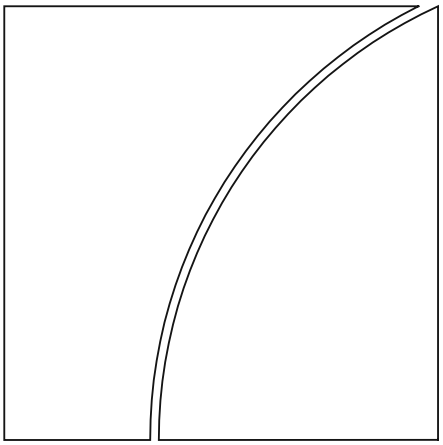
Financial Stability Institute

FSI Insights

on policy implementation

No 20



Turning up the heat – climate risk assessment in the insurance sector

by Patrick Cleary, William Harding, Jeremy McDaniels, Jean-Philippe Svoronos and Jeffery Yong

November 2019

JEL classification: D62, E58, E61, F42, G11, G18, G20, G22, G28, G32, Q28, Q54

Keywords: climate change, insurance supervision, risk management, sustainability

BANK FOR INTERNATIONAL SETTLEMENTS

FSI Insights are written by staff members of the Financial Stability Institute (FSI) of the Bank for International Settlements (BIS), often in collaboration with staff from supervisory agencies and central banks. The papers aim to contribute to international discussions on a range of contemporary regulatory and supervisory policy issues and implementation challenges faced by financial sector authorities. The views expressed in them are solely those of the authors and do not necessarily reflect those of the BIS or the Basel-based committees.

Authorised by the Chairman of the FSI, Fernando Restoy.

This publication is available on the BIS website (www.bis.org). To contact the BIS Media and Public Relations team, please email press@bis.org. You can sign up for email alerts at www.bis.org/emailalerts.htm.

ISSN 2522-2481 (print)
ISBN 978-92-9259-308-7 (print)

ISSN 2522-249X (online)
ISBN 978-92-9259-309-4 (online)

Contents

Turning up the heat – climate risk assessment in the insurance sector[1]

Executive summary

Climate risks[2] are recognised as a critical threat to society, with potentially adverse implications for financial stability and the viability of insurers. Climate change is under way, affecting the economy and posing material financial risks. The effects of weather-related natural catastrophes are being amplified by climate change, and are causing hundreds of billions of dollars[3] in economic losses worldwide. As the transition to a climate-resilient and low-carbon future gains momentum, technological innovations, market forces, policy frameworks and social sentiment create new risks and opportunities for corporates and financial institutions. Over the last few years, the impacts of climate change have become a growing concern of financial regulators and central banks worldwide, triggered partly by the Financial Stability Board Task Force on Climate-related Financial Disclosures and its recommendations.

Efforts have been made by insurance supervisors[4] and insurers in some jurisdictions to better understand climate risks but further efforts are needed to increase awareness. In the crowded regulatory and supervisory space, there is limited scope for focusing attention on new issues but climate risks need immediate action in order to limit or reverse the impact of some of the negative trends under way. It is incumbent on supervisors to put in place the necessary measures for insurers to address any significant risks that could adversely affect policyholders and financial stability. In previous financial crises, events once deemed implausible have materialised. Climate change poses the same threat.

Climate risks comprise at least three elements: physical risks, transition risks and liability risks. Physical risks arise from weather and climate-related events, for example rising sea levels due to melting ice caps. Transition risks arise as society adjusts to a low-carbon economy, including the risk that investments may lose value as a result, leading to so-called stranded assets. Liability risks relate to climate-related insurance claims under liability insurance policies and direct legal claims against insurers for failing to manage climate risks. Currently, in the surveyed jurisdictions, physical climate risk assessment is most advanced, followed by transition risk assessment. Assessing liability risk exposures is still at an early stage as there has been only limited litigation related to climate risks to date.

This paper covers climate risk assessment from both regulatory and supervisory perspectives. Based primarily on a survey of 18 insurance authorities, it describes the range of regulatory approaches that specify how insurers are expected to assess their climate risk exposures and techniques that supervisors can use to conduct their own assessment of climate risks. In most cases, supervisors rely on existing rules related to enterprise risk management (ERM) to express their expectations to insurers on how climate risk should be assessed, addressed and managed. Using tools such as stress testing and

[1] Patrick Cleary (Patrick.Cleary@bankofengland.co.uk), Bank of England, William Harding (William.Harding@apra.gov.au), Australian Prudential Regulation Authority, Jeremy McDaniels (Jeremy.mcdaniels@un.org), Sustainable Insurance Forum, Jean-Philippe Svoronos (Jean-Philippe.Svoronos@bis.org), Bank for International Settlements (BIS) and Jeffery Yong (Jeffery.Yong@bis.org), BIS. The authors are grateful to Patrizia Baudino, Denise Garcia Ocampo, Petr Jakubik and Kumar Jegarasasingam for their helpful comments, and Christina Paavola for her valuable support with this paper. The views expressed in this paper are those of the authors and not necessarily those of the BIS or the Basel-based standard setters.

[2] In this paper, the term "climate risks" is used to denote financial risks arising from climate change in the insurance sector in the broadest sense.

[3] See Munich Re (2019).

[4] In this paper, the terms "insurance supervisor" and "insurance regulator", and "supervisor" and "regulator" are used interchangeably.

scenario analysis, supervisors themselves can take steps to better understand how climate risk could impact the financial and solvency position of insurers as well as the financial system.

All insurance authorities that provided information for this paper see climate risks as being "reasonably foreseeable and relevant material risks", as stated in the Insurance Core Principles. By implication, these authorities would expect insurers to address climate risks in their ERM frameworks, mainly in terms of their manifestation in other risk categories. However, few authorities have set explicit requirements in this regard. One reason is that most authorities deem existing principles-based requirements to be sufficiently broad to apply to climate risks. For example, climate risks are implicitly covered under the European Union Solvency II framework, as insurers are expected to cover these risks in their ERM frameworks if deemed material. Moreover, flexibility and adaptability in the regulatory approach, rather than prescriptive requirements, are probably needed in fast-developing policy areas.

It is important for supervisors to clearly express their expectations on how insurers are expected to manage climate risks. Clear articulation of supervisory expectations will help insurers develop concrete responses. For example, almost all of the surveyed supervisors expect insurers to consider climate risks, if material, in their own risk and solvency assessments (ORSAs), even if no explicit regulatory requirements have been set.

Risk quantification techniques and models that explicitly cover climate risks are most advanced for physical risks but are still at an early stage for transition and liability risks even in the most developed jurisdictions. It is challenging for both supervisors and insurers to fully assess the impact of climate risks and consequently determine insurers' ability to honour their obligations to policyholders under adverse climate scenarios. Nevertheless, there are risk assessment tools such as stress testing and scenario analysis that can be used by insurers to improve their understanding of climate risk exposures as well as provide illustrative loss estimates. The models typically involve translating potential future climate outcomes (such as global average temperature rises) into stress factors, and applying those factors to financial statements or risk variables.

Undertaking climate risk modelling and the associated governance processes can facilitate helpful discussion on risk strategy within an insurer, which some may argue as being more important than the numerical results from the models. Given current uncertainties surrounding the modelling of future climate outcomes, models can be most useful in supporting discussions within insurers on their climate risk strategy and enhancing their understanding of the risks. Scenario outputs can still be useful, even if the results are subject to uncertainty. From a corporate governance perspective, most of the surveyed authorities expect corporate decision-making to be informed by climate risk reporting to the board, while recognising the limitations and assumptions underlying the risk assessment models. The results are also useful to insurers in meeting the growing demands to disclose their climate risk exposures.

Although few authorities currently undertake supervisory or system-wide stress tests that explicitly cover climate risk, supervisors appear to have a growing interest in including climate-related events in such exercises. Climate-related stress testing is at an early stage and faces many methodological and capacity challenges. Supervisors may need to liaise with experts such as climate specialists to develop appropriate stress tests, including time horizons that are relevant for different business lines. Supervisors can use generally available information and risk assessment techniques and tailor them to their specific market and geography. Despite the various challenges, supervisors are increasingly aware that they need to start this process early and improve steadily. It is likely that the early exercises will be far from perfect but the quality of outcomes should gradually improve with experience, advancements in risk modelling and better data.

Looking ahead, there is room to enhance international cooperation among insurance supervisors and other climate-related forums to improve understanding of climate risks and their potential impact on insurers, policyholders and financial stability. Such initiatives can build on the work done by the International Association of Insurance Supervisors (IAIS), the Sustainable Insurance Forum (SIF) and the Network for Greening the Financial System (NGFS). Addressing climate risks is an area

where there is willingness and openness both among supervisors and industry players to share experience and collaborate. There is a broad agreement that not enough is known about the nature of climate risks and that time is quickly running out. Nevertheless, the main point is to get insurers to build capacity while accepting that the first step will not be perfect. Supervisors can enhance their technical expertise by taking advantage of the capacity-building efforts offered by various international bodies.

Other key policy issues that require consideration relate to potential financial exclusion and the potential use of capital requirements to address climate risks. On financial exclusion, as insurers become more aware of their climate risk exposures and are better able to quantify the risks, they may end up raising premium rates or withdrawing cover from certain business lines or geographical areas. As regards capital, it is currently not obvious if additional requirements are the right tool to explicitly address climate risks. Currently, most of the surveyed supervisors do not use insurers' climate stress-testing or scenario analysis results when assessing the capital adequacy of insurance firms. These issues might benefit from further thought at the international level.

Section 1 – Introduction

1. **Climate risks pose significant threats to the economy and could adversely impact the viability of insurers and financial stability.** There are plausible climate scenarios in which insurers could end up with significant investment losses or significantly higher than expected insurance claims. Failure to prepare for these possibilities in time may turn out to be a costly and irretrievable mistake that could jeopardise firms' viability. Insurers and supervisors should consider taking concrete steps as soon as possible to better understand climate risks and what they can do to improve resilience against future climate possibilities.

2. **The wide range of potential "climate futures" and the need to choose the most likely ones pose major uncertainties to insurers' business activities, particularly in the areas of underwriting, investment and risk management.** The potential financial impacts of climate change are of key relevance to insurance supervisors in the light of their mandate to protect policyholders and safeguard financial stability. Although there has been some progress in a small number of jurisdictions by insurers and supervisors in assessing climate risk exposures, climate risk quantification techniques are still at an early stage of development. Setting business strategies without a clear understanding of how future climate scenarios could affect investment values or claim payouts is a risky way of running a business.

3. **A key unanswered question is the current and future financial effect of climate risks on insurers.** This gap can be attributed to a lack of awareness on the materiality and urgency of climate risks, a lack of technical expertise and resources to undertake proper risk assessment, and data-related challenges in parts of the industry. The nature of these rapidly evolving and poorly understood risks warrants the use of quantification tools such as stress testing and scenario analysis, which should allow exploration of severe yet plausible scenarios.

4. **This paper aims to provide insurance supervisors with ideas on where to start in addressing climate risks, and how to improve current practice, through both regulatory and supervisory perspectives.** More specifically, the paper outlines the range of different regulatory approaches[5] to encourage insurers to pay greater attention to climate risk assessment. It also describes how some supervisory authorities have undertaken climate risk assessment exercises, focusing on stress test and

[5] Regulatory approaches can take the form of legally binding instruments such as regulatory requirements or "softer" tools such as supervisory statements.

scenario analysis approaches. The paper is based primarily on an FSI survey (FSI survey) carried out in July 2019 among members of the Sustainable Insurance Forum (SIF), with responses received from 18 insurance authorities,[6] as well as interviews with selected authorities, insurers and academia.

5. **While climate change is one of many elements that can influence environmental and sustainability-related risks, this paper focuses solely on climate risks.** This is due primarily to the focus within the global supervisory community on climate change as a wide-ranging and potentially large-scale transformation, as well as the more direct impact of climate risks on insurers, as compared with other aspects of sustainability.

6. **The paper is organised into seven sections.** Section 2 describes the significance of climate risks to the insurance sector and their relevance for supervisors. Section 3 outlines regulatory approaches on climate risk assessment, focusing on ERM requirements. Section 4 describes approaches to insurers' risk assessment models. Section 5 reviews the different ways insurance supervisors can assess insurers' climate risk exposures, including through system-wide stress tests. Section 6 discusses the challenges in climate risk assessments and Section 7 concludes with key considerations for insurance supervisors going forward.

Section 2 – Significance of climate risks in the insurance sector

Climate change as a financial issue

7. **Climate change – the warming of the earth's climate system caused by increasing concentrations of greenhouse gases (GHG) stemming from human activities – is under way across the world.** Global temperatures have already risen 1°C above pre-industrial levels, and are on track to reach at least 1.5°C of average global warming as early as 2030, on present trends.[7] The physical impacts of climate change are being felt globally, as weather-related natural disasters such as wildfires, droughts and floods have increased in frequency and severity. There is also evidence that significant increases in temperatures in certain parts of the world, such as the Arctic, are pushing critical conditions (eg permafrost or frozen ground) towards tipping points, which will further amplify the impacts of global warming.[8] Climate scientists[9] warn that extreme floods, which historically occurred only once a century, are likely to occur once a year by 2050 in many regions.

8. **The transition to a low-carbon, climate-resilient economy will require significant investments in mitigation and adaptation but these investments are likely to be lower than the long-term cost of inaction.** The Paris Agreement,[10] which aims to limit the rise in global average temperatures to well below 2°C relative to pre-industrial levels (and to pursue efforts to limit the rise to 1.5°C), has set a clear pathway for the reorientation of the global economy towards a low-carbon model. Meeting a 1.5-degree target – which scientists now agree to be the maximum allowable level to avoid major impacts – will require the global economy to halve its emissions over the next three decades, leading to "net zero" emissions by 2050. Estimates of total investment necessary to deliver this precipitous decline in emissions through a transformation of the world's energy, transport, agricultural and industrial systems

6 See Annex 1 for a list of participating authorities.

7 See Intergovernmental Panel on Climate Change (2018a).

8 See Nature Climate Change (2019).

9 See Intergovernmental Panel on Climate Change (2019).

10 See United Nations (2018).

are between US$ 1 trillion and US$ 2.4 trillion per year until 2035.[11] Alongside efforts to reduce emissions, investments to strengthen adaptation capacity are critical, and can significantly reduce the costs of climate damages. Investing US$ 1.8 trillion globally in five areas (early warning systems, climate-resilient infrastructure, improved agriculture, mangrove protection and water resources) between 2020 and 2030 could generate up to US$ 7.1 trillion in total net benefits.[12] Insurers have significant opportunities to contribute to the transition to a low-carbon economy through their role as risk capacity providers and institutional investors.

