



BANK OF ENGLAND
PRUDENTIAL REGULATION
AUTHORITY

Climate-related financial risk management and the role of capital requirements

Prudential Regulation Authority

Climate Change Adaptation Report 2021

28 October 2021

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Foreword



Climate change and the transition to net-zero emissions will affect our planet, our economy and our financial system. As a prudential regulator, it is our job to ensure that UK banks and insurance companies are prepared for these changes and able to play their part in supporting the transition.

Over the past two years, our daily lives have been upended by the Covid-19 pandemic, and the authorities and the financial sector had to step up to support the flow of finance to the real economy.

Climate change requires us to take an equally ambitious approach, and a proactive response is needed to ensure financial institutions are resilient to the financial risks from climate change and able to support an economy-wide transition to net-zero emissions. Delivering against this is a priority for the Prudential Regulation Authority (PRA) and the wider Bank of England.¹

This is the second climate change adaptation report we have produced. Our first report in November 2015 set out our findings on the impact of climate change on the UK insurance sector², and kicked off our climate work. As illustrated by this report, we have made significant progress since that publication.

In April 2019, we became the first financial regulator to publish a set of supervisory expectations for banks and insurers on their management of climate-related financial risks. A year later in July 2020, I wrote to the CEOs of those firms to provide additional guidance and feedback on industry-wide progress. Recognising the significant challenges firms face in developing effective climate-related financial risk management capabilities, we have helped accelerate this process by working with them through industry groups like the Climate Financial Risk Forum.

We have seen good progress to date on our supervisory expectations across a number of dimensions. As an example, when we started our work on climate change six years ago, if I asked the CEO of a bank or insurer what they were doing on climate change, they would typically mention their Corporate Social Responsibility department. Today when I ask them, they increasingly talk to their firm-wide strategy, investment they are making in climate data analysis, and how they are supporting their clients through the transition. This is a

¹ The Bank of England's climate strategy is set out in the [2020/21 climate-related financial disclosure report](#).

² The PRA submitted its first climate change adaptation report on [the impact of climate change to the UK insurance sector](#), as part of the second round of adaptation reporting powers by DEFRA.

huge change, but there is still much further to go and some firms have demonstrated more ambition than others.

Just as firms must embed our supervisory expectations on climate change, the PRA is also embedding climate change into its supervisory approach from the end of this year. This means that firms will need to demonstrate their ability to understand and manage climate-related financial risks on an ongoing basis, making further improvements with time. As we enter 2022, where firms have not kept pace with our expectations we will stand ready to respond with our supervisory and regulatory toolkit.

A key part of our normal regulatory toolkit is capital requirements. We set these requirements to ensure firms have sufficient resources to help absorb financial losses over time. This supports their safety and soundness and contributes to protecting depositors and insurance policyholders. The report explores the links between climate change and the regulatory capital framework, with the aim of accelerating research to inform our future approach. We find that regulatory capital is not the right tool to address the causes of climate change (greenhouse gas emissions), but should have a role in dealing with its consequences (financial risks). Further work is required to identify whether changes in the design, use or calibration of the regulatory capital framework are needed to ensure resilience against those consequences. To help address this, we will work with our international partners, put out a call for research, and host a conference to discuss these complex issues, with the aim of providing more guidance on our approach by the end of next year.

As we look ahead to COP26 in Glasgow, the financial sector has an important role to play in managing the financial risks from climate change and supporting the transition needed across the economy. In doing so, the financial sector has a unique opportunity to demonstrate the good it can provide in servicing the real economy through a structural change. I look forward to the PRA continuing to play its part in this endeavour.

A handwritten signature in black ink, appearing to read 'S. Woods', with a stylized flourish at the end.

Sam Woods

CEO of the Prudential Regulation Authority and Deputy Governor for Prudential Regulation, Bank of England

Background to the Report

The Prudential Regulation Authority (PRA) has produced this report in response to an invitation by the Department for Environment, Food & Rural Affairs (DEFRA) to participate under the third round of the climate change adaptation reporting power.³

The report sets out the response of the PRA to the risks posed by climate change to its operations and policy functions in two parts:

- **Part A** of the report examines the risks posed by climate change to PRA regulated firms; the progress they have made in their management of these risks; what the PRA's response to these risks has been⁴; and the PRA's supervisory strategy from 2022.
- **Part B** of the report examines the relationship between climate change and the banking and insurance regulatory capital regimes; whether there are gaps that should be addressed; and the PRA's planned future work in this space.

In preparing this report, the PRA has had regard to HM Government's most recent climate change risk assessment and national climate adaptation programme, as well as statutory guidance on climate adaptation reporting. The PRA's approach to climate change is part of the broader Bank of England's (Bank) climate strategy as set out in the Bank's [climate-related financial disclosure report 2020/21](#).

³ The Climate Change Act (2008) provides for the Secretary of State to direct certain organisations to produce reports on the current and future predicted impact of climate change in relation to the organisation's functions, their proposals and policies for adapting to climate change, and an assessment of progress towards implementing policies and proposals set out in previous reports. DEFRA has chosen to request Climate Change Adaptation reports rather than exercise its Climate Change Act powers. For further details see [here](#). The PRA produced its [first adaptation report](#) in November 2015 in response to the second round request from DEFRA.

⁴ In the 2015 climate adaptation report, the PRA set out its programme of future work, which included international collaboration, research, dialogue and engagement, and supervision. Chapters 1 and 2 of Part A sets out details on progress with each of these elements.

Executive Summary

Part A: Climate-related Financial Risks

Climate change creates material risks to the PRA's objectives

Climate change and the transition to a net-zero economy create financial risks which can affect PRA regulated firms such as banks, building societies and insurance companies (hereafter 'firms').

This directly affects the PRA's primary objective to promote the safety and soundness of the firms it regulates. Over the past six years the PRA has built up its understanding of these climate-related financial risks, how they affect firms, and how they should be approached through its supervision and regulation. As the risks from climate change are economy-wide and global, the PRA works collaboratively on these issues with domestic and international partners, for example as part of the Government's Green Finance Strategy and the international central banks and supervisors 'Network for Greening the Financial System' (NGFS).

Whilst the responsibility and policy tools for driving the transition to net-zero sit with government through setting climate policy and industry through climate action and innovation, the financial sector and financial regulators also have a role to play. An orderly transition to a net-zero economy will minimise not only the risks to the climate, but also the future financial risks faced by firms and the financial system. This outcome is therefore aligned with the PRA's objectives. **The PRA's role in supporting the transition is to ensure that firms are effectively managing the climate-related financial risks they face.** For example, through the PRA's actions, firms are being pushed to stretch beyond their usual business planning horizons and think strategically about future risks and mitigating actions (such as supporting clients in reducing emissions) across different climate scenarios. Whilst firms are also increasingly recognising the opportunities from the transition to net-zero emissions, their activities largely remain aligned with the current shape of the real economy, which is not yet consistent with achieving the Paris Agreement goals. The financial sector can help pull forward the transition but governments around the world need to deliver clear climate policy pathways to make this effective.

Progress in understanding and managing climate-related financial risks in firms

In examining the impact of climate change to the UK banking and insurance sectors, the PRA found that firms had insufficient capabilities to effectively manage climate-related financial risks. In response to this, in April 2019 the PRA became the first financial regulator to publish a set of [climate-related supervisory expectations](#) for these firms. These expectations should be embedded as fully as possible by the end of 2021. In addition, alongside the Financial Policy Committee (FPC), in December 2019 the PRA became the first regulator to propose a framework for a climate scenario exercise - known as the [Climate Biennial Exploratory Scenario \(CBES\)](#) - to assess the resiliency of the UK's largest

banks, building societies and insurance companies, and the wider financial system to different climate scenarios. The exercise was launched in June 2021 and the results will be published in 2022.

Since the PRA set its climate-related supervisory expectations in 2019, there has been a step change among senior executives and boards at firms. There is an increasing recognition that climate change is about more than ‘Corporate Social Responsibility’, it can create real financial risks to businesses and operations, and therefore requires a strategic response. However, more progress is needed, especially with respect to firms’ risk management and scenario analysis capabilities. **Some firms are exhibiting genuine ambition in how they embed climate-related financial risks, demonstrating what can be achieved and highlighting where other firms could, and should, embed further.** A timeline of the PRA’s key publications in response to climate change can be found in Chart 1.

Next steps and supervisory approach for 2022

As we enter 2022, the PRA will switch its supervisory approach on its climate-related supervisory expectations from one of assessing implementation to actively supervising against them. While challenges arising from issues such as data gaps persist, firms should use their judgement, expertise, and the tools available to them, to demonstrate understanding and management of the risks posed by climate change to their businesses. This approach will then need to evolve, as industry-wide understanding of climate-related financial risks, data, tools, and best practice continue to develop.

