress tests discussed in this paper are just a part of. This has led to a debate on the central banks’ objectives as well as the scope of their mandates. For example, various academics have examined the ECB’s legal mandate relating to climate change. The broad conclusion appears to be that the ECB has a mandate with a primary objective of price stability, yet as secondary objective it should support economic policies of the EU.¹⁰³ The question arises to what extent at least some of these economic policies, which the ECB is supposed to support explicitly as part of its secondary mandate, are

100 Graham S. Steele, “The Tailors of Wall Street”, University of Colorado Law Review 93 (2022), 993.

101 Patrizia Baudino/Jean-Philippe Svoronos, Stress-testing banks for climate change – a comparison of practices, FSI Insights on policy implementation No 34, July 2021 (<https://www.bis.org/fsi/publ/insights34.pdf>, last accessed 27 January 2023).

102 Baudino/Svoronos (fn. 101), p. 12.

103 Kern Alexander, “Reconciling lopsided mandates, secondary objectives and the importance of sustainability: the role of the European Central Bank in the Single Supervisory Mechanism”, European Business Law Review 33 (2022), 331; and Michael Ioannidis/Sarah Jane Hlášková Murphy/Chiara Zilioli, “The mandate of the ECB Legal considerations in the ECB’s monetary policy strategy review”, ECB Occasional Paper Series No 276, September 2021 (<https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op276~3c53a6755d.en.pdf>, last accessed 27 January 2023).

already implicit in its first mandate. In the current context, sustainability and environmental protection may be regarded as a precondition for financial stability. This view has been supported by other central banks in Europa, such as the Deutsche Bundesbank, viewing price- and financial stability as a precondition for integrating any climate change related factors.¹⁰⁴ The Banque de France presents similar arguments.¹⁰⁵ However, some commentators suggest that, as the mandate arises from the ECB's secondary objectives, the ECB cannot go as far as designing its own environmental policies.¹⁰⁶ However, neither interpretation of the legal mandate or conclusion appears to impede the legitimacy of conducting climate change-related stress tests, which is of course the central theme of this paper.

The policy debate on the reach of central banks is not limited to Europe: in the US, the Federal Reserve is under similar scrutiny. Some commentators suggest that the Federal Reserve has done less in combating climate change than its European counterparts because it has a more limited legal mandate.¹⁰⁷ Others have suggested, however, that financing of carbon-intensive industry and fossil fuels carries significant financial stability risks relating to climate change: it causes systemic risks which clearly falls under the mandate of e.g. the Federal Reserve and which highlights the need for macro prudential regulation.¹⁰⁸ There is resistance from the banking lobby against this approach: they argue that the Federal Reserve is overstretching, questioning whether there really is significant financial risk for large banks.¹⁰⁹ Although admitting that it might be useful to conduct further studies, their main concern is that it would result in high capital requirements, thereby of course increasing the costs of doing business.

104 *Claudia M. Buch/Benjamin Weigert*, Climate Change and Financial Stability: Contributions to the Debate, July 2021 (<https://www.bundesbank.de/resource/blob/869058/f33e5c6b7081fe801dc663205f7fccc9/mL/paper-buch-weigert-data.pdf>, last accessed 27 January 2023).

105 *François Villeroy de Galhau*, Climate change: central banks are taking action, in: Banque de France, Financial Stability Review, June 2019 (https://entreprises.banque-france.fr/sites/default/files/media/2019/08/27/financial_stability_review_23.pdf, last accessed 27 January 2023), p. 8.

106 *Chiara Zilioli/Michael Ioannidis*, "Climate change and the mandate of the ECB: potential and limits of monetary contribution to European green policies", *Common Market Law Review* 59 (2022), 363.

107 *Christina Parajon Skinner*, "Central Banks and Climate Change", *Vanderbilt Law Review* 74 (2021), 1301.

108 *Steele* (fn. 4).

109 *Bill Nelson/Lauren Anderson*, "Is Climate Really a Financial Stability Risk or Solvency Risk for Large Banks?", Bank Policy Institute, September 2022 (<https://bpi.com/is-climate-really-a-financial-stability-risk-or-solvency-risk-for-large-banks/>, last accessed 27 January 2023).