9. **While action on climate change implies transformative changes, the impacts of dangerous levels of climate change (eg average temperatures significantly above 2°C) are recognised as a systemic, and potentially existential, threat to humanity.** Scenarios for dangerous climate change consider an increased likelihood of systemic disruptions with major impacts on the economy and financial stability[13] such as a collapse of food systems, loss of major cities due to temperature increase and sea level rise, mass migration, political instability and war.[14] While the overall likelihood of such catastrophic and potentially existential threats manifesting is debatable, concerted action over the next decade will be critical in mitigating the worst outcomes and future livelihoods.

10. **Climate change is already having a major economic impact, and may pose material risks for the global financial system.** For the insurance industry, climate risks impact the financial system through two main channels: physical risks and transition risks (see Box 1). Some industry commentators view climate risks, for the time being, as being driven mainly by urbanisation and increased asset concentration in climate-exposed areas. They deem such increased concentration of risk exposures to be a more significant factor than climate change effects in increasing their climate risk exposures. Recent years have seen many examples of physical and transition risks manifesting themselves through the economy, resulting in significant financial losses. Most institutional frameworks for climate risks focus on physical and transition risks, and consider liability risks a specialised category relevant for certain institutions (or as a dimension of physical or transition risks). Legal precedent relating to climate change liability is at an early stage of evolution, with few examples of judgments resulting in implications for financial markets. However, climate risk liability could have significant implications in the future.

Box 1

Defining physical and transition risks

In 2017, the Financial Stability Board (FSB) Task Force on Climate-Related Financial Disclosures (TCFD) developed a framework to assess how climate change may pose risks to financial institutions. This framework built upon work by the Bank of England, and earlier efforts by research institutions and non-governmental organisations (NGOs) seeking to examine the channels through which climate change and responses to it could affect the valuation of financial assets, impact the safety and soundness of firms, and potentially influence financial stability.

Physical risks include:

i) acute risks, which are event-driven (eg weather-related natural catastrophes such as hurricanes or wildfires); and

ii) chronic risks, which are longer-term in nature such as changes in weather patterns that affect water availability.

[11] See Intergovernmental Panel on Climate Change (2018b).

[12] See Global Commission on Adaptation (2019).

[13] See Ecological Economics (2018).

[14] See Breakthrough – National Centre for Climate Restoration (2019a,b).

Acute physical risks as amplified by climate change and increased urbanisation are causing damage costing hundreds of billions, with 2018 being the fourth costliest year since 1980 in terms of insured losses.② Over the medium to long term, chronic risks are set to significantly and increasingly disrupt agricultural, energy and other economic sectors. Heightened exposure to physical risk impacts is having implications across the financial system, with increased insurance costs and a lack of available cover, which influences mortgage default rates. Exposure to both acute and chronic climate risks is also affecting credit ratings, including for municipal bonds and sovereign debt. Under a business-as-usual emissions scenario, estimates of the value-at-risk of global financial assets stemming from physical climate impacts range as high as US$ 24.1 trillion by 2100.③

Transition risks arise from responses to climate change within the economy and society, leading to policy and legal risks, technology risks, market risks and reputational risks. A critical component of transition risks is the potential for stranded assets in the energy sector as the world moves away from a fossil-fuel driven energy system towards renewable energy. The concept of stranded assets (as relevant to environmental risks) was promulgated in the academic literature assessing policy and regulatory changes within the electricity sector. Specifically, it relates to recovery of sunk costs rendered unrecoverable through the introduction of competition policy.④

The potential value-at-risk posed by transition risks vary widely, with the International Energy Agency (IEA) estimating that a shift towards a low-carbon pathway could result in US$ 10 trillion in stranded assets in high-carbon sectors by 2050.⑤ Over the longer term, investment banks have suggested that these losses could be as high as US$ 28 trillion by 2100.⑥ The current year, 2019, has seen evidence of increasing market movements due to transition risks. Over 110 globally significant financial institutions have announced policies to phase out business in the coal sector in terms of credit, investment and underwriting.⑦ At the end of August 2019, ExxonMobil dropped out of the S&P 500 Top 10 companies for the first time since the index's inception in 1957.⑧

① The TCFD comprises 31 users and preparers of disclosures from a broad range of sectors and financial markets. ② See Munich Re (2019). ③ See Nature Climate Change (2016). ④ For a review of the literature and notes on development of the concept, see University of Oxford (2014). ⑤ See International Energy Agency and International Renewable Energy Agency (2017). ⑥ Kepler Cheuvreux (2014). ⑦ See Institute for Energy Economics and Financial Analysis (2019a). ⑧ See Institute for Energy Economics and Financial Analysis (2019b).

The evolution of the climate risk agenda

11. **Over the past two decades, there has been a paradigm shift in how financial institutions, regulators and policymakers respond to climate risks**. This evolution has advanced through a process of innovation by four stakeholder groups and interactions between them – financial market players, research institutions, regulatory institutions and international institutions.[15]

12. **Initial efforts to assess the implications of climate change for the financial system were market-driven and uneven across different asset classes.** General insurers and reinsurers have had the longest history of assessing climate risks in the form of exposures to weather-related natural catastrophes. This followed significant investment in risk modelling capabilities after Hurricane Andrew in 1992. Interest in climate change as an investment concern emerged during the growth of "ethical" or "responsible" investment during the 2000s, which focuses on the integration of environmental, social and governance (ESG) factors into investment practices. As data on carbon emissions became more accessible, via the work of entities such as the Carbon Disclosure Project,[16] investors started to assess carbon emissions associated with their investment activities. However, carbon emissions data were still not widely used as a proxy for climate risk exposure. During the 2000s, coalitions of investment institutions such as the Principles for Responsible Investment (PRI) and United Nations Environment Programme Finance Initiative (UNEP-FI) set

[15] For information on the evolution of climate risks as part of the broader agenda relating to sustainable finance, see United Nations Environment Programme (2016).

[16] The Carbon Disclosure Project (CDP) is a not-for-profit organisation that supports companies and cities to disclose the environmental impact of major corporations. It aims to make environmental reporting and risk management a business norm, and to drive disclosure, insight and action towards a sustainable economy.

out initial frameworks to explore ways that climate change could influence financial markets and asset values. Up until 2010, the majority of climate-related thinking within the financial sector was undertaken at a high level, as technical capacities and data gaps made it difficult to perform granular analysis on individual assets.

13. **In the wake of the Great Financial Crisis of 2007–09, new ways of quantifying carbon-related risks influenced a step-change in the climate risk agenda.** A key development in this agenda was the introduction of the concepts of unburnable carbon and stranded assets. Specifically, stranded assets are financial holdings in high-carbon sectors such as upstream energy producers or electrical utilities that could face unanticipated or premature write-downs, devaluations or conversion to liabilities. These can result from physical climate impacts, policy and regulation, technological innovation or social change. Regarding unburnable carbon, in 2011, research by the Carbon Tracker Initiative[17] estimated that only 20% of fossil fuel reserves held by publicly traded entities could be commercialised if the world were to meet a two-degree warming pathway. This suggests that the other 80% is unburnable, posing major risks to firms' value. From 2013 onwards, an evolving body of research assessing risks associated with thermal electricity generation, oil and gas capital expenditure, and other climate-vulnerable sectors began to translate physical climate impacts and policy changes into financial metrics.[18] In response to the growing awareness of potential downside risks associated with the low-carbon transition, financial institutions, NGOs, and consultancies began to develop different methodologies to assess how climate-related risk factors could influence asset values and default risk. Increasing demand from institutional investors for relevant information on climate risks has inspired a profusion of service offerings from data providers and ESG ratings specialists, while credit rating agencies began to integrate climate-related risk factors into products and services such as risk evaluation tools.

14. **In recent years, an increasing number of regulatory authorities and central banks have begun to recognise that climate risks could lead to prudential risks.**[19] In 2015, the Bank of England's review[20] of climate change risks to the UK insurance sector, and a widely recognised speech[21] by Bank of England Governor Mark Carney, broke new ground. They clearly linked climate change factors to financial risks relevant to the safety and soundness of firms and broader financial system stability. An increasing number of central bank governors and other executives have made public statements emphasising the significance of climate change as a prudential risk. In addition, several regulatory authorities have taken steps to formally clarify how climate change is relevant to their core mandates and objectives.[22] Assessments of climate risk exposures in the insurance sector have been undertaken by various regulatory authorities and central banks, including in Australia, Belgium, California, the European Union, France, the Netherlands, Singapore, the United Kingdom and Washington State. For the past 10 years, a number of state insurance regulators in the United States have required more than 1,000 insurers to report annually on how climate change affects their business through the Climate Risk Disclosure Survey.[23]

15. **Climate risks have been elevated to the international level through the work of the FSB TCFD, the G20 and, most recently, through coalitions of regulatory authorities.** Since their release in

17 See Carbon Tracker (2011).

18 See Nature (2015).

19 Regulatory action on climate change risks emerged in the United States in 2010, where a coalition of state insurance regulators implemented a mandatory survey on climate change risks for regulated entities. For further information, see California Department of Insurance (2018).

20 See Bank of England (2015a).

21 See Bank of England (2015b).

22 See Network for Greening the Financial System (2018).

23 See California Department of Insurance (2009).

2017, the FSB TCFD Recommendations have emerged as a de facto international benchmark for the disclosure of climate-related risks by financial institutions. In 2017, the G20 Green Finance Study Group identified a range of methodologies through which financial institutions could assess climate and other environmental risks.

16. **The SIF – a global network of insurance supervisors and regulators collaborating on sustainability issues, including climate risks – was initiated with the support of the United Nations Environment Programme in 2016.** A major achievement was the publication of the 2018 Issues Paper on Climate Change Risks to the Insurance Sector,[24] which provided guidance to help supervisors evaluate responses from firms to their climate risk exposures. The SIF brings together insurance authorities to share knowledge, approaches and tools to strengthen climate risk assessment activities by firms and supervisors. At the time of this paper's publication, the SIF, together with the International Association of Insurance Supervisors (IAIS), was developing an Issues Paper on Climate Risk Disclosure focusing on TCFD implementation by insurers in order to raise awareness of the importance of climate change risk disclosure and to provide an overview of current and contemplated supervisory practices. In addition, the SIF has developed a question bank as an engagement tool to help supervisors better understand the exposures and strategic responses of insurers to climate change risks and opportunities. The question bank provides a framework and example questions, which supervisors can adapt for use in their own jurisdictions.

17. **Another institutional coalition, the Central Banks and Supervisors Network for Greening the Financial System (NGFS) published its first comprehensive report[25] in 2019.** The report outlined recommendations for central banks, supervisors, policymakers and financial institutions to enhance their role in the greening of the financial system and management of environment and climate-related risks. To achieve these aims, the NGFS has made a commitment to developing:

- a handbook on climate and environment-related risk management for supervisory authorities and financial institutions, detailing concrete steps for these institutions to better understand, select, measure, price, mitigate and control exposures to climate and environmental risks;
- voluntary guidelines on scenario-based risk analysis to assist authorities to conduct their own analyses; and
- best practices for incorporating sustainability criteria into central banks' portfolio management (particularly with regard to climate-friendly investments).

18. **Also, international standard-setting bodies and climate-related forums are considering climate risks in their agenda.** Bodies such as the IAIS have begun to develop guiding principles and supporting materials on how supervisors could address climate risks.

[24] See International Association of Insurance Supervisors and Sustainable Insurance Forum (2018).

[25] See Network for Greening the Financial System (2019).

Climate risk and insurance supervision

19. **Many insurance supervisory and regulatory agencies now consider climate risks to be within their mandates.** Importantly, maintaining prudential and financial stability objectives requires close coordination among the involved financial sector authorities, including central banks. It is plausible that climate risks could severely impact the financial sector, necessitating central banks to intervene, for example by buying large volumes of stranded assets.[26] The SIF and the IAIS have confirmed the relevance of climate-related risks in insurance supervision and regulation in terms of solvency, protection of policyholders, access and affordability as shown in Table 1.

Relevance of climate risks for insurance supervisory mandates — Table 1

Objective	Relevance of climate risks
Microprudential	Potential for physical, transition and liability risks to adversely affect the safety and soundness of individual firms and viability of their business models through underwriting, investment, market, strategic, operational, reputational or other channels.
Macroprudential	Potential for physical, transition and liability risks to have systemic implications for the insurance sector and broader macroeconomy.
Financial inclusion	Potential for climate change to render assets uninsurable, affecting affordability and availability of insurance products.

Source: Adapted from International Association of Insurance Supervisors and Sustainable Insurance Forum (2018).

20. **Broadly speaking, insurance supervisory and regulatory approaches to climate risk assessment are relatively more advanced in the financial sector, given the more direct exposure of insurers in underwriting climate-related risks.** Looking across jurisdictions, such approaches can be grouped into five key categories:[27]

- integrating climate factors into supervisory risk rating frameworks to assess how climate risks may affect mainstream or traditional financial risks (eg insurance risk, market risk, credit risk, liquidity risk, operational risk);
- strengthening disclosure of climate-related information by insurers through voluntary or mandatory public disclosure requirements or supervisory reporting;
- integrating climate-related issues in routine supervisory review tools such as insurers' own risk and solvency assessment (ORSA);
- integrating climate risks into financial stability assessments, for instance by integrating weather-related natural catastrophes into general insurance stress test exercises or life insurance stress test to examine the potential impact of climate risks on longevity risk; and
- undertaking forward-looking assessments of climate risks including through scenario analysis.