As climate change becomes part of the core supervisory approach, firms should expect to demonstrate effective management of climate-related financial risks through regular supervisory engagements and reviews. **Where progress is insufficient and assurance or remediation is needed, the PRA will request clear plans and, where appropriate, consider exercise of its powers and use of its wider supervisory toolkit.** For example, from the beginning of 2022, this might include the use of risk management and governance related capital scalars or capital add-ons and the appointment of a Skilled Persons under Section 166 of FSMA in accordance with our existing policies on exercise of these powers.⁵

Part B: Climate change and the regulatory capital framework

As described in Part A, the PRA is using its supervisory toolkit to ensure that firms develop effective risk management capabilities for climate-related financial risks. A key part of this toolkit is regulatory capital requirements, which help to ensure that firms have sufficient resources to absorb future financial losses. This supports their safety and soundness and contributes to the stability of the financial system as a whole. The amount of capital firms are required to hold depends on how much risk

⁵ For further information on the PRA’s approach to setting Risk Management & Governance capital scalars see Statement of Policy ‘[The PRA’s methodologies for setting Pillar 2 capital](#)’. For further information on the PRA’s appointment of Skilled Persons Reviews under Section 166 of the Financial Services Markets Act (2000) see Supervisory Statement ‘[Reports by skilled persons](#)’ (SS7/14).

they take and create. The traditional approach to sizing these risks for capital-setting purposes has been to assess historical losses associated with exposures.

Under the existing regulatory capital framework, there is scope to use capital requirements to address certain aspects of climate-related financial risks. For example, we expect firms to incorporate judgements of their exposure to climate-related financial risks in the way they assess their own capital requirements, as they do for other drivers of financial risks. In addition, under our existing policies, where firms have significant climate-related financial risk management and governance weaknesses, we will also be prepared to impose an additional capital charge or scalar where appropriate.

However, the unique features of climate-related financial risks pose challenges to some elements of traditional capital-setting approaches. In particular, climate-related financial risks will crystallise over short, medium and long time horizons, and will likely grow over time. They might profoundly alter historical trends, are characterised by tipping points, and could be influenced by policy interventions. Historical data will therefore be less useful in calibrating future risks. Accordingly, research and analysis on sizing climate-related financial risks for capital purposes is nascent and not always conclusive.⁶ As this report highlights, determining whether changes to the design, use or calibration of the existing capital framework are needed to address climate-related financial risks beyond what is currently in place is complicated and needs to be supported by further work and research.

Against this background, international work has begun on the linkages between climate-related financial risks and regulatory capital⁷. To help inform this work, and to explore parts of the capital frameworks that are specific to the UK, the PRA has undertaken an initial review on this topic. Part B of this report presents our four key initial findings, including the PRA's considerations on the complexities and trade-offs for the first time.

Finding 1: Capital can be used to address the consequences, not the causes of climate change

In the context of the PRA's and the Bank's objectives, the regulatory capital framework is not the right tool to address the causes of climate change (greenhouse gas emissions). Research shows that the use of capital requirements as a tool to affect financing and investment decisions directly is not likely to be effective unless calibrated at very high levels. These levels could give rise to unintended consequences, such as the erosion of capital in the system or build-up of risks in other areas. Ultimately, regulatory capital cannot substitute for government climate policy.

However, the evidence is clearer that the regulatory capital framework could provide resilience against the financial consequences of climate change. For instance, when climate change or transition policies alter the prudential risks associated with exposures, this may need to be reflected in the

⁶ See Annex 1 for a Research Deep Dive.

⁷ The BCBS, FSB and IAIS are doing work on climate-related financial risks and their interaction with regulatory frameworks.

microprudential capital framework. At the same time, if climate change causes system-wide risks to grow, macroprudential frameworks may need to account for this. This raises the question as to whether the design and application of current regulatory capital frameworks are appropriately capturing these dynamics.

Finding 2: Climate-related financial risks are partially captured by current frameworks, but there are gaps

The current regulatory capital framework captures the consequences of climate change to some extent, including through reference to credit ratings and the accounting regime. However, this capture is imperfect as there are ‘capability gaps’ and ‘regime gaps’:

- **‘Capability gaps’ refer to the difficulties inherent in estimating climate-related financial risks due to lack of relevant granular data or modelling techniques that can fully incorporate climate factors.** As set out in Part A, the PRA is already working with industry to help address “capability gaps” including through the ongoing CBES exercise.
- **‘Regime gaps’ refer to possible challenges in capturing climate-related financial risks due to the design or use of methodologies in capital regimes themselves.** In the microprudential regime, methodologies are mostly calibrated using past data to capture risks that crystallise over a relatively short-term time horizon. While this helps ensure capital is set in more objective and quantifiable ways, it might underestimate future climate-related financial risks. The macroprudential regime for banks can take a more flexible approach to time-horizons, but its current application might be less suited to non-cyclical risks that increase gradually over an extended period of time. In insurance, the capital regime does not contain an analogous capital buffer aimed at macroprudential risk.

Finding 3: Estimating the materiality of these gaps is complex

Identifying and sizing these gaps requires us to look forward, a complex task that also raises fundamental questions. In particular, regulators will need to assess the relevant time horizon for capital in light of climate change, for instance by taking account of specific products and exposures. Regulators will also need to assess what a ‘plausible but severe scenario’ would be for those time horizons. A key question here is whether to wait for clarity on the detail of transition roadmaps (implying capital reflects risk changes resulting from climate policy) or whether any actions are required in the absence of climate policy (implying capital would build resiliency to absorb potential future physical or transition risks).

Finding 4: More analysis and research is required, including on specific options

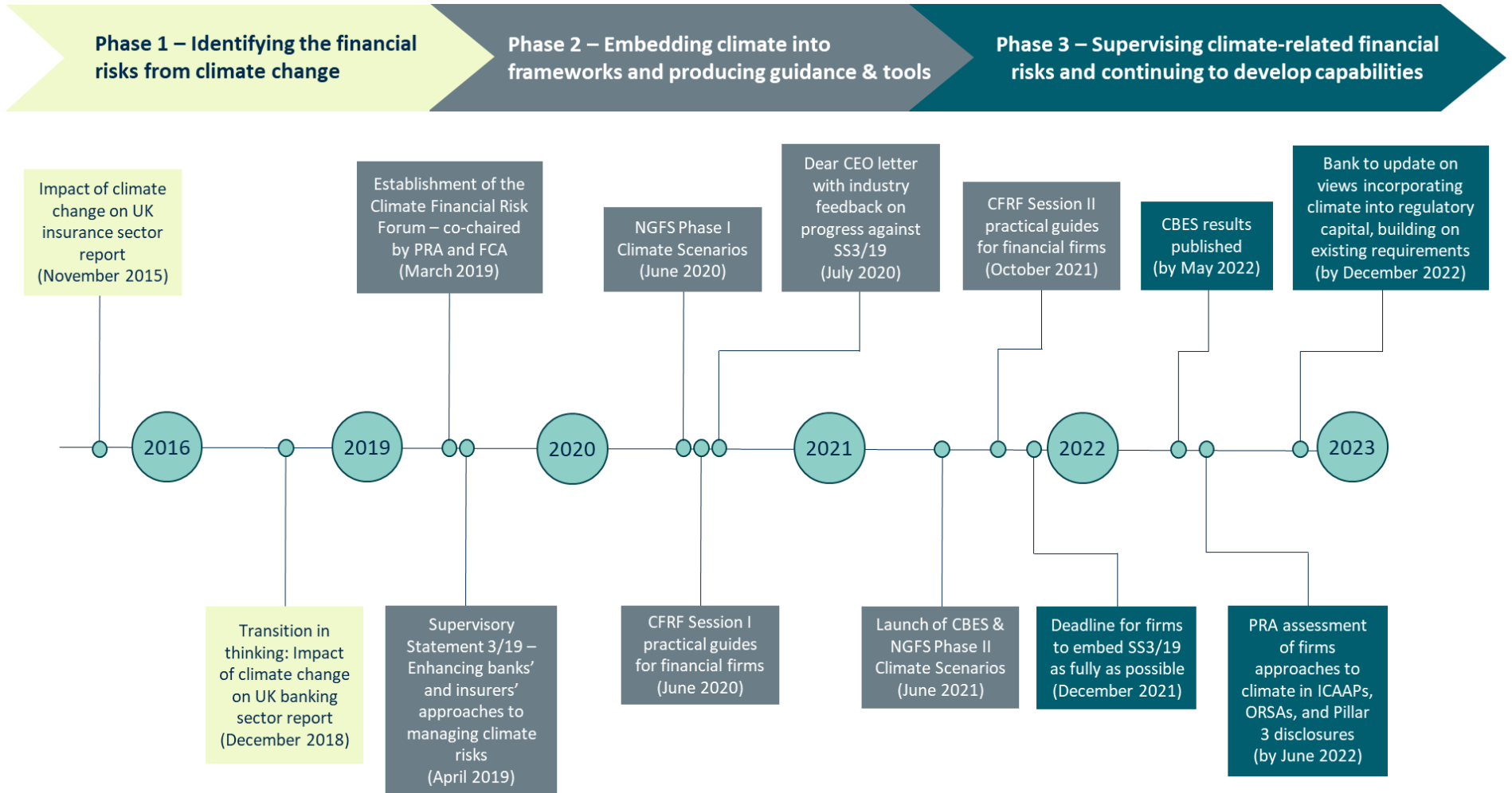
The PRA recognises that there is no established approach as to how these issues should be addressed as yet, but is contributing to early thinking in this area by mapping a non-exhaustive sample of options to fill any gaps identified. In due course, if this work indicates the need for more specific policy measures to be taken, the PRA will follow its standard policy-making process, including through further consultation.