There have even been more innovative suggestions for the Federal Reserve to combat climate change through the financial system, such as requiring disclosure of financed emissions and by creating climate bad banks, which could support businesses negatively impacted by climate change.¹¹⁰ Commentators arguing the other side have suggested US Congress must not and cannot delegate its authority to tackle climate change to administrative agencies.¹¹¹ Their argument is in essence that it is up to the lawmakers alone to design climate change policy and to set priorities. The Chair of the Federal Reserve, Mr. Powell, recognized this by stating the Federal Reserve will not become a ‘Climate Policymaker’, settling the debate for now.¹¹² Taken into consideration the views expressed in a letter by policymakers to the Federal Reserve, it appears that it may become increasingly difficult for the Federal Reserve to engage with climate-related financial risks due to political pressure and constraints, even when it is through stress testing and risk management within the financial sector.¹¹³

F. Integration in the Prudential Framework

Much of the above is currently work in progress, and whilst it will support ongoing work, a more consequential response to the question what to do with the initial outcomes is desirable. Keeping in mind the debate on central banks’ mandate, one could ask the question what further financial regulatory policy responses are desirable? In particular it draws out the question of how the results of the climate change-related stress tests should be used to improve the wider prudential framework?¹¹⁴ A first response could be to integrate the monitoring and managing of these risks further into the internal governance and decision-making process at banks. Regulatory pressure might encourage

110 *Bryan Hamerschlag*, “A ‘Green New Fed’: How the Federal Reserve’s Existing Legal Powers Could Allow It to Take Action on Climate Change”, *Texas Law Review* 100 (2022), 577.

111 *Mark Nevitt*, “Delegating Climate Authorities”, *Yale Journal on Regulation* 39 (2022), 778.

112 *Colby Smith/Delphine Strauss*, “Fed will not become a ‘climate policymaker’, says Jay Powell”, *Financial Times*, 10 January 2023 (<https://www.ft.com/content/6abb5562-59a0-49a7-8cc0-8fb48e5d6fe9>, last accessed 27 January 2023).

113 Letter from Congress to Jerome Powell, 9 December 2020 (<https://www.politico.com/f/?id=00000176-4cfb-d52c-ad7e-dcff3d220000>, last accessed 27 January 2023), 2022.

114 See also e.g. *Seraina Grunewald*, “Climate Change as a Systemic Risk – Are Macroprudential Authorities up to the Task?”, *European Banking Institute Working Paper Series* – no. 62, April 2020 (<https://ssrn.com/abstract=3580222>, last accessed 27 January 2023).

this integration: the FSB progress report suggests more regular monitoring as well as the embedding of monitoring in risk management and prudential regulatory frameworks.¹¹⁵ Indeed, developing the framework for assessing the impact may just be a first step, which could be followed by developing enhanced risk measures as part of the financial regulatory framework.¹¹⁶ Both the NGFS and the BCBS TCFR, as discussed earlier, support the idea of further integration of climate risk in the banks' governance and risk management process.¹¹⁷ The ECB suggests banks lack real long-term planning on climate change and integration into risk management is at early stage.¹¹⁸ The Bank of England suggests firms must gain greater insight in their climate risks.¹¹⁹ Those banks that have already started doing so are gaining new insights into the effects of climate change on their operations: for example banks have started to realize that mitigating options might not be available, or less attractive, if the whole sector makes similar attempts at the same time.¹²⁰ Another example presented by the Bank of England is that banks find that simultaneously seeking finance from elsewhere, or withdrawing some lending activities (causing increased number of insolvencies), results in increased market pressures. Likewise, problems appear when everyone turns towards green assets at the same time. Moreover, the Bank of England suggests climate policies must be aligned, e.g. transition in actual move from fossil fuels towards renewables must coincide with shift in financing, otherwise it will create even more issues in the financial system.¹²¹

This approach would start to treat climate change as part of the common risk framework used within banks.¹²² Integrating financial risks relating to climate change in the existing risk framework appears a logical step to take. In fact, some commentators argue that the whole ESG movement should be nothing more than including all relevant and import factor into long-term business decision making.¹²³ The approach of integrating climate risk into the existing gov-

115 Financial Stability Board (fn. 31), p. 9-11.

116 *Emanuele Campiglio/Yannis Dafermos/Pierre Monnin/Josh Ryan-Collins/Guido Schotten/Misa Tanaka*, "Climate change challenges for central banks and financial regulators", *Nature Climate Change* 8 (2018), 462.