While this agenda is evolving rapidly, many aspects such as clarification of supervisory expectations relating to climate risk assessment, the use of ORSA to examine climate risks or the application of scenario analysis techniques are at an early stage.

[26] See Bolton et al (forthcoming) for a more detailed explanation of this concept.

[27] See International Association of Insurance Supervisors and Sustainable Insurance Forum (2018).

Section 3 – Regulatory approaches on climate risk assessment

Enterprise risk management

21. **Insurance Core Principle 16 Enterprise Risk Management (ERM) for Solvency Purposes (ICP 16) sets out an international standard that calls for insurance supervisors to require an "insurer's ERM framework to provide for the identification of all reasonably foreseeable and relevant material risks and risk interdependencies for risk and capital management".** In this context, it is encouraging that all surveyed jurisdictions regard climate risks as being "reasonably foreseeable, relevant and material". While this affirmation may appear self-evident, it is a strong signal that all of the surveyed supervisors expect insurers to address climate risks in their ERM frameworks. In other words, this group of supervisors is calling for action. Even just a few years ago, this may not have been the case as climate risks were deemed rather remote and inconsequential relative to other risks facing insurers. As an example, in Germany, more attention will be given to the integration of sustainability risks, including climate risks, into insurers' risk management frameworks.

22. **Although all of the surveyed supervisors agree that insurers should address climate risks in their ERM frameworks, not many have explicitly prescribed regulatory requirements in this regard.** This may explain why the integration of climate risks in ERM frameworks is still uncommon among insurers. Most of the surveyed jurisdictions consider that existing principles-based ERM requirements are broad enough to capture climate risks. This suggests that supervisors can achieve their prudential objectives without needing to create new ERM regulations that specifically cover climate risks. Nevertheless, most jurisdictions that do not currently have specific ERM requirements on climate risks plan to introduce them in the future. Currently, only Italy and the United Kingdom have specific and explicit ERM requirements that cover climate risks. Insurance supervisory authorities in Australia and Singapore require insurers to capture climate risks if material, but regulatory requirements do not explicitly identify climate risks. Under the European Union Solvency II framework and in South Africa, climate risks are implicitly covered if the risks are viewed to be material. It is important for supervisors in such principles-based regimes to have the necessary tools to express and signal their expectations clearly and effectively to insurers on how they should manage their climate risk exposures.

23. **Some supervisors have found less formal or less legally binding tools to be effective and efficient in setting out timely and realistic expectations to insurers on how they should manage climate risks.** An example of how supervisors can quickly express their expectations to insurers is the issuance of a Supervisory Statement[28] by the Prudential Regulation Authority (PRA) in the United Kingdom. The document describes the nature of physical and liability risks and sets out the PRA's expectations on how insurers (and banks) should manage these risks from the perspectives of governance and risk management. The Supervisory Statement has been instrumental in initiating industry action and providing support to front-line supervisors in starting conversations with insurers on climate risks.

24. **Authorities in other advanced economies seem to be taking a less direct approach, for example, by setting out expectations, using moral suasion bilaterally or engaging the industry through dialogues to prompt insurers to consider climate risks in their ERM frameworks, rather than imposing explicit regulatory requirements.** Such an approach has proven to be effective in bringing about change and action by insurers in those jurisdictions. However, such an approach may not work in all jurisdictions, especially if insurers tend to react only to formal and legally binding requirements.

25. **As climate risk management is still an evolving area, supervisors may wish to consider insurers' current level of expertise and good practices when setting out guidance or expectations.** Close engagement with the industry will facilitate the development of supervisory guidance or

[28] See Bank of England (2019).

expectations that are realistic, applicable in a local context and feasible to implement. For instance, the Monetary Authority of Singapore (MAS) has convened a working committee comprising MAS and industry representatives to co-create a set of environmental risk management guidelines for insurers. Greater buy-in from insurers is important for guidance that is not legally binding.

26. **Risk disclosure requirements and explicit supervisory expectations in this regard are another set of important tools that can prompt improvements in insurers' management of climate risks.** The FSB TCFD recommendations[29] have been instrumental in facilitating clearer, more comparable and more consistent disclosure by financial institutions including insurers on risks and opportunities presented by climate change. Although these recommendations are voluntary, more and more insurers are taking steps to implement them. One recommendation is for insurers to describe their resilience to climate risks, taking into consideration the different climate-related scenarios. To disclose their climate risk exposures, insurers will need to be able to (qualitatively or quantitatively) assess their exposures (see Section 4 for further explanation of the main types of models). To do so, the TCFD recommends that firms use scenario analysis to assess their climate risk exposures. In one of the surveyed jurisdictions, the TCFD recommendations have prompted insurers to develop bespoke climate scenarios as part of their scenario analysis exercises.

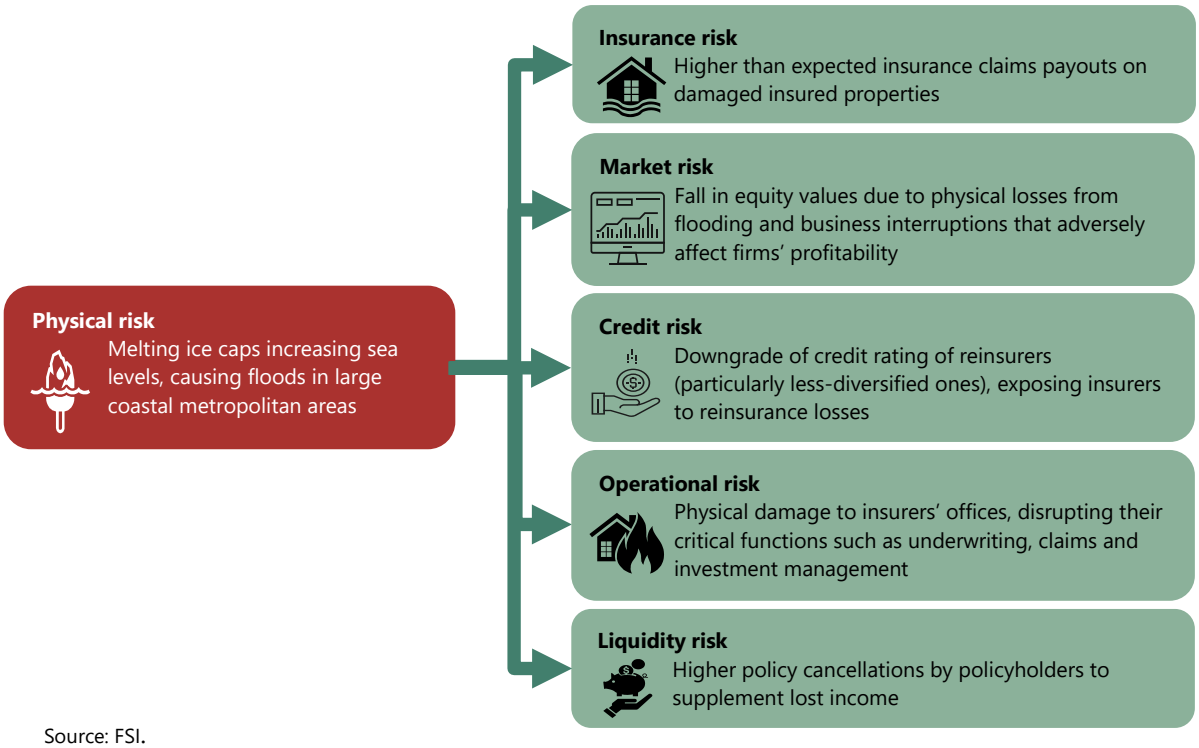
27. **Other developments that are pushing insurers to enhance their climate risk assessment capability are the increasing focus from external auditors and credit rating agencies on insurers' climate risk exposures as the risks are seen to be material.** One of the surveyed supervisors views greater attention by external auditors as a positive development in facilitating better risk quantification techniques. Credit rating agencies have warned of insurers' increasing vulnerabilities to climate risks and that, without swift action, insurers will struggle to meet their financial obligations. These agencies have started to incorporate ESG factors in their credit assessment of insurers (and other businesses). Poor management of climate risks could weigh down on insurers' credit ratings.

28. **Most of the surveyed authorities expect insurers to allow for manifestation of climate risks in other risk categories.** However, three authorities consider it appropriate for insurers to capture climate risks as a standalone risk category. In the SIF/IAIS Issues Paper,[30] examples were provided on how climate risks, namely physical risks, transition risks and liability risks, can materialise in the form of other (more established/understood) risks such as credit, market and insurance risks. Such an approach has the advantage of using existing taxonomy to express climate risks, making it easier to communicate and understand their financial impact on insurers. It also has the advantage of showing how climate risks can be linked to financial risks and translated into financial terms. On the other hand, the alternative approach of capturing climate risks separately in an ERM framework is more explicit and gives prominence to climate risks. Both approaches can be regarded as a step forward since they require insurers to consider climate risks in their ERM frameworks. Figures 1 and 2 provide examples of how physical and transition risks can manifest themselves in insurance, market, credit, operational and liquidity risks.

[29] See Task Force on Climate-related Financial Disclosure (2017).

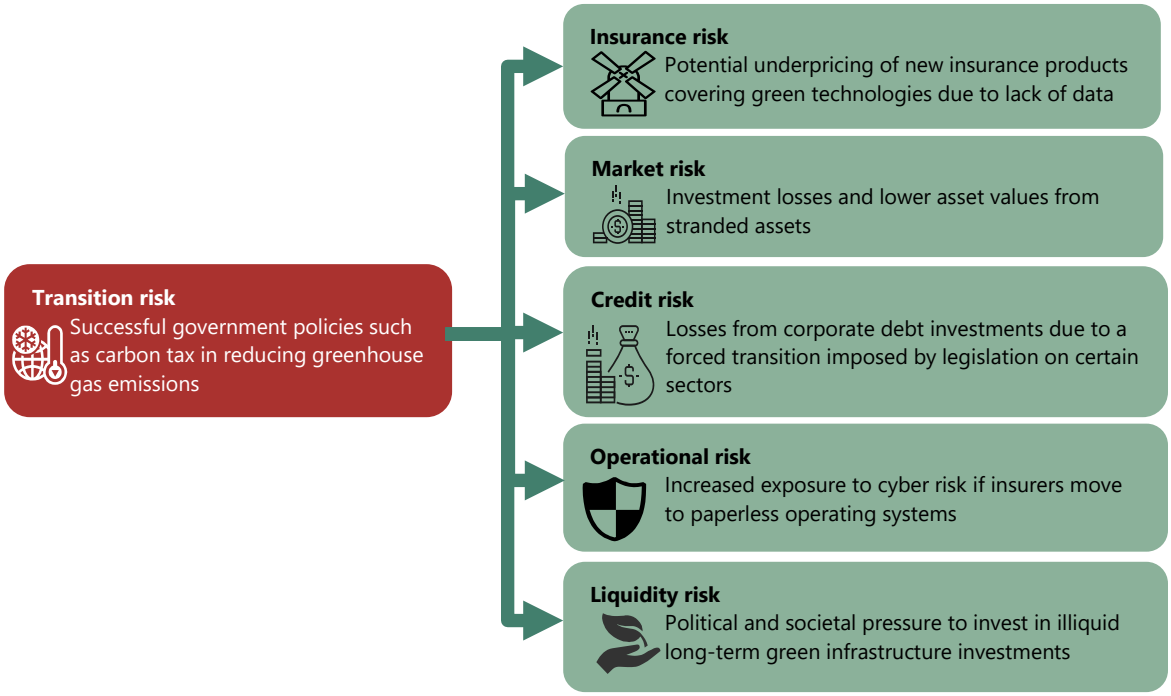
[30] See International Association of Insurance Supervisors and Sustainable Insurance Forum (2018).

Figure 1: Examples of potential manifestation of physical risk in mainstream risks



Source: FSI.

Figure 2: Examples of potential manifestation of transition risk into other mainstream risks



Source: FSI.

Own risk and solvency assessment

29. **Since the IAIS introduced the concept of ORSA[31] in ICP 16 in 2011, most jurisdictions around the world have put in place regulatory requirements for ORSA.** This development has been extremely useful in providing a practical ERM tool through which insurers can consider their climate risk exposures on a forward-looking basis. Almost all of the surveyed supervisors expect insurers to consider climate risks in their ORSA, if material, even without necessarily prescribing explicit regulatory requirements in this regard. Only one of the surveyed authorities does not expect insurers to capture climate liability risks in their ORSA, as it does not expect these risks to be significant over the next three years.

30. **In general, the surveyed supervisors do not distinguish between climate risks and other material risks that insurers face in terms of their expectations of risks that should be captured in an ORSA.** Examples of what some of the surveyed supervisors expect in an insurer's ORSA report in relation to climate risks are shown in Table 2.

Examples of coverage of climate risks in ORSA reports — Table 2

ERM step	Expected coverage in ORSA report
Risk identification	• Clear description of an insurer's exposure to the different climate risks • Explanation of how climate risks can manifest in other risk categories
Risk assessment	• Description of techniques used to assess climate risks • Justification of assumptions used to model the risks, including any management actions • Forward-looking assessment of potential impact of climate risks on an insurer's risk profile and capital in normal and stressed situations
Risk monitoring	• List of indicators used to monitor climate risk exposure • Risk monitoring processes • Risk owners within an insurer of the different climate risks
Risk mitigation	• Description of risk mitigation actions, particularly any reliance on reinsurance

Source: FSI survey.

31. **Some of the surveyed supervisors view ORSA as an important supplement to regulatory capital requirements as these are not currently calibrated to reflect climate risks.** There are various reasons why regulatory capital does not currently explicitly capture climate risks. For example, there could be a lack of understanding of the nature of climate risks on the part of supervisors, a lack of data to calibrate capital requirements (for example, it can be difficult to convert long term risks into a one-year capital measure) or a view that capital requirements are inappropriate to correct mispricing of climate risks within the financial system. One advantage of ORSA in a climate change context is the scope for insurers to consider the impact over a longer time horizon than typically allowed for in regulatory capital requirements.