Prior to any future determinations, the PRA will continue to use the existing prudential framework to mitigate climate-related financial risks as described in Part A. For example, firms will continue to be responsible to ensure capital adequately covers identified risks and the PRA can continue to consider tools that impact capital, such as the application of firm-specific capital scalars or capital add-ons.

Next steps

Over the coming year, the PRA and the Bank will undertake further analysis to explore enhancements to the regulatory capital frameworks. To support this work, the Bank will put out a 'Call for Papers' and host a Research Conference on the interaction between climate change and capital in Q4 2022. Informed by these steps and internal analysis, the Bank will publish a follow-up report on the use of capital including on the role of any future scenario exercises.

Chart 1: High-level timeline of key PRA climate-related work



Part A: Climate-related Financial Risks

1. Our role

Role of the Bank of England

The mission of the Bank of England (the Bank) is to promote the good of the people of the United Kingdom by maintaining monetary and financial stability. Climate change is relevant to this mission as the physical effects of climate change (e.g. sea-level rises and more frequent severe weather events) and the transition to a net-zero emissions economy (e.g. changes in government policy, consumer preferences, and technology) create financial risks and economic consequences. These risks and consequences can affect the safety and soundness of the firms we regulate, the stability of the wider financial system, and the economic outlook. In addition, HM Treasury has updated the remits and recommendations it provides to the Bank's policy committees to specify that the committees should take into account the government's economic strategy of a transition to a net-zero economy.⁸

The Bank has established an organisation wide climate work programme to address these challenges and has made climate change a strategic priority. The objective of the Bank's work on climate change is to:

'Play a leading role, through our policies and operations, in ensuring the financial system, the macroeconomy, and the Bank are resilient to the risks from climate change and supportive of the transition to a net-zero economy.'

The Bank delivers this objective across five key goals:



Ensuring the financial system is resilient to climate-related financial risks



Supporting an orderly economy-wide transition to net-zero emissions



Promoting adoption of effective TCFD-aligned climate disclosure



Contributing to a co-ordinated international approach to climate change



Demonstrating best practice through our own operations

⁸ In March 2021, HM Treasury's remit and recommendation letters to the Monetary Policy Committee, Financial Policy Committee, and Prudential Regulation Committee were all [updated](#) to include a transition to a net-zero economy as part of the government's economic strategy, which the committees must 'have regard to'.

Further details on how the Bank's climate work programme supports these goals can be found in the Bank's [2020/21 climate-related financial disclosure report](#), which has been produced in line with the framework recommended by the Taskforce on Climate-related Financial Disclosure (TCFD).

Role of the Prudential Regulation Authority

The Prudential Regulation Authority (PRA) is the part of the Bank responsible for the prudential regulation and supervision of around 1,500 banks, building societies, credit unions, insurers and major investment firms providing services in the UK (collectively 'firms'). The PRA's primary objectives are to promote the safety and soundness of the firms it regulates and to contribute to securing an appropriate degree of protection for insurance policyholders.

Climate change is relevant to these objectives as the firms the PRA regulates are exposed to climate-related financial risks. The PRA is therefore taking action to ensure that regulated firms identify, measure, manage and, where outside appetite, mitigate the climate-related financial risks they face. This is consistent with the existing supervisory and regulatory principles, in the same way that the PRA expects firms to manage other drivers of financial risks. However, climate change presents firms with unique challenges in developing these capabilities, which is set out in further detail in section 3 of this report. The PRA therefore also has a role in supporting firms in accelerating the development of these capabilities.

In addition to its primary objectives, HM Treasury and Parliament have provided clarifications to the PRA on how it should take into account the risks from climate change. HM Treasury's March 2021 recommendations letter for the Prudential Regulation Committee (PRC)⁹, which is responsible for exercising the PRA's functions, states that it should '*have regard to the Government's commitment to achieve a net-zero economy by 2050 under the Climate Change Act 2008 (Order 2019) when considering how to advance its objectives and discharge its functions*'. The Financial Services Act 2021 also states that the PRA, when using certain rulemaking powers, must have regard to the target for net-zero emissions.¹⁰

Both of these additions are consistent with the PRA's climate strategy and work-plan to ensure firms develop capabilities to manage effectively climate-related financial risks. The PRA will continue to have regard to the transition to a net-zero economy as it goes about its future work in these areas. The roles of

⁹ March 2021 [letter](#) from the Chancellor of the Exchequer to the Governor of the Bank of England providing recommendations for the Prudential Regulation Committee.

¹⁰ See [Financial Services Act 2021 \(Chapter 22\)](#) for further details. Section 144C (1)(d) of the Financial Services Market Act states that when making CRR rules, the PRA must, among other things, have regard to 'the target in section 1 of the Climate Change Act 2008 (carbon target for 2050)'. Exceptions to this are set out in Section 144E.

the PRA and the financial sector in supporting the transition to a net-zero economy are described further in Box A.

Box A: Transition to a net-zero economy

Climate targets

Limiting global warming in line with Paris Agreement goals¹¹ will require substantial reductions in emissions of greenhouse gasses within the next decade, reaching net-zero by around 2050. The latest [report](#) from the Intergovernmental Panel on Climate Change (IPCC) has found that human-linked activity has already led to warming of over 1°C since pre-industrial levels and that even under a ‘very low emissions’ scenario temperatures will rise by 1.5°C by 2040. A failure to transition to net-zero could result in significant economic and financial risks. Analysis from the NGFS suggests that such an outcome could lead to global GDP being as much as 13% lower than it would have been by the end of the century, and that is before accounting for issues such as sea level rise and more chronic weather events.¹²

Against this background, in April 2021, the UK government [announced](#) its commitment to reduce UK greenhouse gas emissions by 78% by 2035 compared to 1990 levels, building on its existing commitment to reduce these emissions by 68% by 2030. In addition, the UK has enshrined its commitment to achieve net-zero greenhouse gas emissions by 2050 in legislation through the Climate Change Act (2008). Achieving these goals will necessitate a fundamental structural change within the UK economy. Every geography, sector, and company will be affected by these changes and will have a part to play. On 19 October 2021, the UK government provided further details on its plans to reach its net-zero target and the challenges faced in doing so through its [Net-Zero Strategy](#) and [Net-Zero Review](#).

As noted earlier in this report, the PRA must have regard to this target for net-zero emissions through aspects of its policymaking and through the general exercise of its functions as a result of the Financial Services Act 2021 and the March 2021 PRC recommendations letter respectively.

The PRA and financial sector roles in supporting the transition to a net-zero economy

The responsibility and policy tools for driving the transition to net-zero sit with government through setting climate policy and industry through climate action and innovation. However, the financial sector and

¹¹ Signatory nations to the [2015 Paris agreement](#) committed to “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels”.

¹² See [NGFS climate scenarios](#).

financial regulators also have an important role to play.

The financial sector is exposed to both the risks and opportunities from the transition. In supplying the real economy with finance, insurance, and investment, the financial sector can help pull forward the transition through prudent risk management (e.g. by requesting climate data from counterparties) and stewardship (e.g. by encouraging clients to act and supporting them in making the changes they need to align their business to net-zero).

The PRA has a role in ensuring firms are prudently managing the financial risks that arise from climate change. Key to this will be understanding the impacts from the transition to net-zero, the different pathways to it, and the dependency on actions by firms. The PRA will also continue to press firms to demonstrate resilience to different climate scenarios – through both the CBES and supervisory engagement. This should encourage firms to think more strategically about the issues posed and identify ways they can support the transition where it results in reduced future financial and macroeconomic risks to the firm. The PRA is considering the implications for the supervision and regulation of firms in light of different transition pathways, especially those involving more severe, late and disorderly transitions. The steps taken by firms between now and 2030 will directly impact the action required over the subsequent period to 2050.

Banks' and insurers' contribution to the transition

Banks and insurance companies have increasingly recognised the opportunities from the transition to a net-zero economy and have stepped up their funding of 'green' activities such as renewable energy infrastructure and technologies. Some have also stepped back from providing services to, or investments in, companies that are not making sufficient efforts to reduce emissions. Many firms have also made public commitments to support the transition. Around 300 financial institutions across the world, including UK banks and insurance companies, have now joined the Glasgow Finance Alliance for Net-Zero (GFANZ) and made commitments to support the transition and reduce the emissions associated with their activities (including Scope 3 emissions¹³) to net-zero by 2050.¹⁴

¹³ Scope 3 greenhouse gas emissions include emissions from the corporate value chain as defined under the [Greenhouse Gas \(GHG\) Protocol](#).

¹⁴ The [Glasgow Finance Alliance for Net-Zero](#) (GFANZ) was launched in April 2021 by Mark Carney, UN Special Envoy for Climate Action and Finance and UK Prime Minister Johnson's Finance Adviser for COP26, and the COP26 Private Finance Hub in partnership with the UNFCCC Climate Action Champions, the Race to Zero campaign and the COP26 Presidency.