117 Network for the Greening of the Financial System (fn. 54); and Basel Committee on Banking Supervision (fn. 63).

118 European Central Bank (fn. 77), p. 19-21.

119 Bank of England (fn. 72), para 6.2.

120 Bank of England (fn. 72), Box E.

121 Bank of England (fn. 72), section 6.

122 *Sarah E. Light/Christina P. Skinner*, "Banks and Climate Governance", *Columbia Law Review* 121 (2021), 1895.

123 *Alex Edmans*, "The End of ESG", *Financial Management* 2022, 1.

ernance structures seems to be in line with that. Challenges for integration, however, remain.¹²⁴

A second policy response could be to consider whether these risks should lead to a revision of the current capital adequacy framework, in particular whether these risks should be included explicitly into the calculation of the minimum amount of capital banks are required to hold. Alternatively, one could consider whether these risks are included sufficiently though implicitly within other categories, notably in credit risk calculations. Some commentators propose quite extensive ‘green micro- and macro prudential regulation’.¹²⁵ Others even propose to extend the current framework to include preventative regulatory actions.¹²⁶ As a first observation, it would seem odd to achieve climate change objectives, i.e. to stimulate moving away from greenhouse gas emissions, by way of capital requirements. It would be more efficient to regulate emissions directly rather than indirectly, and capital requirements cannot be the main solution to achieving climate change neutrality.¹²⁷ Moreover, climate change-related financial risks could already be included implicitly in existing risk weighting of assets, in particular through credit risk.¹²⁸ Many other identifiable risks are not included explicitly, but are included this way. If one were to adjust risk weightings for climate change, one ends up with an odd choice on how to make these adjustments. Assuming one could reach a clear agreement on what constitutes green and brown assets, the first option is to stimulate green investments by lowering the risk weightings on green assets. However, this may no longer adequately reflect their risks, leading in itself to a large degree of undercapitalization for all banks holding green assets. The alternative is to increase

124 See generally, *Clara I. Gonzalez/Soledad Nunez*, “Markets, Financial Institutions and Central Banks in the Face of Climate Change: Challenges and Opportunities”, Banco de Espana Occasional Paper No. 2126, October 2021 (<https://ssrn.com/abstract=3949560>, last accessed 27 January 2023).

125 *Simon Dikau/Ulrich Volz*, “Central Banking, Climate Change and Green Finance”, ADBI Working Paper 867 (<https://www.adb.org/sites/default/files/publication/452676/adbi-wp867.pdf>, last accessed 27 January 2023), 2018; *Agnieszka Smoleńska/Jens van ‘t Klooster*, “A Risky Bet: Climate Change and the EU’s Microprudential Framework for Banks”, *Journal of Financial Regulation* 8 (2022), 51.

126 *Veerle Heyvaert*, “Governing Intersystemic Systemic Risks: Lessons from Covid and Climate Change”, *The Modern Law Review* 85 (2022), 938.

127 See e.g. *Fernando Restoy*, “The role of prudential policy in addressing climate change”, Suerf Policy Brief No. 213, Nov 2021 (https://www.suerf.org/docx/f_710eec06bc39ec7c6bd28ddf5f3a5668_35367_suerf.pdf, last accessed 27 January 2023).

128 *Maria J. Nieto*, “Banks, climate risk and financial stability”, *Journal of Financial Regulation and Compliance* 27 (2019), 243.

risk weights for not-green (or brown) assets.¹²⁹ Whilst this in itself may reflect the results of the stress tests, the question remains whether this adjustment should be an explicit and separate risk, or whether it is simply one of the factors determining credit risk.