32. **In a number of surveyed jurisdictions, to supplement quantitative assessment of climate risk exposures, some insurers are also undertaking qualitative measures.** In general, there is no established industry practice on qualitative measures and as a result, insurers' qualitative assessments tend to vary considerably. Some of the concrete qualitative actions that insurers have taken are shown in Table 3.

[31] An ORSA is a component of an ERM framework that insurers use to assess the adequacy of its risk management and, current and likely future solvency position. In the banking sector, the equivalent concept is more commonly known as internal capital adequacy assessment process (ICAAP).

Examples of qualitative assessment of climate risk exposures Table 3

Action	Example
Interaction with supervisors	• Respond to information requests, for example, regular or ad hoc surveys from supervisors
Information gathering	• Dialogue with relevant external experts such as climate scientists, national meteorology centres and housing finance institutions (to better understand the potential effects of property damage prevention measures), property developers, investee companies and academia • Collect relevant data, for example exposure to specific perils
Risk assessment and review	• Consider climate risk exposure by business lines and geography • Consider potential impact of climate risks on risk diversification, investments, adequacy of reinsurance coverage, reputation and competitive position • Review post climate-related events, for example, assess improvements to insurer's response, and catastrophe claims management
Disclosure	• Develop climate-related risk metrics and include in public disclosure

Source: FSI survey.

Section 4 – Insurers' approaches to climate risk assessment

Insurers' risk assessment models

33. **As described in Section 3, regulatory measures are playing a crucial role in motivating insurers to establish and enhance their ability to assess their climate risk exposures.** For many years, insurers have been able to quantify weather-related risks for pricing and reserving purposes. They have usually been able to withstand severe episodes of weather-related insurance claims and even to underwrite them profitably. Nevertheless, such models may not explicitly nor accurately capture future climate possibilities and the past may not be a good guide to the future. Moreover, climate risks could adversely affect not only the insurance liabilities of insurers, but also other parts of their balance sheets, including investments.

34. **Risk quantification techniques or models used by insurers to assess their climate risk exposures are still at an early stage of development.** This is because, for non-life insurers, for example, even with a long history and experience of modelling natural catastrophe risks, the insurance industry is faced with significant challenges when attempting to quantify or estimate the size of climate risks (such challenges are described in Section 6). For life insurers, it is complex to assess the effect of climate change on longevity risk. On the other hand, qualitative measures are more advanced, particularly governance-related actions such as raising awareness among board and senior management on insurers' climate risk exposures and developing internal technical capacity to explore how business strategies could be impacted by climate risks.

35. **In general, the surveyed supervisors do not prescribe specific requirements or signal expectations on the approach insurers should take to quantify climate risks.** This is largely due to the embryonic state of the techniques and models. It also provides flexibility to insurers, allowing them to select the most appropriate risk models or approaches to assess climate risk exposures that may be idiosyncratic in the respective jurisdictions. Any methodology would necessarily need to consider the

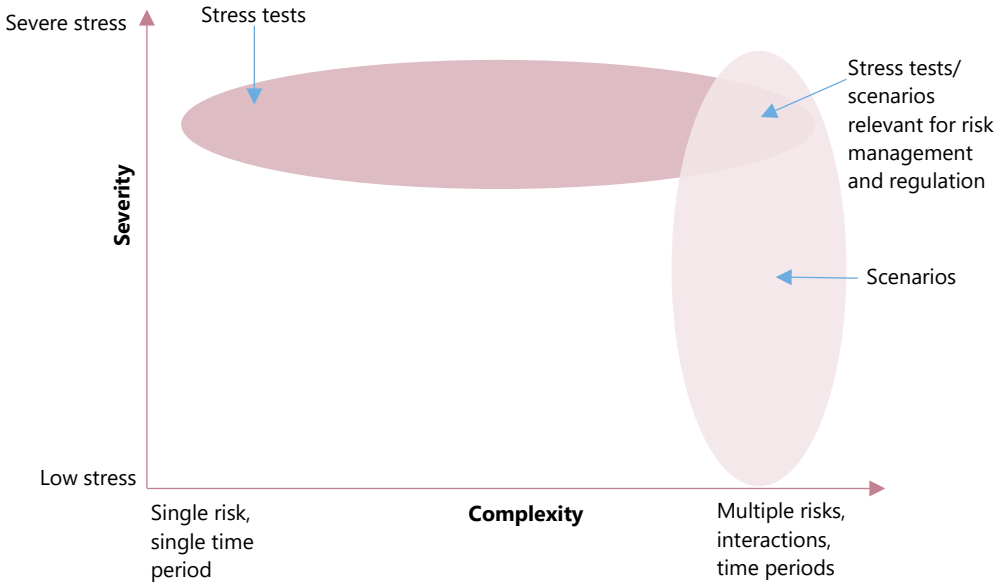
likelihood and impact that each material and relevant risk could have on an insurer both under normal and stressed situations. Modelling climate risk impact under stressed conditions is difficult.

36. **Nevertheless, a few of the surveyed supervisors expect insurers to use stress testing and scenario analysis to assess their climate risk exposures.** Supervisors can express such expectations through regulatory tools at their disposal such as written guidance or supervisory statements, or using less formal approaches such as speeches or dialogues with the industry. Specifically, some of the surveyed supervisors view stress test and scenario analysis as useful tools that insurers can use to:

- identify key drivers of climate risks that could impact their assets and/or liabilities;
- assess potential impact on their capital resources and business strategy; or
- assess their climate risk exposure against their risk appetite.

37. **In general, insurers typically use stress testing and scenario analysis to assess their climate risk exposures.** In this paper, definitions are proposed to clarify references to the two terms in the following sections. In ICP 16, the IAIS considers stress tests to be a risk assessment tool that "measures the financial impact of stressing one or more factors which could severely affect the insurer," while scenario analysis "considers the impact of a combination of circumstances to reflect historical or other scenarios which are analysed in the light of current conditions (...) (which) may be conducted deterministically using a range of specified scenarios or stochastically, using models to simulate many possible scenarios, to derive statistical distributions of the results".[32] In practice, the distinction between the two risk quantification techniques is not entirely clear-cut. There is a spectrum of approaches, ranging from stressing only one variable to stressing multiple variables in a coherent way that reflect their dependencies. Figure 3 by the International Actuarial Association (IAA)[33] shows the range of stress tests and scenario analyses, Figure 4 outlines their potential uses.

Figure 3: Range of stress tests and scenario analyses

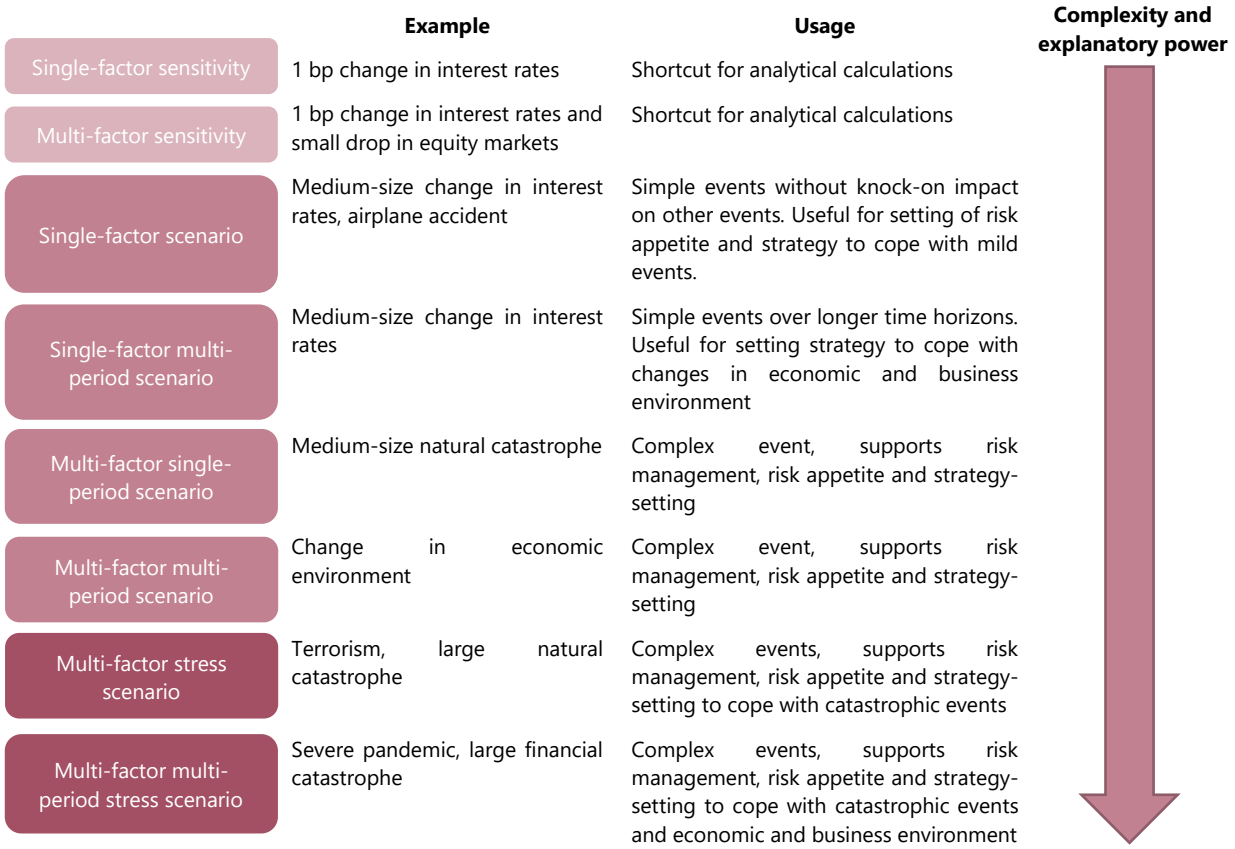


Source: IAA (2013).

[32] See ICP 16.2.18 in International Association of Insurance Supervisors (2019).

[33] See International Actuarial Association (2013).

Figure 4: Different designs and uses of stress tests and scenario analyses



Source: IAA (2013).

38. **Among insurers that assess climate risks using stress test or scenario analysis, most are likely to cover physical risks only.** Capturing transition risks is less common, and liability risks are rarely covered. This probably reflects the level of familiarity of insurers with these different climate risks as well as the priority they place on each. Nevertheless, to avoid any risk management blind spots, there may be a need to consider all three types of climate risk in a stress test or scenario analysis. Importantly, the various potential climate futures could lead to very different manifestations of these climate risks. If efforts are successful in transitioning to a less carbon-intensive future, an insurer's transition risk may be heightened if it holds stranded assets. On the other hand, if such efforts are unsuccessful, insurers may face greater physical risk arising from weather-related impacts from the higher global temperature. In both climate scenarios, liability risk may increase due to greater public awareness of climate issues, thus increasing the pressure to hold corporates and executives accountable for climate inaction.

39. **Once a risk assessment technique has been determined, insurers typically translate their future climate assumptions into specific stress factors.** This requires being clear on the aim of the risk assessment exercise, for example to determine the potential impact on earnings volatility, capital position or business model viability. Significant technical and multi-disciplinary expertise is needed in this process. In addition, and in the absence of established methodologies, there will be heavy reliance on expert judgment. Examples of variables that insurers might stress in a stress test or scenario analysis are shown in Table 4.

Examples of stress variables Table 4

Item	Variable
Balance sheet	• Asset values • Insurance liability values • Other (non-insurance) liability values • Capital position
Income statement	• Profit • Premium revenue • Investment income • Insurance losses
Risk factors	• Probability of occurrence of weather-related events • Severity of weather-related insurance claims and other losses • Credit rating

Source: FSI survey.

40. **While it is acknowledged that determining appropriate assumptions and stress levels in a stress test or scenario analysis is difficult, insurers can rely on existing sources of information.** As a starting point, insurers can familiarise themselves with the relevant reports by the Intergovernmental Panel on Climate Change (IPCC), which sets out potential future climate scenarios. Other international authorities such as the IEA have developed scenarios for decarbonisation of the global energy mix, which can prove useful in assessing potential transition risks. Additional sources of information include stress-testing specifications developed by insurance supervisors (see Box 3), national agencies dealing with climate change and environmental issues, industry publications on recent weather-related economic and insured losses, and risk modelling providers. In 2020, the NGFS is expected to publish climate change scenarios that are relevant for financial sector stress testing.

41. **Most of the surveyed authorities do not typically opine on the assumptions or stresses used by insurers but some may require insurers to provide justification.** This is probably due to the wide range of variables relevant to climate risk factors and, correspondingly, the assumptions underlying stress-testing or scenario analysis. Nevertheless, it is important to understand the thinking behind the assumptions to interpret the results appropriately and recognise any limitations of the model outputs.

42. **Apart from technical difficulties in coming up with a plausible stressed climate scenario and translating it into concrete stress factors, it is a challenge to evaluate whether the stressed scenario is sufficiently severe.** To answer this question, insurers may need to engage with climate specialists to ascertain their stress assumptions. Despite these difficulties, a stress test or scenario analysis can be informative even if the appropriateness of the stress severity is uncertain. Insights can be gained into the direction of risks and vulnerabilities of firms from scenarios with varying degrees of severity. Expert judgments will vary when considering "what if" scenarios.

43. **Most of the surveyed jurisdictions expect insurers to consider longer time horizons than those typically used for calibrating regulatory capital requirements.** This reflects the very long-term nature of climate risk exposures. While insurers, especially life insurers, are used to considering risks over 50 years or more, assessing climate risks may require equally long, if not longer, time horizons. It is helpful to distinguish between two aspects of time horizons, as defined by the IAIS, as follows:

- the shock period, which is the period over which a shock is applied to a risk; and
- the effect period, which is the period over which the shock applied to a risk will impact the insurer.

For regulatory or economic capital purposes, insurers typically consider a one-year shock period, effectively dealing with what could go wrong over the forthcoming year and how much capital they will need to keep running their business. On the other hand, insurers may need to consider a longer shock period in a climate risk assessment model in order to capture the nature of climate risks that could materialise over periods longer than a year. To be consistent, appropriate management mitigation actions could be considered over such longer periods of time.