Domestic and international collaboration

The UK houses an open international finance centre playing home and host to financial firms that operate in multiple jurisdictions. As a result, and in order to deliver its objectives, the PRA works collaboratively with both domestic and international partners on the risks to the safety and soundness of firms, including those from climate change and the transition to a net-zero economy.

Domestically, the PRA works closely with the Government and other UK regulators through the Green Finance Strategy and other collaborative efforts.¹⁵ Recent examples of such efforts have included the Government's roadmap for the implementation of an economy wide sustainable disclosure regime.¹⁶ The PRA has also supported the government in international efforts on climate-related finance and regulatory issues. For example, it has worked closely with the government's Private Finance hub in the preparations for the UN COP26 in Glasgow and has supported the government through the UK's presidency of the G7.

In March 2019, the PRA and the Financial Conduct Authority (FCA) co-convened the [Climate Financial Risk Forum](#) (CFRF), to bring industry and regulators together to produce guidance and share best practice on how to address climate related financial risks and opportunities. More detail on the CFRF is set out later in this report.

The Bank and PRA have played a leading role in establishing international climate-focused fora for central banks and supervisors, including as a founding member of the Network for Greening the Financial System (NGFS) and Sustainable Insurance Forum (SIF).¹⁷ In addition, the PRA have been active in climate-related discussions at existing international bodies such as the Basel Committee on Banking Standards (BCBS), the Financial Stability Board (FSB), the International Association of Insurance Supervisors (IAIS), and the Committee on Payments and Market Infrastructures (CPMI). Through these fora the PRA has sought to share best practice and build towards a common understanding of how to address climate-related financial risks across the financial system.

As a leading global financial centre, the UK is well placed to push for advances in climate finance, including through convening private sources of finance to support the transition, innovative financial regulation, and developing green financial markets. This financial ecosystem is supported by a huge range of academic and private institutions headquartered in the UK that make the country a driving force for research and innovation. World-leading universities, pioneering research hubs such as the Grantham Institute, and other

¹⁵ See [UK Government Green Finance Strategy](#).

¹⁶ See [Greening Finance: A Roadmap to Sustainable Investing](#).

¹⁷ The Bank's Executive sponsor for climate change, Sarah Breedon, is the chair of the Macrofinancial workstream of the Network for Greening the Financial System. The Bank's Executive Director of Insurance Supervision, Anna Sweeney, is the chair of the Sustainable Insurance Forum.

thought leaders such as the UK Green Finance Institute and the UK Centre for Greening Finance and Investment, enrich the UK's reputation as a global thought leader, and play a key role in making the UK the global centre for green finance and climate-related financial risk management.

Looking ahead to 2022 and beyond, the PRA and wider Bank will continue to engage constructively with international and domestic partners on the risks and opportunities from climate change and the transition to a net-zero economy.

2. Resiliency of UK banks and insurers to climate-related financial risks

Characteristics of climate-related financial risks

The financial risks from climate change arise through two key channels – physical risks and transition risks:

- Physical risks – Physical risks arise from increasing severity and frequency of climate and weather-related events, such as sea-level rises and floods. These events damage property and other infrastructure, disrupt business supply chains, impact agricultural output and more broadly can lead to loss of life and migration. This reduces asset values, results in lower profitability for companies, damages public finances, increases the cost of settling underwriting losses for insurers and may lead to gaps in insurance coverage. Indirect effects on the macroeconomic environment, such as lower output and productivity, exacerbate these direct impacts.
- Transition risks – Transition risks arise from the adjustment towards net-zero emissions, which will require significant structural changes to the economy. These changes will prompt a reassessment of a wide range of asset values, a change in energy prices, and a fall in income and creditworthiness of some borrowers. In turn, this entails potential credit losses for lenders and market losses for investors. The transition to a net-zero economy also presents some opportunities for the financial sector, for example, financing investments in building energy efficiency, renewable energy and carbon-neutral transportation.

There are also liability (litigation) risks that can arise from people or businesses seeking compensation for losses they may have suffered from the physical or transition risks from climate change outlined above or legal challenges taken to require a particular course of action¹⁸. Whilst litigation risks were previously

¹⁸ See *Milieudefensie et al v Royal Dutch Shell*.

identified as a separate channel, they are increasingly considered as a sub-category of physical and transition risks.

Climate-related financial risks also have unique characteristics that pose challenges for firms in managing them effectively:

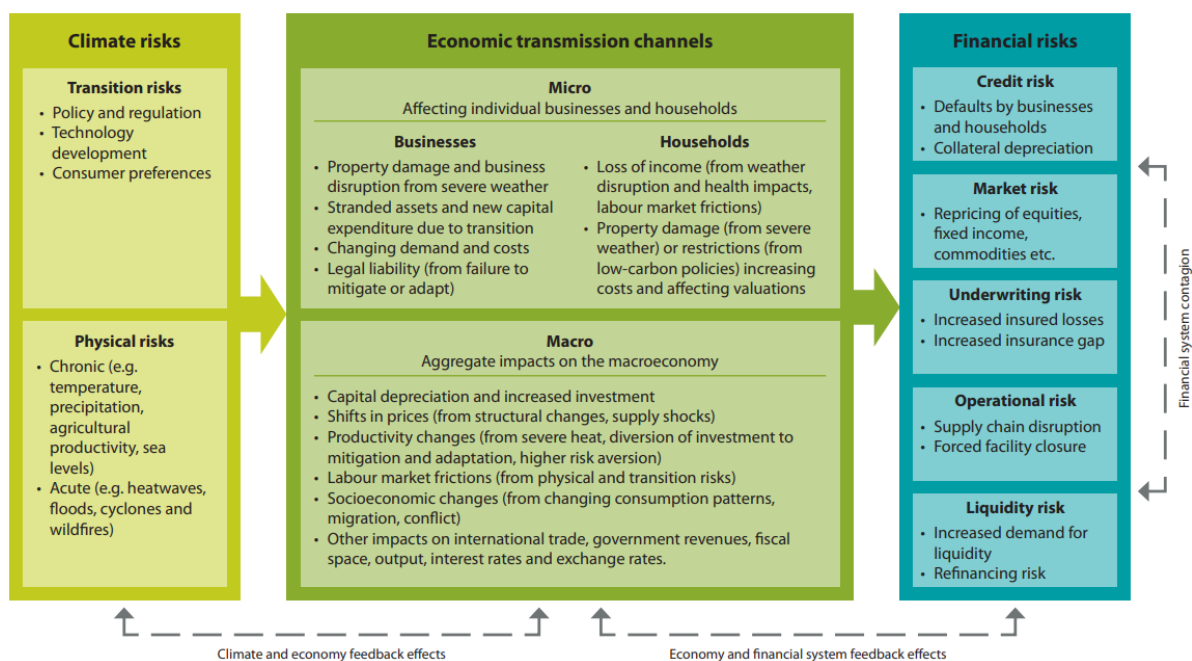
1. The risks are **systemic**. They will affect every consumer, every corporate, in all sectors and across all geographies. Their impact will likely be correlated, non-linear, irreversible, and subject to tipping points. They will therefore occur on a much greater scale than the other risks that firms are used to modelling and managing.
2. The risks are **simultaneously uncertain and yet totally foreseeable**. The exact combination of physical and transition risks that will emerge is uncertain, but it is clear that we will either carry on our current emissions pathway and face greater physical risks or we change our pathway by reducing emissions and face greater transition risks.
3. The size and balance of the future risks we face will be **determined by actions we start to take now**. Once physical risks begin to manifest in a systemic way it will already be too late to reverse many effects through emissions reductions. Similarly, the longer that meaningful adjustment to our emissions path is delayed, the more disruptive a transition we will see.

Managing the risks in light of these challenges will require forward thinking and advances in the capabilities of firms, as well as action by governments to provide clarity on the path ahead for climate policies that support the transition to a net-zero economy.

Transmission channels

Understanding the transmission channels between these climate-related financial risks and financial risks is a complex task due to the multiple and material interdependencies. There are also second and third order effects from economic and operational impacts which are difficult to model. Chart 2 illustrates some of the key transmission channels of relevance to central banks, financial regulators, and financial firms.

Chart 2: Key climate change transmission channels



Source: NGFS

Impact of climate-related financial risks to the UK banking and insurance sectors

Financial firms such as banks and insurance companies are exposed to climate-related financial risks through their business activities and operations. For example, these risks may impact the probability of default for a loan or the size and probability of a claim on an insurance contract, resulting in greater than expected financial losses. In addition, firms may suffer from business interruption due to physical risks leading to property damage on their own premises or affect the service provision of third parties they rely on.

The PRA explored the potential impact of climate change to the UK banking and insurance sectors through two key reports in 2018 and 2015 respectively. These reports identified the key transmission channels for how the physical and transition risks from climate change could affect UK banks and insurers as well as key gaps in their capabilities to manage these risks effectively. The findings reflect the structural issues associated with these firms' business models and the novel nature of climate-related financial risks as described in the previous section. They form the foundation and analytical basis for the steps the PRA has taken since then.

Insurance sector

In 2015, the PRA produced a [report](#) on the impact of climate change to the UK insurance sector as part of the second round of climate change adaptation reports requested by the Department for Environment, Food and Rural Affairs (DEFRA). The report identified that the UK insurance sector is exposed to both physical risks and transition risks.