The Bank of England suggests capital requirements are not a tool suited for addressing underlying causes of climate change.¹³⁰ It is less effective than immediate policy interventions aimed at cutting greenhouse gas emissions. It could have unintended consequences for the safe- and soundness of the financial system. Adjusting prudential (capital) requirements should only serve to increase resilience against financial losses emerging from climate change, however, measures to improve financial stability may as a side effect contribute towards a reduction in greenhouse gas emission. In a recent brief by the Financial Stability Institute of the Bank for International Settlements (BIS) it is argued that, due to large uncertainty as to how climate-related financial risks may materialize, the ‘Pillar 1’ instruments (e.g. capital requirements) are less suited than the flexibility of ‘Pillar 2’ (e.g. through stress tests and scenario analysis) in the risk and governance framework.¹³¹ The ECB, through the Single Supervisory Mechanism (SSM), acts as a prudential supervisor for systemically important banks in the Eurozone. As part of European capital requirements and corresponding guidelines, this now includes e.g. ESG risks in the Supervisory Review and Evaluation Process (SREP).¹³² It has been argued more broadly that climate change risks already enter the existing supervisory framework for the European Supervisory Authorities, as it is a financial risk, without any change to existing legislation being required.¹³³

The above analysis has sought to argue in favour of including climate change-related financial risk as part of Pillar 2 (risk and governance) of the prudential framework, but is more cautious on inclusion in Pillar 1 (capital requirements). Capital requirements may cushion financial risks emerging from climate

129 Jay Cullen, “After ‘HLEG’: EU Banks, Climate Change Abatement and the Precautionary Principle”, *Cambridge Yearbook of European Legal Studies* 20 (2018), 61.

130 Bank of England (fn. 72), para 6.2.

131 Rodrigo Coelho/Fernando Restoy, “The regulatory response to climate risks: some challenges”, Financial Stability Institute, Bank for International Settlements (<https://www.bis.org/fsi/fsibriefs16.pdf>, last accessed 27 January 2023), 2022.

132 European Banking Authority, On the Management and Supervision of ESG Risks for Credit Institutions and Investment Firms EBA/REP/2021/18 (https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Reports/2021/1015656/EBA%20Report%20on%20ESG%20risks%20management%20and%20supervision.pdf, last accessed 27 January 2023).

133 Nathan de Arriba-Sellier, “Turning gold into green: green finance in the mandate of European financial supervision”, *Common Market Law Review* 58 (2021), 1097.

change, but perhaps are more appropriately considered a factor in existing risk weightings. It may open central banks to criticism of designing climate change policy, which in turn would be far less effective than direct government policy.¹³⁴ Instead, an increased focus on Pillar 2 might be more productive: the BES by the Bank of England, for example, has gone hand in hand with the supervisory expectations on improving regulated firms' managing of financial risks from climate change generally.¹³⁵ The Bank of England will follow up on the tests as part of the Pillar 2 SREP process.¹³⁶ In particular, a more strategic approach towards such risks is expected, including embedding these into the governance and risk management of the banks.

G. Conclusion

This paper has set out climate change related financial risks as a new category of systemic risk. The tools used to monitor and mitigate systemic risk, in particular stress testing and scenario analysis, are already being adapted to this new category. International organisations, most notably the ones organized by the NGFS, have developed scenarios which are being adopted by major central banks. The outcome of the first series of stress tests is similar: climate change related financial risks can be severe, in particular when no or limited policy initiatives are taken towards the reduction of greenhouse gasses. The risks associated with a transition towards a climate neutral economy should not be ignored, and neither should risks arising from climate events such as floodings or typhoons. There are various ways to integrate the outcomes of the stress tests within the prudential framework. First, a further integration of climate change risk within the internal governance, risk management, and business decision making processes at banks. Second, a possible explicit inclusion of climate change-related financial risks within the calculation of risks weights for capital requirements. The former seems preferable, whilst the latter less so, although perhaps it could be a supporting option.

134 *Martin Oehmke/Marcus M. Opp*, "Green Capital Requirements", Swedish House of Finance Research Paper No. 22–16 (<https://ssrn.com/abstract=4040098>, last accessed 27 January 2023), 2022.

135 *Bank of England*, Enhancing banks' and insurers' approaches to managing the financial risks from climate change – Supervisory Statement SS3/19, April 2019 (<https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/supervisory-statement/2019/ss319>, last accessed 27 January 2023).

136 Bank of England (fn. 72), para 6 and Box 5.