44. **A feature of a climate risk assessment model is the need to allow for non-linearity (for example clustering of extreme weather events), which is not yet typically reflected in insurers' stress test or scenario analysis models.** Examples of major non-linear climate risks are changes in critical earth system phenomena (eg the break-off of a major Antarctic ice sheet), imposition of a disruptive and uncoordinated suite of policy responses to climate change, and legal precedent relating to climate-related liabilities of corporates or governments. Recently, scenarios[34] for drastic policy changes in response to climate impacts have been developed to support investors' consideration of non-linear developments, which could influence cascading changes through the economy and financial system. There may also be interplay between the different risk factors.

45. **Without allowing for non-linearity, insurers' risk models are likely to underestimate exposure to climate risks.** However, modelling the frequency and severity of one climate-related event is difficult enough, let alone the dependencies between multiple events. This is an area where professional bodies such as the IAA could contribute by helping to build actuarial capacity globally. In the absence of sound statistical or mathematical approaches to reflect this feature, insurers may allow for non-linearity in a more qualitative way, by stressing several events concurrently or establishing plausible dependencies without actually quantifying them, for example reflecting the direction of change of sets of dependent variables.

46. **An important feature of a risk assessment model, including stress test and scenario analysis, is how it allows for risk mitigation actions, as this could have a significant effect on the results.** If risk mitigation assumptions are overly optimistic, adverse impacts can be significantly underestimated. The most common risk mitigation actions considered in climate risk models are reinsurance arrangements. Other examples of risk mitigation actions, although less common, include recognition of diversification benefits (for example due to different geographical exposures), ability to recapitalise, changes to business plan, changes to investment strategy and ability to reprice, allowing for customer affordability. However, these actions have not been widely used in practice so far with regard to climate risks, which raises the question of whether such actions should be recognised in climate risk models. It is useful to consider running the risk models with and without risk mitigation actions to identify their effects and feasibility in practice.

47. **There is a wide range of quantitative outputs that can be obtained from climate risk stress testing and scenario analysis**. Examples include:

- claims and investment losses;
- profitability;
- capital requirement;
- capital resources;
- average annual loss change;

[34] See Principles for Responsible Finance (2019).

- aggregate or occurence exceedence;
- market value of investments; and
- value-at-risk or tail value-at risk.

These indicators show the different ways insurers could be affected by climate risks. A good source of practical examples of output indicators is publicly available climate disclosure[35] by insurers.

48. **How frequently insurers undertake climate stress testing or scenario analysis varies across jurisdictions, although this is typically on an annual basis as part of an ORSA.** In certain jurisdictions, larger insurers are required to undertake stress tests and scenario analyses as frequently as semiannually, at quarterly intervals or when their risk model and/or portfolio changes significantly.

49. **Insurers typically rely on expert judgment to inform the calibration of their climate risk models.** As such, it is sensible to validate the results by undertaking sense or reasonableness checks, especially since backtesting techniques are less useful for climate-related events. Yet most insurers do not currently undertake such checks, although they are likely to do so in the future. An example of a sense check is to compare the results against publicly relevant information, including from supervisors. Qualitative safeguards and reassurances are important to ascertain the reliability of the assessment results, particularly if the results are to be used for decision-making. Just as for other types of risk, board and senior management oversight and critical challenge over validation of insurers' risk models are important.

50. **To undertake climate stress test or scenario analysis, insurers may need to source technical skill and expertise that goes beyond traditional quantitative, modelling or actuarial expertise.** More specifically, insurers may need to engage with experts in climate science areas such as meteorology, geology and hydrology as well as with other, less obvious, parties such as engineers and city planners to better understand the potential trend of growing population concentration in certain geographical areas. Organisationally, insurers may need to enhance interdepartmental cooperation, for example, by enhancing collaboration between actuarial and finance teams to translate climate scenarios from natural catastrophe models into finance models.

51. **From the survey responses, non-life insurers are generally deemed more advanced in climate risk modelling, particularly in assessing physical risk, as most have extensive experience in managing natural catastrophe risks.** Life insurers, although less advanced, are generally stronger in assessing transition risks due to their larger investment portfolios and longer time horizons. In one jurisdiction, life insurers are more advanced as they have been using internal capital models for longer than non-life insurers. One of the surveyed jurisdictions suggested that the distinction may not be between life and non-life insurers. Rather, differences in risk modelling sophistication can be attributed to the size of the insurer, the larger ones having more resources and capabilities.

52. **There is currently a number of open-source and proprietary vendor models that insurers can use to assess their climate risk exposures.** This is a positive development as insurers need not necessarily develop their own models, particularly given the complexities and costs involved. Nevertheless, insurers may need to be mindful of the aims and limitations of open-source and proprietary models. Insurers should not blindly use such models without a full understanding of whether such models can achieve their risk modelling objectives. Anecdotal evidence suggests that not many insurers are using open-source models, potentially due to the differing aims. Among the surveyed jurisdictions, there is no clear trend on whether insurers use mainly internal or external models. Annex 2 outlines the features of selected climate risk models. Annex 3 compares the different climate risk models in terms of the climate scenarios that are considered, the types of physical and transition risk that are captured, the type of output and the intended target users.

[35] As an example, see the climate risk disclosure by Aviva (2018).

Use of risk assessment results

53. **Outputs from climate stress tests and scenario analyses are used by insurers to understand and assess their climate risk exposure, which in turn informs decision-making by their boards and senior management.** It is important to recognise that the outputs can still be useful for decision-making, even if the results are highly uncertain. The absolute numerical results may not be the main focus of the exercise and relative results can be informative. An insurer could still benefit from being able to initiate informed conversations on climate risks within the organisation. Scenarios help to "tell stories", which allow board members and other senior executives to engage and provide input from their experience and viewpoints. Ultimately, this should lead to a better understanding of the insurer's vulnerability to climate risks and, consequently, to prompting the necessary changes to its business strategy in order to remain climate-resilient. More specifically, outputs from climate stress test or scenario analysis can be used to:

- assess viability of new business strategy, most typically investment policies;
- identify necessary changes to existing business model;
- identify risk mitigation and management actions;
- clarify impact of climate risks on an insurer's risk profile;
- provide input to public climate risk disclosures; and
- identify future liquidity and possible capital needs.

54. **There is currently no consensus among the surveyed supervisors on what insurers should include in their stress test or scenario analysis reports.** The surveyed supervisors expect that such reports, which could be part of ORSAs, should at a minimum include a description of the model, data sources, assumptions and contextual qualitative information.

55. **Results from risk assessment have had positive impacts on insurers' business strategy.** For example, in Belgium, insurers have started adjusting their investment strategy in response to current and potential climate change impacts.

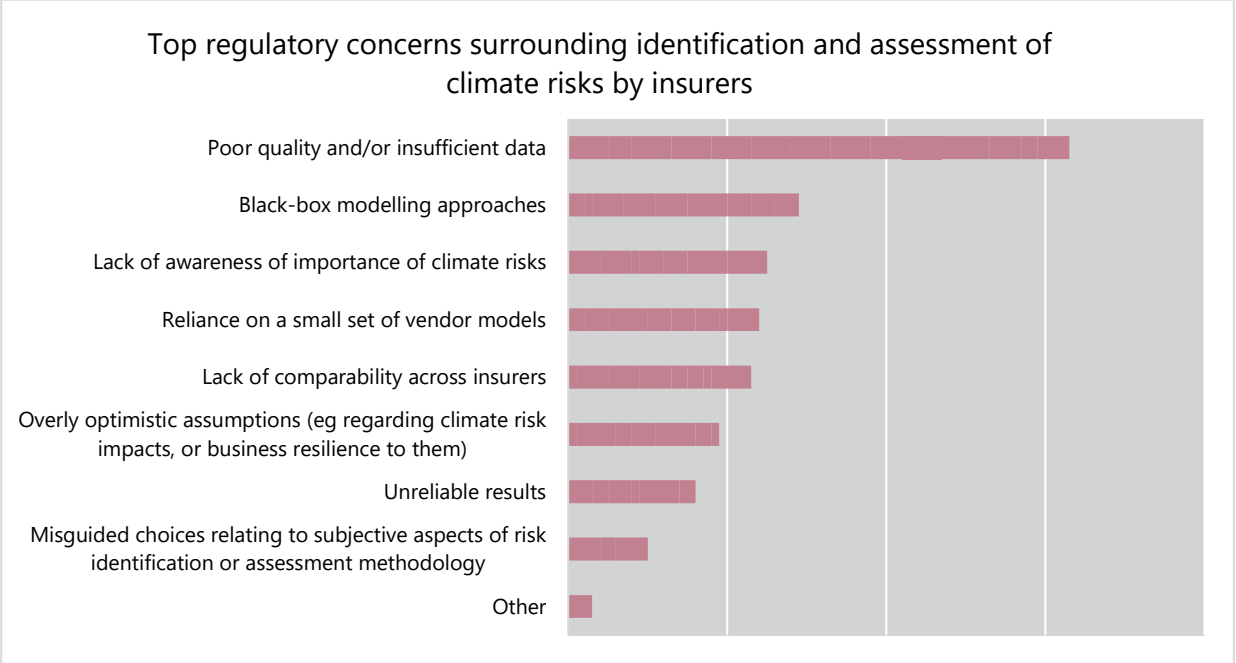
56. **In most of the surveyed jurisdictions, any material risks including climate risks should be reported to the boards of the respective insurance firms.** In some jurisdictions, the ORSA report should be approved by the board. The report should include results of stress tests in an understandable way to the board and senior management. In one surveyed jurisdiction, the ORSA reports for regulators must be based on an insurers' ERM report to its board. Most of the surveyed authorities expect insurers not to treat climate risk reporting to boards merely as a compliance exercise. On the contrary, climate risk reporting to the board should be used to inform decision-making. A good practice is to require a named senior manager to be responsible for the management of climate risks as this is likely to increase the accountability and ownership of an insurer's actions in response to climate risks. In one of the surveyed jurisdictions, the supervisor discusses the results of climate risk assessments in its periodic meetings with the directors of insurers.

57. **Most of the surveyed supervisors do not use insurers' climate stress test or scenario analysis results when assessing the capital adequacy of insurance firms.** Arguably, the whole point of requiring insurers to assess their climate risk exposures is to prompt them to adjust their business strategy and risk management approaches appropriately. Moreover, it is currently unclear if capital is the right mitigant for climate risks. Nevertheless, a small number of the surveyed supervisors may impose capital add-ons for climate risks that they deem not to be captured in existing capital adequacy requirements.

Regulatory concerns

58. **The surveyed supervisors consider data issues as the biggest regulatory concern surrounding insurers' climate risk models.** This is not only about a lack of data generally, but the lack of data in appropriate formats as well as reliability of the data. See Section 6 for more about the data challenges faced by insurers. Graph 1 shows the ranking of the other regulatory concerns.

Graph 1



Source: FSI survey. The figures in this chart are weighted by the ranking of the greatest concerns as determined by survey respondents.

59. **Another set of concerns relates to the risk of overreliance on external vendors providing risk modelling services**. Assumptions in vendor models are proprietary. They are not usually disclosed by insurance firms to supervisors and may not even be fully disclosed by the vendor to the insurance firm. This hinders firms and supervisors when validating models and assessing the extent to which the model outcomes sufficiently reflect the specific risk characteristics of the insurance firm's exposures. Given that significant business decisions could be made based on the results of such models, it is important to properly validate the models and to engage closely with the vendors to obtain a clear understanding of the models and their outputs. In practice, though, results from vendor models for a particular hazard tend to converge.

60. **One common concern among the surveyed supervisors is that climate risk assessments may be based on overly optimistic assumptions.** As for any other risk type, the need for stress tests and scenarios to seem plausible and reasonable – if only to secure buy-in from boards and senior management – may encourage insurers to use overly optimistic assumptions and relatively mild scenarios. Features specific to climate risks, such as non-linearity, difficulties in estimating frequencies and severities of events, and the fact that the past may not be a good guide to the future may feed into and increase such concerns.

61. **Proper risk quantification could potentially have adverse implications on customers in terms of financial exclusion and reduced insurance coverage.** This could arise if an insurer's climate risk exposure is deemed too high relative to its risk appetite. As a result, insurers could decide to exclude certain coverage, for example, properties exposed to flooding, increase premium rates steeply or completely withdraw from certain business lines. While this may be a sensible prudential outcome and good risk management by insurers, a trade-off will need to be considered at societal and policymaking levels as to whether such an outcome is in line with financial inclusion objectives.

Section 5 – Supervisory tools to assess insurers' climate risk exposures

62. **The Great Financial Crisis of 2007–09 prompted supervisors to enhance their understanding of potential shocks that could adversely impact the financial sector, so as to be better prepared should such risks materialise.** Some insurance supervisory authorities started undertaking stress tests in the insurance industry to assess insurers' resilience to potential adverse situations. Initially, most of the stress tests focused on risks arising from financial market and economic disruptions. Gradually, the exercises turned to other major risks faced by insurers, including assessing resilience against natural disasters and demographic shocks. Currently, some jurisdictions cover weather-related natural catastrophes – such as a concentration of high-intensity Atlantic hurricanes – in stress-testing exercises for general insurers and reinsurers. However, these scenarios may not explicitly consider climate change factors. In addition to revealing potential solvency weaknesses of insurers, stress tests have been useful in raising the industry's awareness of emerging risks, and actions that can mitigate the potential impact of such adverse events before a solvency-relevant event can occur.

63. **In recent years, a growing number of insurance supervisory authorities have started to conduct system-wide stress tests and scenario analyses to assess the impacts of climate-related physical and transition risks on insurers.** These authorities typically specify scenarios that insurers should use in their own risk assessment models. To a lesser extent, an alternative approach followed in certain jurisdictions involves the supervisory authorities themselves running the scenarios in a risk model for each insurer using insurer-specific data from supervisory or public reporting. Box 2 summarises the climate-related stress tests that have been undertaken in the Netherlands.