Physical risks are most clearly of relevance to general insurers' liabilities, through larger and more frequent claims on property, travel, and liability insurance contracts. Life insurers' liabilities may also be affected by physical risks due to an increase in mortality rate from heat waves (e.g. term life products) or in some areas of the world an increase of longevity due to more moderate temperature (e.g. impact on annuity products).

Conversely, transition risks are more relevant to the asset side of life and general insurers' balance sheets, through the impact of stranded assets on investment portfolios (e.g. investments in carbon-intensive assets). In the longer term, these physical and transition risks could pose challenges to business models across the insurance sector.

The report also identified a number of climate change-related opportunities for insurance firms. These include new sources of premium growth, such as renewable energy project insurance, supporting resilience to climate change through risk awareness and risk transfer, investments in green bonds and providing financial sector leadership on climate change.

The costs of rising insurance claims as physical risks increase will not be borne by insurance companies alone, insurance policyholders will also end up paying through any resultant increases in premiums. Research from SwissRe suggests that climate-related financial risks are expected to result in a 22% increase in global property premiums, or up to \$183 billion by 2040 as weather-related catastrophes will likely become both more intense and frequent.¹⁹ Where policyholders are unable or unwilling to absorb costs, insurers are unable to source reinsurance or unwilling to take on the level of risk, coverage may reduce leading to insurance protection gaps. Rising physical risks are also likely to lead to increasing demand on industry-backed pooling schemes such as FloodRe.²⁰

¹⁹ SwissRe Institute – '[sigma 4/2021 - More risk: the changing nature of P&C insurance opportunities to 2040](#)'.

²⁰ [FloodRe response to principles](#), August 2020.

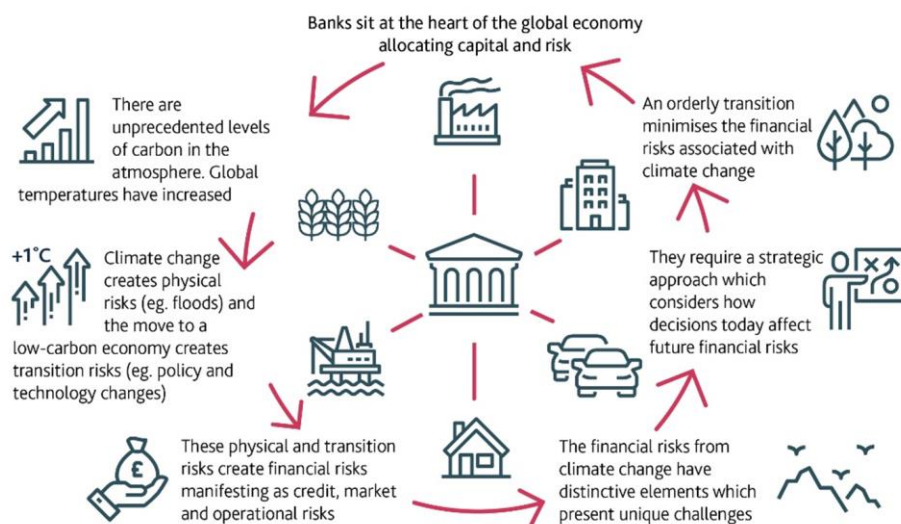
Banking sector

In 2018, the PRA produced a [report](#) on the impact of climate change to the UK banking sector. The report found that the UK banking sector is exposed to physical risks, in particular through the potential impact on mortgages to properties with high flood risk, and to transition risk, for example through banks' financing of companies with carbon-intensive assets at risk of becoming 'stranded'.²¹ A stylised diagram below illustrates the interconnections between the banking system and climate change.

As part of the banking sector report, the PRA undertook a survey of banks that found that only 10% were taking a 'strategic' forward-looking and organisation-wide approach to climate change. This was particularly concerning as banks are a key source of finance for the transition, especially for small and medium size companies who are unable to tap into international capital markets.

The banking sector report identified that the impacts of physical and transition risks on banks could be observed through traditional risk categories such as credit, market, operational, liquidity, and reputational risks. This observation was also shared by the BCBS in its report on climate-related risk drivers and their transmission channels in April 2021.²²

Chart 3: The links between the banking system and climate change



Source: 'Transition in thinking: The impact of climate change on the UK banking sector', PRA, September 2018

²¹ 'Stranded' assets are assets that have suffered from unanticipated or premature write-downs, devaluation or conversion to liabilities. In the context of climate change this is typically driven by the imposition of government climate policy. For example, restrictions or disincentives on the extraction of fossil fuels may leave a company with licences to extract those fossil fuels facing significant asset devaluation.

²² BCBS '[Climate-related risk drivers and their transmission channels](#)', April 2021.

Interlinkages between banking and insurance sectors, and risks to financial stability

The interlinkages between the banking and insurance sectors could result in climate-related financial risks propagating from one to the other, creating wider systemic issues. As an example, insurance contracts for property damage are typically written annually, but mortgages have an average term of 25-30 years. Should physical risks lead to more severe and frequent floods resulting in property damage, premiums may rise to unaffordable levels or coverage may reduce, leaving homeowners to bear the costs. A bank providing a mortgage against such homes could see loan-to-value ratios increase as the value of the home falls (either from actual property damage or a pricing in of increased risk of future property damage), resulting in losses for the bank. The homeowner may also suffer from a loss of income and have a higher probability of default.

Corporates may also have business interruption insurance which protects them from physical losses. If physical risks from climate change increases this risk, the resulting repricing could lead to insurance protection gaps. Banks' lending to these corporates may therefore face a higher probability of default if these corporates are less protected against business interruption from physical events.

As banks and insurers respond to the growing risks from climate change, there is a risk that banks and insurers take similar management actions around the same time, which could lead to volatility in financial markets and create risks to wider financial stability. An example of this could be firms divesting from specific sectors or assets on a large scale in anticipation of or in response to the government introducing specific climate policies, triggering fire-sale dynamics which could amplify losses across the financial sector. If there is uncertainty about which parties hold the ultimate exposure to the affected assets, these effects could be even greater.

The PRA and broader Bank continue to explore the transmission channels and interlinkages in greater detail through the ongoing Climate Biennial Exploratory Scenario (CBES) exercise. This is explored later in this report.

Macroeconomic impacts

As well as the direct impacts of climate-related financial risks, banks and insurance companies will also be affected by the resulting changes in the macroeconomy. Inflation, growth, interest rates, productivity, and labour markets are all likely to be affected by physical and transition risks over time. Further research is needed to improve understanding of potential macroeconomic effects of climate change and different transition pathways. The Bank is undertaking work in this space and the PRA will incorporate findings in its

work where relevant – for example in improving the understanding of the degree to which these macroeconomic affects can feed back into financial risks for banks and insurance companies.

Challenges firms face in managing climate related risks

In addition to the challenges posed by the nature of climate-related financial risks, there are also specific technical challenges that firms must address in responding to them. In particular, there is a lack of high-quality climate **data** and **disclosure**, complexities in **scenario analysis** and **risk management**, and **governance** structures may not lend themselves well to making trade-offs between near term incentives and long term strategic risk management.

Data and Disclosure

- The availability of high quality decision-useful information on climate-related financial risks across the economy remains limited. Financial firms do not routinely collect such data from their clients or it does not currently exist as the majority of businesses do not yet publicly disclose information on climate-related financial risks.
- Even where this information is reported or collected, the quality or assurance over it may be limited and it may not be comparable across firms. These ‘data gaps’ in both quality and quantity create significant challenges for risk modelling and management. Use of proxy data and other assumptions is often required to compensate.

Scenario analysis

- Climate scenarios bring together climate and transition pathways with their financial and macroeconomic consequences. Scenario analysis involves using these climate scenarios to assess the impact on a firm’s business and operations. This new discipline presents multiple complexities.
- The time horizon of the scenarios (often several decades and in some cases running until the end of the century) is far beyond the usual business planning horizon that firms are used to when considering strategy and risk management. The data gaps described earlier can compound these issues.
- Smaller firms may appropriately take a proportionate approach with qualitative focused scenario analysis, but larger firms need to develop quantitative assessments to assist with decision-making.

- Constructing the climate scenarios themselves is the most challenging element, but groups such as the NGFS have produced a set of scenarios that are freely available for use by firms.

Risk management

- Given the unique characteristics of climate-related financial risks, implementation of an effective approach for managing them creates challenges. This is likely to remain the case, at least in the near-term, while firms seek to overcome the constraints associated with climate data gaps required to feed into quantitative elements in risk management frameworks.
- In particular, this affects the ability of firms to formulate Risk Appetite Statements (RAS) that accurately reflect (through thresholds and subsequent detailed management actions) firms' appetite for and management of climate-related financial risks.
- Another challenge for firms is understanding and agreeing what metrics they should be using for specific elements of their business and the extent to which these metrics can meaningfully inform decisions on business strategy from a risk management perspective.

Governance

- Data gaps also hamper firms' governance processes as firms need to ensure that decision makers are provided with management information that is of sufficient quality and detail to support the execution of effective business strategy.
- Firms also need to hire or build executive knowledge and capabilities on climate related risks and ensure that the board is well equipped for such discussions.