Box 2

Climate change stress tests in the Netherlands

The Netherlands Bank (DNB), the Dutch central bank, has included climate change considerations in a number of recent stress tests.

Physical risk stress test

In 2017, DNB conducted a stress test that included stresses related to the physical climate risks of a sample of Dutch non-life insurers. The physical risk stress test focused on windstorm frequency and severity as well as hail risk severity. Insurers were asked to model the impacts of a large windstorm event; three medium-sized windstorm events happening in a single year; and a large local extreme weather event occurring in the area where the insurer has the largest concentration risk. The outcomes of the exercise have been discussed with the participating insurers in bilateral meetings.

Transition risk stress test

In 2018, DNB conducted a stress test of Dutch banks, insurers and pension funds, analysing four severe but plausible energy transition scenarios. Each of the scenarios were developed to materialise within five years, to ensure that the stresses are relevant to the firms' decision-making time horizons.

- The policy shock: in this scenario, policies designed to reduce carbon emissions are abruptly implemented, leading to an increase in the carbon price by US$ 100 per ton. This carbon price is modelled as a shock on the prices of coal, oil and gas.
- The technology shock: the technology shock involves a rapid increase in the availability and use of renewable energy, such that the share of renewable energy in the energy mix doubles within five years. The new technology sparks a process of creative destruction whereby old, fossil-fuel dependent technologies are gradually replaced by renewable alternatives, thus resulting initially in capital stock write-offs.

- The double shock: the double shock scenario combines the technology and policy shocks. The carbon price increases by US$ 100 per ton, while technological advances decrease the costs of renewable energy production, devaluing fossil-fuel dependent technologies.
- The confidence shock: this scenario involves modelling uncertainty regarding climate policies and its impact on the confidence of consumers, producers and investors. Here, consumers delay their purchases, businesses invest more cautiously and investors demand higher risk premiums.

DNB provided the impacts on gross domestic product (GDP), consumer prices, interest rates and the global stock prices of each of these scenarios in a stress test report.① To determine the impacts of each of the scenarios on industries that are most reliant on high-carbon activities – and correspondingly, the impact on portfolios of financial institutions investing in such industries – DNB constructed transition vulnerability factors (TVFs). These TVFs translate macroeconomic conditions in each scenario into industry-specific losses, and are published in full in the report.

Stress test framework

The DNB built upon its 2018 stress test to develop a framework for measuring financial stress under disruptive energy transition scenarios.② This framework is designed to be readily used by financial institutions or by prudential supervisors. The framework details the approach of the DNB in constructing scenarios, deriving macroeconomic and industry-specific implications and applying these impacts to financial institutions.

① See Netherlands Bank (2018). ② See Netherlands Bank (2019b).

64. **There are different ways to organise system-wide stress tests within a supervisory agency.** Supervisors can develop and run the stress tests on their own. For example, in the Netherlands, the macroprudential department runs the stress test using microprudential data on insurers' asset holdings. Alternatively, supervisors can partner with specialist risk model providers to undertake stress tests. For example, the California Department of Insurance has engaged a third-party entity to perform a forward-looking scenario analysis of insurers' investments alignment with a low-carbon pathway.

65. **In most jurisdictions, there is no fixed frequency for stress-testing exercises.** Some authorities conduct the tests on an ad-hoc basis, others plan to run the tests annually. The types of insurer that are included in the exercises vary from jurisdiction to jurisdiction. Some authorities include all insurers, while others include only insurers of a certain size, type, or risk exposure (for example, to certain sectors such as agriculture). MAS, for instance, has undertaken an industry-wide stress test on the larger general insurers (representing more than 80% of the market share), focusing on physical risk arising from natural catastrophe (flood) based on historically extreme domestic scenarios. The insurers were also required to provide qualitative assessments on the possible impact of such a scenario on their business lines.

66. **Most supervisory stress tests or scenario analyses cover physical and transition risks but not liability risk.** There could be valid reasons for not capturing liability risk, for example due to the currently insignificant contribution of this risk to insurers' exposures or the difficulty of accurately estimating litigation costs in the absence of legal precedents. Nevertheless, as mentioned in Section 3, care should be taken to avoid any supervisory blind-spots on how climate risks could adversely affect insurers. Future changes in consumer behaviour could sharply heighten liability risk and such a possibility should be considered appropriately by supervisors.

67. **A key step for supervisors in designing a stress test or scenario analysis is to select and design appropriate climate scenarios and the associated variables.** Based upon the experience of supervisors that have run climate stress tests, a common starting point is to refer to the scenarios in the relevant IPCC studies. It is important that the scenarios are relevant to local circumstances. In practical terms, some of the surveyed supervisors would typically prescribe scenarios that are relevant domestically based on past climate-related events, such as flooding in specific geographical areas. Supervisors by themselves may find it difficult to identify useful climate scenarios, as such expertise is not typically found within their organisations. There is a need to draw on the expertise of other specialists in this domain, for

example, climate scientists and meteorology specialists, in coming up with plausible and useful climate scenarios. Box 3 summarises a climate stress-testing exercise in the United Kingdom.

Box 3

Climate change scenarios in the UK Prudential Regulation Authority insurance stress test

The Bank of England has indicated that climate change presents far-reaching financial risks that are eminently foreseeable.① As part of its response to financial risks posed by climate change, the Prudential Regulation Authority (PRA) has included exploratory climate change scenarios into its biennial insurance stress test (IST).

The PRA has asked large life and non-life insurers to explore – on a best-efforts basis – their exposures to the physical risks of climate change as well as risks associated with the transition to a low-carbon economy. Mark Carney, Governor of the Bank of England, stated that such exploratory scenarios can "help supervisors and climate policymakers judge the adequacy of the current transition and whether further actions could be expected".②

Three exploratory scenarios

The PRA specified three climate change scenarios and requested insurers to consider the impact of each scenario on selected metrics of their business models and asset valuations:

- The first scenario involves a sudden, disorderly transition to a low-carbon economy. This scenario is based on the disorderly transitions described in the IPCC Fifth Assessment Report (2014).
- The second scenario also involves maximum temperature increases being kept well below 2°C, via a long-term, orderly transition, in line with the Paris Agreement. The underlying assumptions for this scenario are based on scenarios within the IPCC Special Report on Global Warming of 1.5°C (2018).
- The third scenario, focusing on physical risks inherent in failing to make improvements in climate policy in the future, involves no transition. This scenario considers temperature increases of 4°C above pre-industrial levels by 2100.

The point in time at which the shocks occur differs for each scenario, with the illustrative potential impacts occurring in 2022, 2050 and 2100. However, the shock is designed to be applied to assets and liabilities of insurance companies as at 31 December 2018. Firms were asked to apply the scenarios to their current balance sheets and not roll forward the value of asset prices in the future, to ensure consistency in assessing the impacts across firms.

A second section of the PRA IST on climate change included a request for information on assumptions and parameters relating to the work that firms have already undertaken to assess the financial impacts of climate change. The PRA requested information on climate scenario assumptions that firms employed (including timing, temperatures and policy initiatives involved) and how these scenarios were translated into material business impacts (such as impacts on asset valuations by investment class and on the valuation of insurance liabilities).

Impacts on investments for physical and transition risk

The impacts on investments from both physical and transition risks of the PRA's climate change scenarios are detailed in the IST. The PRA provided a set of assumptions in a table, enabling firms to quantify the impacts of each scenario using simple metrics.

Further to this, the granular shocks designed in the PRA IST can be applied using the 2° Investing Initiative PACTA tool (see Annex 2). This open-source tool allows users to input their investment exposures to different sectors and calculate the effect of the climate stress test on the value of their portfolios.

Engagement with experts

In addition to liaising with the 2° Investing Initiative to modify the PACTA tool for use in the IST, the PRA engaged with academics, consultants and modellers to develop the three climate change scenarios. The assumptions underlying each of the scenarios were developed based on the PRA's interpretation of available literature and

engagement with the experts. Each source was acknowledged in the IST report. The PRA also sought input from industry, requesting technical input via email and through roundtables held in 2019.

Other supervisory tools

In addition to covering climate change factors in the IST, regulators in the United Kingdom utilised other supervisory tools to encourage immediate action in responding to climate risks. Combined with speeches from senior figures at the Bank of England and the PRA, a Supervisory Statement③ from the PRA provided clarity of its expectations on the industry and assisted firms in developing a strategic approach that considered how actions today might affect future financial risks. The PRA also supported the non-life insurance sector by releasing a framework for assessing financial impacts of physical climate change.④ This framework explains how non-life insurers can utilise and tailor expert judgment, hazard maps, footprints and catastrophe models in undertaking climate risk assessments.⑤

① See Bank of England (2019c). ② See Bank of England (2019a). ③ Bank of England (2019b). ④ See Bank of England (2019e). ⑤ See Bank of England (2019f).

68. **The types of variable that are typically stressed in a supervisory stress test are similar to those used in tests conducted by insurers.** Examples of variables that are stressed include:

- Transition risk: asset values; and
- Physical risk: total risk exposure, frequency and severity of claims, asset values, aggregate exceedance probability, occurrence exceedance probability.

See Annex 4 for examples of stress test factors used in the UK IST.

69. **Given that climate risk assessment is a relatively new topic for many supervisors, supervisory stress tests are used mainly as a tool to enhance understanding rather than as input for supervisory actions.** None of the surveyed jurisdictions currently use stress test results to impose supervisory actions or adjust capital requirements. The surveyed supervisors seek to achieve the following aims through insights gathered from supervisory stress tests or scenario analyses:

- identify the level and concentration of risk exposure of insurers;
- increase awareness of climate risk exposure to prompt action eg divestment from coal investments;
- provide basis for discussion with industry and individual insurers on potential risk mitigation actions against climate risks;
- serve as an input into the supervisory risk rating process of an insurer; and
- evaluate climate risks on aggregate basis at national level.

70. **As a measure to ascertain the reliability of the stress test results, supervisors typically undertake certain reasonableness checks.** This is particularly important for climate risk stress tests given the significant uncertainties about future climate-related assumptions. Examples of reasonableness checks that supervisors can undertake include the following:

- check the supervisory stress tests assumptions and results against information on climate risks in insurers' ORSAs;
- ask insurers to explain underlying modelling assumptions;
- review consistency of assumptions from year to year to assess comparability of results;
- consider if movements of stress test results over time are reasonable;

- compare methodologies (benchmarking) across insurers to identify outlier insurers that may have assumed overly optimistic scenarios;
- compare different sets of related data such as the reported total climate-related exposure and claims against insurers' business profiles;
- review governance process surrounding risk modelling:
- require submission of model validation report or evidence (in one jurisdiction, the model validation is done by the ministry of agriculture);
- compare results between internal and external models, where available; and
- for insurers with approved internal models for capital purposes, assess how climate risks are considered in the models.

71. **In addition to or instead of conducting quantitative risk assessment of insurers' climate risk exposure, supervisors can employ other qualitative tools to gain a better understanding.** For example, in Belgium, the authority did not a perform stress test and instead mapped insurers' investment portfolio to exposures to greenhouse gas-intensive sectors. It also published statistics[36] on (banks' and) insurers' exposures to physical and transition risks including reported claim amounts related to extreme weather. In California, under the Climate Risk Carbon Initiative, insurers were required to report their fossil fuel investments in order to identify potential stranded assets. The European Insurance and Occupational Pensions Authority (EIOPA) has also published information on climate-related asset exposures of the European insurance sector.[37] Such exercises are useful in sizing up the potential problem faced by insurers.

72. **It is important to acknowledge that supervisors may have specific aims when conducting stress tests or scenario analyses on climate risks, which may determine the focus, design and calibration of the exercise.** In other words, there is no one-size-fits all approach to supervisory stress testing or scenario analysis. Each exercise needs to be tailored to meet the supervisor's objectives. For example, a stress test on transition risk can focus solely on the impact of potential change in government policy on carbon taxation. Alternatively, the stress test can seek to identify broader impacts of future climate scenarios on an insurer's risk profile.

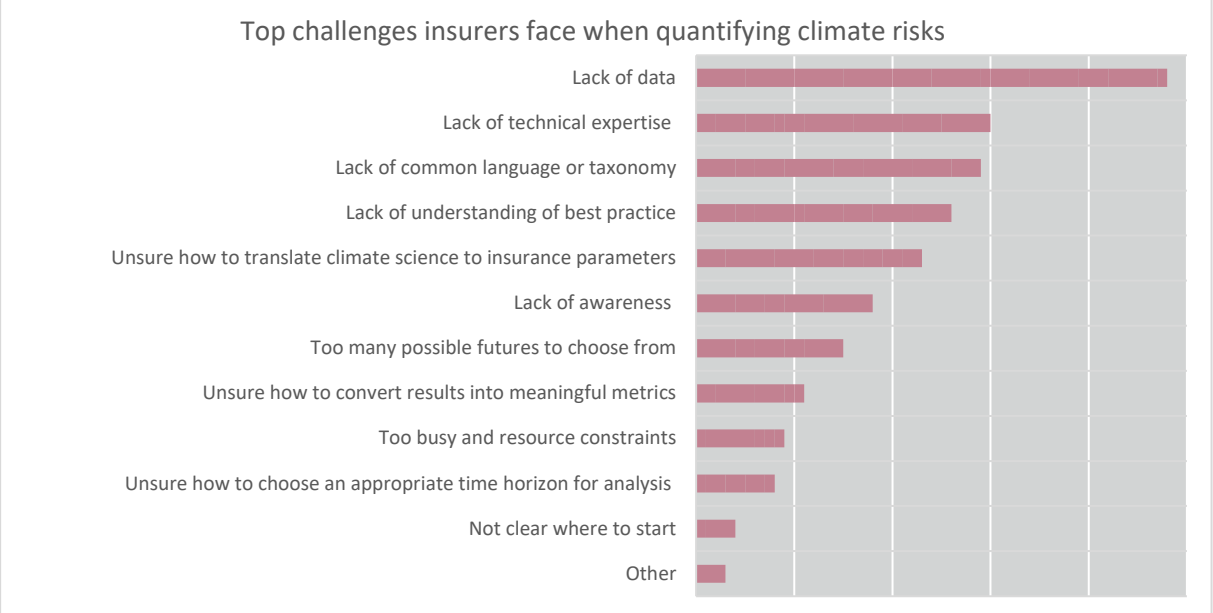
[36] See National Bank of Belgium (2019).