The PRA's supervisory expectations, work with industry, and broader climate work programme, as set out in the next section of this report, are designed to address these barriers.

3. The PRA's response to climate-related financial risks

PRA supervisory expectations for managing climate-related financial risks

In April 2019, the PRA became the first prudential regulator to publish a comprehensive set of expectations in [Supervisory Statement 3/19](#) (SS3/19) for how banks and insurers should enhance their approaches to managing the financial risks from climate change. These expectations are designed to ensure firms adopt a strategic, holistic and ambitious approach to managing climate-related financial risks. While recognising that climate-related financial risks will affect all firms, the PRA built in scope for firms to take different

approaches to meeting the expectations consistent with their business model and proportionate to the size and complexity of their operations. In summary, the key expectations are for firms to:

1. embed climate-related financial risks into their governance framework;
2. under the Senior Managers Regime (SMR), allocate responsibility for identifying and managing climate-related financial risks to the relevant existing Senior Management Function (SMF), and ensure that these responsibilities are included in the SMF's Statement of Responsibilities;
3. incorporate climate-related financial risks into existing risk management frameworks;
4. undertake longer-term scenario analysis to inform strategy and risk assessment; and,
5. develop an appropriate approach to climate disclosure in line with the FSB's TCFD framework.

In July 2020, the PRA sent a [letter](#) to the CEOs of firms stating that: “*by the end of 2021, your firm should be able to demonstrate that the expectations set out in SS3/19 have been implemented and embedded throughout your organisation as fully as possible*”. Recognising the challenges firms face, they were also provided with additional guidance on how to meet these expectations, feedback on progress to date across the sector, and sharing examples of good practice.

The PRA also made clear in SS3/19 that “*a firm's response to the financial risks from climate change to be proportionate to the nature, scale, and complexity of its business. As a firm's expertise develops, the PRA expects the firm's approach to managing the financial risks from climate change to mature over time. The PRA intends to embed the measurement and monitoring of these expectations into its existing supervisory framework.*” In this context, the PRA expects firms to demonstrate how they have implemented its expectations, where they have identified challenges or barriers what alternative interim measures have been considered and adopted, and how firms intend to overcome these challenges in the future.

Collaboration with industry

Since the launch of SS3/19, the PRA has actively engaged with financial firms to build a shared understanding of its expectations on climate change and to support efforts by firms to develop their capabilities. In March 2019, the PRA and the Financial Conduct Authority (FCA) co-convened the [Climate Financial Risk Forum](#) (CFRF), an industry group established to produce guidance and support firms' efforts to address climate related financial risks. In June 2020, the CFRF published its first set of guides for the financial sector containing practical tools, information and case studies on climate-related financial risk management, scenario analysis, disclosure, and innovation. More recently, on 21 October 2021, building

on the guides published as part of the first session, the CFRF published a further set of 10 practical guides and tools. These included a set of guides for climate-related Risk Appetite Statements (RAS) for different sectors, a guide on implementing scenario analysis, and a climate data dashboard of recommended metrics for use by banks, insurers and asset managers. In addition, the report by the CFRF innovation workstream provides commentary on innovation opportunities to mobilise financial capital and help steward the economy to net zero.²³

The PRA took similar steps to support general insurers' ability to quantify the impact of physical risks. Working with a group of representatives from the general insurance sector, in May 2019 the PRA published a framework for assessing [financial impacts of physical climate change](#). The paper provides an aid for practitioners to use to assess climate-related financial risks, using tools that are already available within the general insurance sector. The framework is designed as a starting point for firms to assess the physical risk impacts in the context of their business decisions and disclosure requirements. In 2020, the PRA considered the feedback provided and reflected on how to address it within the context of the Bank's current and future climate workstreams. The Bank has issued a [response](#) summarising the main feedback points received and areas where further development is recommended.

Climate Biennial Exploratory Scenario (CBES)

Building on lessons learned from a previous exercise focused on insurers, in June 2021 the PRA and FPC launched a [Climate Biennial Exploratory Scenario \(CBES\)](#) exercise to explore the resilience of major UK banks, insurers, and the financial system to these risks under three climate scenarios. The objectives of the CBES are to: (1) size the financial exposures of individual firms and the financial system to climate change; (2) understand how firms might respond to different climate scenarios and the impact on their business models; and (3) improve firms' management of the financial risks from climate change. This is different to the PRA's annual solvency test that assesses whether firms are holding sufficient capital to withstand a severe stress scenario, typically over 3 years. The design of the CBES exercise (e.g. 30 year time horizon, static balance sheet assumptions etc.) and its exploratory nature mean it is not well suited to calibrate capital requirements in the way that the annual solvency test is. However, the learnings from the exercise could be informative in forming views on the relevance of climate-related capital requirements (see Part B) as well as firms' current capabilities to manage these risks.

The CBES utilises three scenarios that test a wide variety of pathways: (1) Early Action; (2) Late Action; and (3) No Additional Action. The first two scenarios consider different routes to net-zero greenhouse gas emissions and primarily explore transition risks:

²³ All of the CFRF guides, meeting minutes, and related materials can be found on the Bank's [webpage](#).

- **Early Action:** the transition to a net-zero economy starts in 2021 so carbon taxes and other policies intensify relatively gradually over the scenario horizon. Global carbon dioxide emissions are reduced to net-zero by around 2050. Global warming is limited to 1.8°C by the end of the scenario (2050) relative to pre-industrial levels.²⁴ Some sectors are more adversely affected by the transition than others, but the overall impact on GDP growth is muted, particularly in the latter half of the scenario once a significant portion of the required transition has occurred and the productivity benefits of green technology investments begin to be realised.
- **Late Action:** The implementation of policy to drive the transition is delayed until 2031 and is then more sudden and disorderly. Global warming is limited to 1.8°C by the end of the scenario (2050) relative to pre-industrial levels. The more compressed nature of the reduction in emissions results in material short-term macroeconomic disruption. This affects the whole economy but is particularly concentrated in carbon-intensive sectors. Output contracts sharply in the UK and international economies. The rapid sectoral adjustment associated with the sharp fall in GDP reduces employment and leads to some businesses and households not being able to make full use of their assets, with knock-on consequences for demand and spending. Risk premia rise across multiple financial markets.

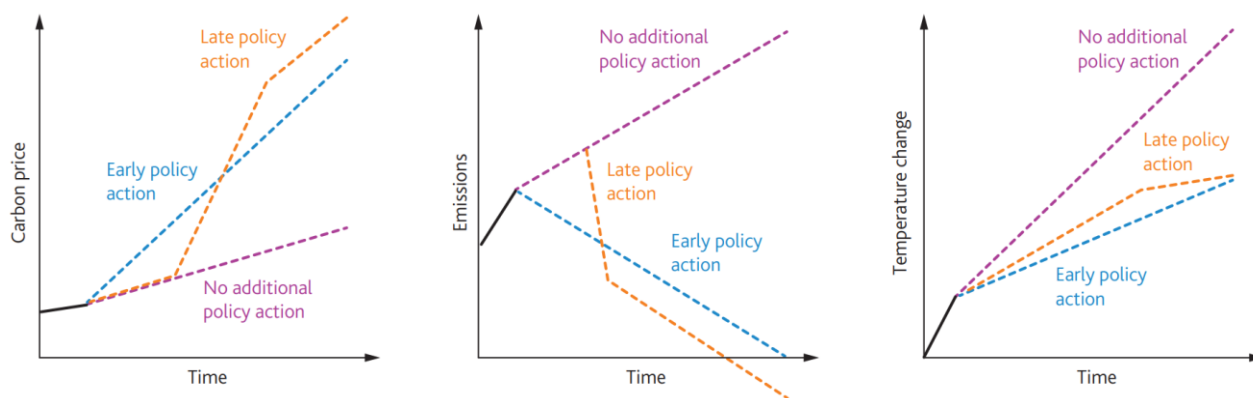
The third and final scenario - **No Additional–Action** - primarily explores physical risks from climate change. Here, there are no new climate policies introduced beyond those already implemented. The absence of transition policies leads to a growing concentration of greenhouse gas emissions in the atmosphere and, as a result, global temperature levels continue to increase, reaching 3.3°C relative to pre-industrial levels by the end of the scenario.²⁵ This leads to chronic changes in precipitation, ecosystems and the sea level. There is also a rise in the frequency and severity of extreme weather events such as heatwaves, droughts, wildfires, tropical cyclones and flooding. There are permanent impacts on living and working conditions, buildings and infrastructure. UK and global GDP growth is permanently lower and macroeconomic uncertainty increases. Changes in physical hazards are unevenly distributed with tropical and subtropical regions affected more severely. Many of the impacts from physical risks are expected to

²⁴ In the Early and Late Action scenarios, carbon dioxide emissions globally (and greenhouse gas emissions in the UK) reach net-zero. Because of the significant lags between emissions and warming levels, temperatures continue to rise, reaching a global warming level of 1.8°C by this point. The degree of warming is then projected to fall slightly from its peak in these scenarios to 1.6°C by the end of the century, due to actions (eg changes in land-use) that help to remove some greenhouse gases from the atmosphere. This is close to the goal in the Paris agreement for limiting temperature rises to 1.5°C.