[37] See European Insurance and Occupational Pensions Authority (2018).

Section 6 – Challenges in climate risk assessment

73. **Challenges that insurers face in assessing climate risks can be categorised into data and methodology, expertise and resource, and governance issues.** Graph 2 shows the ranking of these challenges based on the views of the surveyed authorities.

Graph 2



Source: FSI survey. The figures in this chart are weighted by the ranking of the most challenging options as determined by survey respondents.

Data and methodology challenges

74. **The main challenge that insurers face in assessing their climate risk exposures relate to data.** The issue is not only about lack of data but also their form, relevance and consistency. Rather than the absence of data, the issue is often that data are not directly usable and/or lack granularity. While data on climate events may have been collected for decades, in particular for some types of extreme weather event, this is not necessarily the case for other sources of climate risks. For instance, although data on the carbon-intensity of specific sectors might be available, these are likely to be estimates and/or national averages. Because they lack granularity, their use may be limited for an insurance firm attempting to assess the risks of specific investments. Some concrete examples of data deficits include the following:

- key metrics driving climate risks such as records of greenhouse gas emission and energy certifications of real estate portfolios;
- reliable forecasts of socio-economic and customer behaviour changes due to climate change;
- risk exposure amounts of insurers, for example investee entities' and insured's reliance on carbon-intensive business activities.

Until further progress is made by the relevant national agencies, public bodies and the industry to improve data availability, reliance on estimates derived from averages and adjusted through expert judgment will be unavoidable.

75. **Even where historical data exists, past insurance claims and climate data may not be a good predictor of future climate-related risk exposures.** The relevance of historical claims data may be limited due to rapidly changing weather patterns arising from climate change, as well as the risk exposure of insurers. For example, a large increase in population and building density in geographical areas exposed to climate perils would considerably limit the usefulness of past climate data. Even more difficult is to forecast potential societal and policy changes in response to climate change that may quickly render historical climate-related data irrelevant.

76. **The absence of industry standards, established practices and mature methodologies for climate risk assessment as well as a lack of globally accepted nomenclature or taxonomies is another challenge.** The lack of industry standards on climate scenarios, model assumptions, output requirements and the lack of a globally accepted framework for climate risk assessment are typical of a discipline still in its infancy. Most of the surveyed supervisory authorities emphasised that such issues alongside a lack of expertise, uncertainties regarding where to start or how to select appropriate scenarios were among the main challenges facing insurance firms under their supervision.

77. **Setting appropriate climate-relevant assumptions is difficult and validating them perhaps even more so, especially in the absence of benchmarks and tools allowing for comparisons.** In setting assumptions for their risk models, firms may need to engage with internal and external experts and use expert judgment. The range of experts who may need to be consulted could be wide – depending upon a firm's lines of business, its investment portfolio and the scope of its international activities. Moreover, expert advice may itself need to be assessed and evaluated, especially when expert views may be contradictory or not entirely consistent.

78. **Another challenge relates to adjusting risk modelling approaches to allow for longer time horizons.** For example, assessing the impact of transition risks over multiple decades is needed in order to capture socio-economic, legal and political trends. Here also, firms and authorities may have limited experience in assessing cumulative effects of climate change over the long term, for example the effects of long periods of droughts on buildings.

Expertise and resource challenges

79. **Most firms and public sector authorities, even in advanced economies, have limited expertise in translating potential climate futures into stress factors.** It is challenging to select which climate-related metrics to use when determining stresses or variables. For example, it is not easy to select between different greenhouse gas emission pathways, temperature targets, or energy mix benchmarks as each metric has its own merits. Nevertheless, it may be useful to consider a wide range of metrics, within resource constraints, in order to capture various future climate possibilities.

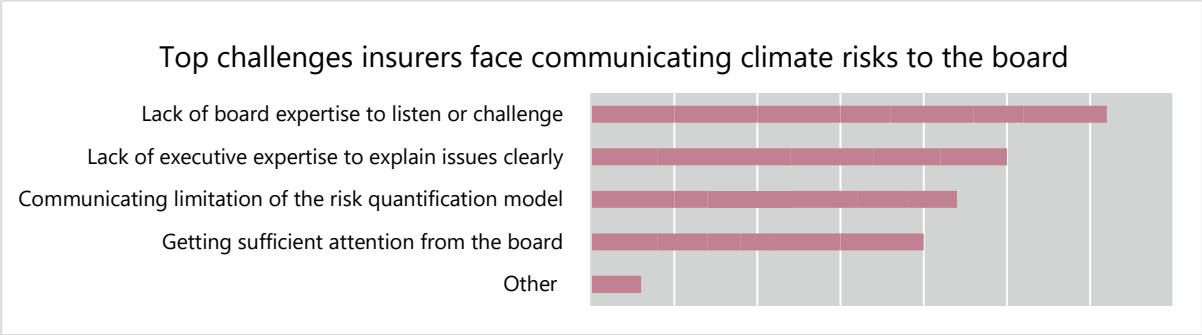
80. **Skills shortages both within insurers and insurance authorities may explain reliance on external models and highlight the need to pool efforts and optimise limited resources.** Weather and climate experts with risk assessment and modelling skills are scarce. They are in huge demand worldwide not only from insurance firms and insurance authorities, but also from banking firms and their supervisory authorities, from commercial and industrial firms, from large institutional investors and from government climate agencies. Even expertise more closely related to insurance activities, such as natural catastrophe modellers with climate expertise, may be scarce. Efforts to close skill gaps include regulator-industry partnerships, sharing of technical expertise among regulators and the development of training and qualifications programmes. An example of a joint effort between supervisory authorities and the industry is the Climate Financial Risk Forum (CFRF) that was set up in March 2019 in the United Kingdom and co-chaired by the Financial Conduct Authority and the PRA. The CFRF brings together senior representatives from across the financial sector, including banks, insurers and asset managers, with the aim of building capacity and sharing best practice publicly. In other jurisdictions, other efforts include liaising with

government agencies and ministries to better understand climate risks and improve scenarios with examples including consultations with ministries of agriculture and environment, and with climate centres.

Governance challenges

81. **Within an insurer, communicating climate risks to the board can raise various types of challenge.** While a number of jurisdictions mentioned that communicating climate risks to boards is itself a challenge, others pointed out that the topic is increasingly discussed at board level but that such discussions may often be inconclusive. Reasons for this include lack of technical expertise from executives that may limit their ability to present issues clearly and limited board member expertise that may hamper their ability to understand and challenge senior management during such discussions. Communicating the limits of risk quantification models, and therefore explaining to board members and senior executives to what extent quantifications may be imprecise and/or imperfect is particularly challenging. All these could hinder informed decision-making, allocation of internal resources to address climate risks and, more generally, board members' and senior executives' ability and willingness to take appropriate action to address climate risks. Graph 3 shows challenges that insurers face in communicating climate risks to boards of directors.

Graph 3



Source: FSI survey. The figures in this chart are weighted by the ranking of the most challenging options as determined by survey respondents.

Section 7 – Concluding remarks

82. **Climate change is creating new financial risk exposures to insurers primarily through physical and transition risks.** Failure to fully grasp the potential impact of climate risks on insurers and how this could impact their ability to honour their obligations to policyholders is a real threat to prudential mandates of insurance supervisors.

83. **There has been growing momentum by insurers, supervisors and international bodies to improve understanding of the nature of climate risks and the associated risk assessment techniques.** Nevertheless, there is more work that needs to be done within a limited time window to take the necessary steps to seek to avert potential devastating climate scenarios. Certain industry commentators have said that widespread industry mobilisation and targeted collaboration among all industry players is crucial in order to overcome the climate challenge.

84. **Efforts to further develop cross-jurisdictional cooperation, common understandings and, ultimately, common industry practices and standards are welcomed**. Standard-setting bodies and other climate-related forums can play a key role in facilitating advancements in the field of climate risk assessment. There is scope to coordinate industry and supervisory efforts, for example in the area of

converting future climate possibilities into financial metrics. Such efforts could optimise scarce resources and potentially facilitate better comparability of across insurers. Taking this a step further, a more common approach in assessing climate risks could facilitate more comparable disclosure by insurers. This would satisfy demands for greater transparency and comparability from multiple stakeholders including supervisors in the different jurisdictions.

85. **Existing principles-based regulatory ERM requirements can be applied to climate risks but clear supervisory expectations should be expressed to provide certainty to insurers.** All the surveyed supervisory authorities expect insurers to capture climate risks in their ERM frameworks despite not prescribing binding rules. Specifically, insurers are expected to assess their climate risk exposures through ORSAs. Importantly, unlike other financial risks typically captured in ERM frameworks for which insurers can recapitalise in the aftermath of losses, it is difficult to unwind the impact of climate risks on an insurer's financial position.

86. **Climate risks are analytically challenging to assess and quantify as climate systems and their interaction with the financial sector are complicated.** Currently, risk assessment techniques for climate risks are not well developed. A major challenge relates to data issues. Even where data may be available, they can become obsolete quickly due to rapidly changing climate trends. Another key challenge is the lack of technical expertise to assess climate risks. There are calls from insurance supervisors for more support to hone technical expertise in the industry and regulatory authorities so that climate risks can be modelled and assessed more accurately.

87. **Despite technical and operational challenges in undertaking climate risk assessment by insurers and supervisors, it is important to take the first step while recognising that initial efforts will not be perfect.** Climate risk assessment is one area that supervisors may need to be more flexible in accepting insurers' need to improve so as to incentivise insurers to start addressing climate risks now. From a supervisory perspective, very few supervisory authorities currently undertake risk assessment exercises (stress test or scenario analysis) that might be helpful to understand how potential climate futures could impact insurers.

88. **More studies and technical references are becoming available to help supervisors undertake such exercises including through the work of international bodies such as the SIF and the IAIS in the insurance sector.** The IAIS has listed climate risks as one of its key strategic priority areas in the coming years, following publication of the ground-breaking IAIS-SIF Issues Paper in 2018,[38] the first supervisory material published by an international financial standard-setting body. At the time of publication of this paper, the IAIS and the SIF are developing an issues paper on climate risk disclosure by insurers. Other bodies such as the NGFS and the IAA could support insurance supervisors by providing guidance on how technical professionals can go about undertaking climate-informed risk assessments. Consideration should be given to leverage advancements in technology, eg use of big data, machine learning to improve risk quantification techniques.

89. **It remains unclear if capital adequacy requirements are appropriate to address climate risk exposures of insurers.** Climate risk scenario analyses or stress tests undertaken by supervisors are not currently aimed at determining any capital buffers that might be required against longer-term climate risk exposures. Rather, they are used as a learning tool to help insurers prepare themselves for potential future climate scenarios. Some industry commentators view climate risks as impacting earnings more than capital. Linked to capital consideration is whether insurers need to consider climate risks when valuing insurance liabilities. This is a controversial area that requires further thought.

90. **As climate risk quantification techniques mature and insurers' risk assessment become more accurate, certain policy issues will need to be carefully considered.** This includes potential financial exclusion consequences if insurers no longer provide certain insurance coverage or only at very

[38] See International Association of Insurance Supervisors and Sustainable Insurance Forum (2018).

high prices. Going forward, supervisors and relevant coalitions may seek to explore implications of enhanced climate risk quantification on affordability and availability of insurance products. A global roundtable comprising standard-setting bodies, climate-related forums, insurance supervisors, insurers, risk modellers, climate scientists and other relevant professionals could be useful in taking this agenda forward. The roundtable could discuss how to sequence regulatory and supervisory actions to improve climate risk assessment capabilities, the support that standard-setting bodies and climate-related forums can provide and cross-sectoral issues that could benefit from coordinated actions.

91. **Supervisors and insurers can take action to increase their understanding and capacity to respond to climate risks now.** Further reading on climate risk stress testing and scenario analysis is available in the annexes of this paper, including an overview of available climate risk models and details of the stress factors used in the PRA's insurance stress tests. As well as disseminating this paper within their organisation, supervisors and insurers may seek further training on climate risk, such as the FSI Connect tutorial *Climate Risks – Implications for the Insurance Sector*.[39] In addition, supervisors should consider engaging established international groups such as the SIF and NGFS to share learnings, broaden their climate risk networks and benefit from the experiences of other jurisdictions.

[39] FSI Connect is the BIS's e-learning tool that is available to financial sector authorities and central banks worldwide. It can be accessed at www.fsiconnect.org.

References

2° Investing Initiative (2019): *Bank of England insurance stress-test*, July.

Aviva Group plc (2018): *Climate related financial disclosure.*

Australian Prudential Regulation Authority (2019): *Climate change awareness to action*, 20 March.

Bank of England (2015a): *The impact of climate change on the UK insurance sector*, 29 September.

——— (2015b): *Breaking the tragedy of the horizon – climate change and financial stability*, 29 September.

——— (2017): "The Bank's response to climate change", Quarterly Bulletin Q2, 16 June.

——— (2018): *Transition in thinking - The impact of climate change on the UK banking sector*, 26 September.

——— (2019a): "A new horizon", 21 March.

——— (2019b): *Supervisory Statement SS3/19 Enhancing banks' and insurers' approaches to managing the climate financial risks from climate change*, 15 April.

——— (2019c): *Insurance Stress Test 2019: Request for technical input*, 15 April.

——— (2019d): "Avoiding the storm: Climate change and the financial system", 15 April.

——— (2019e): *A framework for assessing financial impacts of physical climate change: A practitioner's aide for the general insurance sector*, 22 May.

——— (2019f): *Insurance Stress Test 2019*, 18 June.

Bolton, P, M Depres, L A Pereira da Silva, F Samama, R Svartzman (forthcoming): "Climate change and financial system stability: what role for central banks, regulators and supervisors?".

Breakthrough – National Centre for Climate Restoration (2019a): *Existential climate-related security risk: A scenario approach*, May.

——— (2019b): *The third degree: Evidence and implications for Australia of existential climate-related security risk*, July.

California Department of Insurance (2009): *NAIC Climate Risk Disclosure Survey*.

——— (2018): *NAIC Climate Risk Disclosure Survey*.

Cambridge Institute for Sustainability Leadership (2019): *Transition risk framework: Managing the impacts of the low carbon transition on infrastructure investments*, February.

——— (2019): *Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios*, February.

Carbon Tracker (2011): *Unburnable carbon: Are the world's financial markets carrying a carbon bubble?*, July.

Ecological Economics (2018): *Coping With Collapse: A Stock-Flow Consistent Monetary Macrodynamics of Global Warming*, May.

EU High-Level Expert Group (2018): *Final report of the High-Level Expert Group on Sustainable Finance*, 31 January.

European Insurance and Occupational Pensions Authority (2018): *Financial Stability Report*, December.

Financial Supervisory Authority, Sweden (2018): *Stability in the Financial System*, November.

Global Commission on Adaptation (2019): *Adapt now: A global call for leadership on climate resilience*, September.

Institute for Energy Economics and Financial Analysis (2019a): *IEEFA update: The global energy transformation is well underway*, May.

——— (2019b): *ExxonMobil's fall from the S&P 500 top ten: A long time coming*, August.

Institute for Public Policy Research (2019): *This is a crisis: Facing up to the age of environmental breakdown*, February.

Intergovernmental Panel on Climate Change (2018a): *Global Warming of 1.5°C: Headline Statements from the Summary for Policymakers*, October.

——— (2018b): *Special Report: Global Warming of 1.5°C*, October.

——— (2019): *Special report on the ocean and cryosphere in a changing climate*, September.

International Actuarial Association (2013): *Stress testing and scenario analysis*, July.

International Association of Insurance Supervisors (2019): *Insurance Core Principles*, November.

International Association of Insurance Supervisors and Sustainable Insurance Forum (2018): *Issues paper on climate change risks to the insurance sector*, July.

International Energy Agency and International Renewable Energy Agency (2017): *Perspectives for the energy transition – Investment needs for a low-carbon energy system*, March.

Kepler Cheuvreux (2014): *Stranded assets, fossilised revenues*, April.

Munich Re (2019): *The natural disasters of 2018 in figures*, 8 January.

National Bank of Belgium (2018): *Financial Stability Report 2018*, June.

——— (2019): *Financial Stability Report 2019*, June.

Nature Climate Change (2016): *Climate value at risk of global financial assets*, April.

Nature Research (2015): *The geographical distribution of fossil fuels unused when limiting global warming to 2°C*, January.

——— (2019): *Permafrost collapse is accelerating carbon release*, May.

Netherlands Bank (2017): *Waterproof? An exploration of climate-related risks for the Dutch financial sector*, October.

——— (2018): *An energy transition risk stress test for the financial system of the Netherlands*.

——— (2019a): *Values at risk? Sustainability risks and goals in the Dutch financial sector*, January.

——— (2019b): *The Heat is on: A framework measuring financial stress under disruptive energy transition scenarios*, February.

Network for Greening the Financial System (2018): *First progress report*, October.

——— (2019): *First comprehensive report: A call for action*, April.

Principles for Responsible Finance (2019): *The Inevitable Policy Response: Policy Forecasts, September.*

Summerhayes, G (2019a): "Financial Exposure: Climate Data Deficit", 22 February.

——— (2019b): "Buy now or pay later", 21 June.

Task Force on Climate-related Financial Disclosure (2016): *Technical supplement: The use of scenario analysis in disclosure of climate-related risks and opportunities*, 14 December.

——— (2017): *Final report*, June.

United Nations (2018): *The Paris Agreement*, October.

United Nations Environment Programme (2016): *The financial system we need: From momentum to transformation*, September.

United Nations Environment Programme Finance Initiative (2019): *Changing course: A comprehensive investor guide to scenario-based methods for climate risk assessment, in response to the TCFD*, May.

University of Oxford (2014): *Stranded generation assets: Implications for European capacity mechanisms, energy markets and climate policy*, January.

Annex 1 – List of authorities that participated in survey

1. Superintendencia de Seguros de la Nación, Argentina
2. Australian Prudential Regulation Authority, Australia
3. National Bank of Belgium, Belgium
4. Office of the Superintendent of Financial Institutions, Canada
5. Financial Regulatory Authority, Egypt
6. Autorité de Contrôle Prudentiel et de Résolution, France
7. Bundesanstalt für Finanzdienstleistungsaufsicht, Germany
8. National Insurance Commission, Ghana
9. Central Bank of Ireland, Ireland
10. Istituto per la Vigilanza sulle Assicurazioni, Italy
11. Netherlands Bank, Netherlands
12. Reserve Bank of New Zealand, New Zealand
13. Monetary Authority of Singapore, Singapore
14. Prudential Authority, South Africa
15. Finansinspektionen, Sweden
16. Bank of England and Prudential Regulation Authority, United Kingdom
17. California Department of Insurance, United States of America (California)
18. Office of the Insurance Commissioner, United States of America (Washington State)

Annex 2 – Overview of selected climate risk models

Comparison of selected climate risk models — Table A.1

	Paris Agreement Capital Transition Assessment (PACTA)	Climate Value-at-Risk	Cambridge Institute for Sustainable Leadership (CISL) Transition and Physical Risk Frameworks
Free or paid	Free	Paid	Free
Developer	2 Degrees Investing Initiative	Carbon Delta	CISL ClimateWise
Objective of model	Used to analyse exposure to transition risks in equity and fixed income portfolios under multiple scenarios	Used to calculate aggregate costs related to specific climate risks over the next 15 years	Enable investors and regulators to manage risks and capture emerging opportunities from low carbon transition
Risk coverage	• Transition risks in public equity and corporate bond portfolios • Covers asset classes in energy (fossil fuels), power, transport (light-heavy duty vehicles, aviation, shipping), and industrial sectors (cement, steel)	• Physical and transition risks • The risk of extreme weather events relating to heat, cold, wind, precipitation, snowfall, wildfires and hurricanes • The risk for companies to comply with emissions limitations if a global goal to prevent no more than 3°C, 2°C or 1.5°C of warming is implemented	• Physical and transition risks • Transition risk framework focuses on infrastructure investments (power asset, water infrastructure, transport, telecommunications infrastructure)
Target audience	Investors seeking to understand the gap between their existing investment portfolio and two-degree benchmarks	Investors seeking to understand climate change resilience of publicly traded companies	Investors and lenders
Overview of model structure	• The model allows for a range of scenarios to be used as benchmarks to assess alignment to 2°C future • Economic scenarios are translated to specified asset classes • The model calculates an expected benchmark exposure for each sector based on information regarding the location, capacity or production, technology, fuel mixture and ownership of each asset in the specific asset class • A portfolio can then be compared against a median portfolio across technology sectors and its alignment with a 2°C benchmark	• The tool calculates the economic effects of climate change on the underlying business model of thousands of companies by developing a detailed analysis of emission reduction requirements in forthcoming regulations, technology opportunities and changing physical climate conditions.	• Transition risk framework: 1. assess the breadth of asset types exposed to transition risk and opportunity across an investor's portfolio (across different subsectors, regions and time frames) 2. define the potential financial impact from the low carbon transition down to an asset level • Physical risk framework: 1. Collect data on physical assets to determine exposure

Annex 3 – Examples of scenarios, risk coverage and target audience of selected risk models for physical and transition risks

Examples of physical risk assessment models

Table A.2

	Scenarios				Risks		Physical risk impact assessment: Macro			Supply chain			Operations			Market			Output		Counter-parties			
Provider	<2°C	2°C	3°C	≤4°C	Policy	Technology	Exposure	Sensitivity	Adaptive capacity	Exposure	Sensitivity	Adaptive capacity	Exposure	Sensitivity	Adaptive capacity	Exposure	Sensitivity	Adaptive capacity	Quantitative	Qualitative	Facility	Firm	Sector	Country
427				✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓			✓	✓	✓	✓	✓
Acc 1		✓		✓	✓	✓				✓	✓		✓	✓					✓			✓	✓	
Acc 2				✓	✓	✓							✓	✓						✓	✓			
C4		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓			✓	✓	✓	✓	✓
CD				✓	✓	✓							✓	✓					✓		✓	✓	✓	✓
CW		✓		✓	✓								✓	✓	✓				✓		✓		✓	✓
Mer		✓	✓	✓	✓	✓	✓	✓			✓		✓	✓					✓				✓	
MIS			(✓)		✓		✓	✓	✓											✓				✓
OF	✓	✓		✓	✓	✓	✓	✓	✓										✓				✓	✓

Legend: 427 – Four Twenty Seven physical risk scores; Acc 1 – Acclimatise for UNEP FI Banking Pilot; Acc 2 – Acclimatise Aware for Projects; C4 – Carbone 4 Climate Risk Impact Screening (CRIS); CD – Carbon Delta Climate Value at Risk; CW – ClimateWise (with Vivid Economics) Managing the physical risks of climate change; Mer – Mercer TRIP framework; MIS – Moody's Investors Service sovereign risk ratings; OF – Ortec Finance – Climate-savvy scenarios set.

Source: Adapted from Vivid Economics.

Examples of transition risk assessment models

Table A.3

							Transition risk impact assessment																	
	Scenarios				Risks		Macro			Supply chain			Operations			Market			Output		Counter-parties			
Provider	<2°C	2°C	3°C	>4°C	Policy	Technology	Exposure	Sensitivity	Adaptive capacity	Exposure	Sensitivity	Adaptive capacity	Exposure	Sensitivity	Adaptive capacity	Exposure	Sensitivity	Adaptive capacity	Quantitative	Qualitative	Facility	Firm	Sector	Country
2dii		✓			✓	✓							✓	✓						✓	✓	✓		
C4		✓	✓		✓	✓					✓			✓	✓		✓			✓		✓	✓	
CD	✓	✓	✓		✓	✓							✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
CT	✓	✓			✓	✓							✓			✓	✓		✓		✓	✓	✓	
Mer		✓	✓	✓	✓	✓							✓	✓		✓			✓				✓	
MIS			✓		✓	✓	✓	✓	✓										✓					✓
OF	✓	✓		✓	✓	✓	✓	✓	✓										✓				✓	✓
OW		✓			✓	✓				✓	✓		✓	✓		✓	✓	✓	✓				✓	✓
Sch					✓					✓	✓		✓	✓			✓	✓	✓			✓	✓	
TPI		✓	✓		✓	✓								✓						✓		✓	✓	
Tru		✓	✓		✓	✓							✓	✓				✓	✓			✓		
VE 1		✓			✓	✓	✓	✓	✓										✓				✓	✓
VE 2		✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	

Legend: 2dii – 2 degrees Investing Initiative PACTA tool; C4 – Carbone 4 Carbon Impact Analytics; CD – Carbon Delta Climate Value at Risk; CT – Carbon Tracker 2 degrees of separation; Mer – Mercer TRIP framework; MIS – Moody's Investors Service sovereign risk ratings; OF – Ortec Finance – Climate-savvy scenarios set; OW – Oliver Wyman for UNEP FI Banking Pilot; Sch – Schroders – Carbon Value at Risk; TPI – Transition Pathways Initiative TPI Tool; Tru – Trucost Carbon Earnings at Risk; VE 1 – Vivid Economy-Wide; VE 2 – Net-Zero Toolkit.

Source: Adapted from Vivid Economics.

Annex 4 – Examples of stress factors used in insurance stress tests in the United Kingdom

Scenario A: A sudden transition from rapid global action and policies, and materialising over the medium-term business planning horizon that results in achieving a temperature increase of less than 2°C (relative to pre-industrial levels) but only following a disorderly transition.

Scenario B: A long-term orderly transition scenario that is broadly in line with the Paris Agreement involving a maximum temperature increase well below 2°C (relative to pre-industrial levels) with the economy transitioning over the next three decades to achieve carbon neutrality by 2050 and greenhouse-gas neutrality in the decades thereafter.

Scenario C: A scenario in which there is no future improvement in climate policy, resulting in temperature increase of more than 4°C (relative to pre-industrial levels) by 2100, assuming no transition and continuation of current policy trends.

Impacts of physical risks on general insurers' liabilities — Table A.4

		Physical risks scenario		
Sector	Assumptions	A	B	C
US hurricane-exposed lines of business	% increase in frequency of major hurricanes	5%	20%	60%
	Uniform increase in wind speed of major hurricanes	3%	7%	15%
	% increase in surface run-off resulting from increased tropical cyclone-induced precipitation (cumecs)	5%	10%	40%
	Increase in cm in average storm tide sea-levels for US mainland coastline between Texas and North Carolina	10cm	40cm	80cm
UK weather-exposed lines of business – flood, freeze and subsidence	% increase in surface run-off resulting from increased precipitation (cumecs)	5%	10%	40%
	Uniform increase in cm in average storm tide sea-levels for UK mainland coastline	2cm	10cm	50cm
	Increase in frequency of subsidence-related property claims using as benchmark the worst year on record	3%	7%	15%
	Increase in frequency of freeze-related property claims using as benchmark the worst year on record	5%	20%	40%

Impacts of physical and transition risks on life and general insurers' investments (selected sectors only shown here) Table A.5

			Transition risks scenario			Physical risks scenario		
Sector	% of investment portfolio in following sectors	Assumptions	A	B	C	A	B	C
Fuel extraction	Gas/coal/oil (including crude)	Change in equity value for sections of investment portfolio comprising material exposure to the energy sector as per below:						
		Coal	–45%	–40%	-	-		
		Oil	–42%	–38%	-	-		
		Gas	–25%	–15%	-	-		
							–5%	–20%
Power generation	Power transmission and delivery of natural gas and renewables (production and transmission)	Coal	–65%	–55%	-	-		
		Oil	–35%	–30%	-	-		
		Gas	–20%	–15%	-	-		
		Renewables (including nuclear)	+10%	+20%	-	-		
							–5%	–20%