²⁵ Climate scientists' projections suggest that absent a rapid transition, some physical risks will crystallise in the period to 2050, but the most material shocks would occur later in the century. To ensure the No Additional Action scenario captures these more severe risks, it has been calibrated based on the level of physical risks that could be prevalent between 2050 and 2080 in the absence of further policy action. The end-of-century warming in this scenario is 4.1°C.

become more severe later in the 21st century and some will become irreversible. So the headwinds facing the economy would be expected to increase further into the future.

Chart 4: Stylised CBES scenario comparisons



Source: Bank of England Discussion Paper: 'The 2021 biennial exploratory scenario on the financial risks from climate change', December 2019

These climate scenarios are based on those developed by the Macrofinancial workstream of the NGFS chaired by the Bank. The scenarios assess the financial and economic impacts of different combinations of temperature pathways and climate policy actions consistent with that outcome. Central banks, financial firms, and policymakers around the world are now using and adapting these scenarios for their own analysis.²⁶

The benefits of the CBES exercise will go well beyond the results generated. In carrying out the exercise, firms will need to reach out to their counterparties, to understand better their climate-related financial risks and plans to address them. This should help prompt further disclosure and climate action by businesses across the real economy, as well as filling some critical climate data gaps. Firms may also use the design of the CBES and the underlying NGFS scenarios to inform their own scenario analysis, build their understanding of the climate-related financial risks they face, and enhance their climate-related financial risk management capabilities.

The results of the exercise are due to be published in H1 2022 and will support further work on the financial stability and macro-prudential implications of climate change by the PRA and FPC. Further details are set out in Section 5 'Next Steps'.

²⁶ The [NGFS scenarios](#) are being used as part of climate scenario exercises and stress tests by a number of central banks and regulators, as set out in the NGFS [Scenarios in Action report](#). In addition, they are being used by other authorities such as the Office of Budget Responsibility in its July Fiscal Report.

Progress by banks and insurers against PRA climate-related supervisory expectations

The end of 2021 will mark 33 months since the PRA first published its supervisory expectations for managing the financial risks from climate change. During that period it has worked closely with industry to provide further guidance and practical tools, helping to accelerate the development of effective climate-related financial risk management capabilities. Drawing on supervisory work, the below sets out early indications of progress to date. Further feedback and details of observed best practice will be provided to industry in 2022.

The PRA's supervisory expectations have helped catalyse a change in how climate-related financial risks are considered by firms. Since the PRA's climate work began in 2015, firms have improved their understanding of the risks posed by climate change to their business, and the need for them to help support the transition to a net-zero economy. There is increased recognition that climate change is about more than 'Corporate Social Responsibility', it can create real financial risks and requires a strategic response. This buy-in across firms is resulting in more investment in developing climate-related financial risk management capabilities and more resources being deployed to support the transition.

Many firms have made progress in embedding the PRA's supervisory expectations, with some adopting more ambitious approaches. Some common themes have emerged across the four key areas of the supervisory expectations:

- **Governance:** Firms have made the most progress in this space. SMF's have been assigned responsibility for managing climate-related financial risks. Boards have become more engaged, are influencing climate strategy and demonstrating increasingly effective challenge.
- **Risk Management:** While firms have made strides in developing their risk management for climate, in many cases the integration of climate-related financial risks into existing risk management frameworks is being constrained by a lack of sufficiently granular data. This is also limiting the ability of firms to establish effective risk appetite statements that integrates climate strategies and is supported by a framework of risk metrics and limits. Whilst data challenges are a recognised issue, they will persist for some time before efforts such as mandatory climate disclosures yield results. As clearly articulated in SS3/19, firms need to adopt alternative approaches to address these gaps in the short-to-medium term, such as the use of proxies, modelling assumptions, and expert judgement. Where firms are using these alternatives they have been better able to articulate their risk profile and risk appetite on climate-related financial risks.

- **Scenario Analysis:** Firms are exploring a number of different approaches to scenario analysis and how it can be integrated into strategic and risk processes. As expected, data and modelling challenges are barriers to the undertaking of conventional quantitative scenario analysis, but as with risk management, alternative solutions are required to address any gaps that arise in the short-to-medium term. The appetite across firms for guidance and tools in this area remains high and usage of the freely available NGFS scenarios and the CFRF practical guide on scenario analysis is widespread. More work by firms is needed to ensure that scenario analysis is appropriately detailed such that it can inform strategic and risk decision making.
- **Disclosure:** Many of the largest firms are now producing some form of climate-related disclosures in line with the TCFD framework - but this is mainly only on a qualitative basis. Consistent with existing requirements on regulated firms to disclose material risks in their Pillar 3 reports, firms will be required to disclose material climate-related financial risks from the end of 2021.

Firms are also required to identify their material exposures and demonstrate they are holding adequate capital against them where relevant as part of their Internal Capital Adequacy Assessment Process (ICAAP) for banks or Own Risk and Solvency Assessment (ORSA) for insurers²⁷. In SS3/19, the PRA asked firms to “*be able to explain what steps your firm has taken to ensure, where appropriate, capital levels adequately cover the risks to which your firms is, or might be, exposed*”. Firms are exploring these issues further and will have to include underlying assessments in their 2021/22 ICAAPs and ORSAs. The considerations around the relationship between climate change and the regulatory capital framework are further explored in Part B of this report.

Overall, the PRA has found that significant progress has been made in embedding some areas of SS3/19, but this is not consistent across firms. Firms will need to invest further to meet expectations and continue to take a strategic and ambitious approach to embedding management of climate related financial risks across their organisations. While it is recognised that challenges in areas such as data gaps remain, additional guidance and practical tools are increasingly available. Firms should therefore be in a position to use these and build on them over time. The progress made by those firms that have invested and adopted alternative solutions shows what can be achieved, whilst also highlighting those firms that have made less progress.

²⁷ Under PRA rules, banks are required to undertake an Internal Capital Adequacy Assessment Process (ICAAP), where they assess their risks and capital adequacy, and periodically summarise this in a document. Insurers are required to undergo a similar process known as an Own Risk and Solvency Assessment (ORSA).

4. The supervisory approach to climate-related financial risks from 2022

The PRA's expectation remains that every firm should be able to demonstrate a proportionate understanding and management of climate-related financial risks from the end of 2021. Therefore, from January 2022, the PRA will start to supervise actively firms against the expectations set in SS3/19.

The PRA expects firms to take a forward-looking, strategic and ambitious approach to implementing SS3/19 supervisory expectations on an ongoing basis. As such, the assessment of firms at the end of 2021 is a checkpoint, not a full-stop. As our collective understanding of climate related risks, data, tools and best practice evolves, firms will be expected to refine and innovate ways to better integrate climate-related financial risk management across their organisation. To help facilitate this, the PRA will continue to support collaboration between UK authorities and industry through the CFRF amongst other fora, and cooperation with international organisations.

The supervisory approach from 2022

With the movement of climate change into the PRA's core supervisory process, the assessment of climate related financial risks will be included in all relevant elements of the supervisory cycle. This means that the management of climate-related financial risks will become subject to formal supervisory assessments. In continuous assessment meetings and supervisory reviews, boards, firm executives and senior managers will be expected to be able to demonstrate their understanding of the risks climate change poses to their areas of responsibility and their plans to address them. This will supplement additional bespoke climate projects such as the CBES exercise.

We will apply our expectations proportionately across firms based on their size, complexity, and exposures to climate-related financial risks, taking into account differences in business models. However, it is important to note that some smaller firms with more geographic or sector concentrated portfolios may face relatively greater climate-related financial risks. For example, a firm with a geographic focus may face greater exposure to physical risks such as floods. It is therefore important that smaller firms still dedicate appropriate resources to improving their capabilities, taking advantage of existing tools and guidance where appropriate.

In addition to the above, from the beginning of 2022 the PRA will undertake firm-specific work to determine continued progress against its SS3/19 expectations. This includes:

- **Assessing firms' plans for meeting SS3/19 expectations:** Supervisors will develop proportionate assessments of firms' individual strategies for meeting SS3/19 expectations. This will draw on firms' internal management information, responses to the PRA's recent surveys, and where applicable the 2021 CBES exercise. Additional reviews in specific areas will be commissioned as required.
- **Assurance over firms' approach to climate-related capital adequacy assessments:** The largest supervised firms will be asked to prepare a short report on how they have embedded the management of climate-related financial risks into their existing risk management frameworks alongside their 2021/22 ICAAP or ORSA. In line with the expectations in SS3/19, firms will be asked to set out in these reports how they have gained assurance that capital positions cover material climate-related financial risks. The designated climate change SMF will be asked to present this assessment to the PRA. The PRA intends to ask a sample of the remaining firms to prepare a report proportionate to their size, the complexity of their business, and the climate-related financial risks they face.
- **Disclosure:** Banks, building societies and insurers have existing requirements to disclose information on material risks within their Pillar 3 disclosures, and on principal risks and uncertainties in their Strategic Report. As set out in SS3/19 the PRA expects firms to develop appropriate climate-related disclosures that are aligned with their approach to managing the associated risks. The PRA will review disclosures provided after December 2021. Disclosure is a fast evolving area which is explored further in Box B.

Firms judged to have not made sufficient progress in embedding the PRA's expectations may be asked to provide a roadmap explaining how they intend to overcome the gaps. These roadmaps would need to highlight dependencies on third parties and/or data and technological constraints that need to be overcome and how that will be achieved. In tandem, supervisors will determine whether additional steps need to be taken to ensure risks are adequately being addressed. Firms should expect to demonstrate effective management of climate-related financial risks through regular supervisory engagements and reviews.

Where progress remains insufficient and assurance or remediation is needed, the PRA may consider exercise of its powers and use of its wider supervisory toolkit. For example, this might include the use of risk management and governance capital scalars or appointment of a Skilled Persons Review under Section 166 of FSMA in accordance with our existing policies on exercise of these powers.

There are also some areas where the PRA will need to go further and by the end of 2022 the PRA intends to provide an update on the following:

- **Regulatory capital:** As set out in more detail in Part B of this report, the PRA intends by the end of 2022 to set out its views on whether changes to the regulatory capital regimes, or their application, are required to address climate related financial risks.
- **Regulatory returns:** As climate moves into core supervision it will become increasingly important to get regular and relevant data. The PRA will consider what regular data supervisors could require from firms and if there is need to obtain this information via regulatory returns.²⁸ Any proposed change to our regulatory returns would follow usual processes, including public consultation.
- **Scenario analysis:** The PRA and wider Bank have not yet set out future plans for climate scenario analysis beyond the CBES and existing expectations in SS3/19. Climate scenario analysis is a key tool that informs both micro and macro-prudential considerations. An update will be provided on the future of climate scenario exercises after the results from the CBES and further lessons from firms' approaches to scenario analysis have been considered.
- **Transition plans:** In order to manage their climate-related financial risks and support the transition to net-zero, many firms have, or are considering, setting out transition plans that align their activities with climate targets. The Government's roadmap to sustainable investing notes the Sustainability Disclosure Requirements (SDR) will 'require disclosures on transition plans'.²⁹ These plans will also be of interest to the PRA, particularly where they set out how firms intend to manage their activities in line with transition pathways. They will also be useful in helping the PRA understand what implications firms' plans may have on the economy wide transition and assessing progress on the transition at a firm and system level. The PRA will provide an update at a later date on how such plans will be considered in the supervisory process.

Sharing best practice

There is particular value in sharing best practice across firms. To assist this, the PRA will provide further feedback to industry from its supervisory approaches and observations in 2022. This feedback will assist firms, and in particular smaller firms, in taking a strategic and ambitious approach to embedded management of climate related financial risks.

²⁸ This area of focus is one of the ongoing workstreams for the FSB's Working Group on Climate Risks.

²⁹ See page 16 of '[Greening Finance: A Roadmap to Sustainable Investing](#)'.

Box B: The evolution of best-practice Pillar 3 disclosures

How firms choose to disclose their climate-related financial risks is important. Comprehensive, comparable, high quality climate disclosure can help investors allocate capital in a climate-efficient way. Disclosure is also an important source of evidence of the work that firms have undertaken to embed climate considerations within their organisations, allowing other stakeholders such as investors and consumers to hold them to account.

Currently banks and insurers are required to publish information on material risks within their Pillar 3 disclosures, and on principal risks and uncertainties in their Strategic Report (as required under the UK Companies Act). Where banks have determined that climate-related financial risk is immaterial, they are also expected to disclose that fact. In addition to these existing obligations, as set out in our supervisory expectations, the PRA expects firms to develop and maintain an appropriate approach to climate-related disclosure, which should be refreshed frequently, evolving in step with the development of their approach to managing climate-related financial risks. The PRA continues to expect firms to consider engaging with the TCFD framework and other initiatives in developing their climate disclosures, in line with the Government's plans for mandatory climate disclosure.

Part B: Climate change and the regulatory capital framework

1. Background

The PRA and wider Bank have established that climate change and the transition to a net-zero economy can create financial risks. As described in Part A of this report, the PRA's primary response to these risks has been to use its supervisory and regulatory toolkit to ensure firms develop effective risk measurement, management and mitigation capabilities, and to support them through collaboration with industry groups such as the Climate Financial Risk Forum (CFRF).

Regulatory capital requirements help ensure that firms have sufficient resources to absorb an appropriate degree of financial losses in stress, supporting their safety and soundness and protecting depositors and insurance policyholders. In some cases, regulatory capital requirements also aim to safeguard the stability of the financial system as a whole. The amount of capital firms are required to hold primarily depends on how much risk they take (and sometimes the risk they themselves pose to the financial system). Given that climate change creates financial risks, a key challenge for regulators is to assess whether firms have enough capital to be resilient to those risks, both now and in the future. The traditional approach to sizing risks for capital-setting purposes has been to assess the history of risks from exposures in order to estimate, and where possible model, the probability of risks arising in a possible stress in the near future. An overview of UK banking and insurance capital regimes is set out in Box C.

Climate-related financial risks have unique features that pose challenges to traditional capital-setting approaches. First, the risks will crystallise over short, medium and long time horizons. They will also likely grow over time, contrasting with other risks which tend to be cyclical or driven by idiosyncratic factors. Second, the risks have the potential to change historical trends, introduce new correlations between existing risks, and other areas of concentration might emerge. Third, the risks reinforce feedback mechanisms both within and outside of the financial system, and are characterised by tipping points. Finally, some climate-related financial risks are dependent on government policy, making their materiality harder to estimate and uncertain. Transition risk in particular will likely be influenced by policy interventions. Some governments, including in the UK, have already committed to ambitious emissions reductions

targets. These targets will likely necessitate far-reaching interventions, many of which have not yet been announced at a global level.

Research and analysis on the appropriateness of capital for climate-related financial risks is still nascent and inconclusive³⁰ and amending capital regimes can have far-reaching, unintended, and even counterproductive consequences. In this context, it is worth recalling that the prudential regime aims to manage and mitigate risks through a number of tools and processes³¹, including but not limited to the use of capital.

Against this background, international work has begun to better understand the linkages between climate-related financial risks and regulatory capital³². This is appropriate, given the international breadth and consistency global standard setters can deliver. However, this work might take some time to conclude, and it will not cover those areas of capital frameworks that are specific to individual countries. To complement this international work, and to help inform the resultant UK approach, the PRA has undertaken an initial review of the key considerations when assessing the use of capital for climate-related financial risks.

The findings of this work, which focusses on both banking and insurance, are described in this report. It does not propose specific policy options, but explores for the first time the PRA's view of the complexities and trade-offs associated with the potential use of capital for climate-related financial risks. The intention is that this thinking will help to form a roadmap for future work and will provide opportunities for interested parties with valuable perspectives to participate in the discussion.

Box C: Overview of banking and insurance capital regimes

Banking capital regime

Regulatory capital is a source of bank funding (mostly in the form of equity) that can absorb losses. The banking capital regime sets 'minimum capital requirements' based on the ratio of a bank's capital to its risk-weighted assets (RWAs). RWAs are calculated by assigning different 'risk weights' to a bank's assets, reflecting the fact that some assets are riskier than others.

According to internationally agreed standards by the Basel Committee on Banking Supervision (BCBS), in

³⁰ See Annex 1 for a Research Deep Dive.

³¹ Other tools include, but are not limited to: the Senior (Insurance) Managers Regime; business model analysis; supervisory interventions; and macroprudential product limits.

³² Both the BCBS and IAIS are undertaking work on climate-related financial risks and their interaction with regulatory frameworks.

addition to 'minimum capital requirements', banks must hold a number of 'capital buffers' to ensure they can absorb losses in times of stress without being deemed to be in breach of minimum requirements.

Minimum capital requirements (Pillar 1 and Pillar 2A) include:

- Under Pillar 1, capital requirements to address credit risk, market risk, and operational risk. For traditional banks, credit risk – the risk that a borrower defaults – will usually lead to their largest capital requirements. They are calculated to reflect unexpected losses for a particular stress level calibrated over one year, either using the standardised approach (SA) based on fixed risk weights or the internal ratings based (IRB) approach using parameters estimated by internal models. Market risk capital requirements address the risk of losses resulting from changes in market prices, typically of traded instruments such as equities. Finally, operational risk addresses the risk of losses resulting from inadequate or failed internal processes.
- The PRA also sets Pillar 2 minimum capital requirements (Pillar 2A) to address risks that are not (fully) captured under Pillar 1. Pillar 2A is a key part of the capital stack, allowing firms to ensure they are capitalised against all material risks.

Capital buffers that form part of the 'combined buffer' include:

- The capital conservation buffer - set at a fixed rate defined by the Basel standard and intended to allow banks to absorb losses in stressed periods (set by the PRA).
- A time-varying countercyclical capital buffer, which can be built up when aggregate growth in credit and other asset classes is judged to be associated with a build-up of system-wide risk (set by the FPC).
- Sectoral capital requirements, allowing a change in capital requirements above microprudential standards on exposures to specific sectors judged to pose a risk to the system as a whole (set by the FPC).
- Additional buffers for institutions that are deemed to be systemically important, that is, those whose failure is likely to be associated with negative externalities and wider spill-over risks (set by PRA under the FPC and FSB frameworks).

Specific to the United Kingdom, the PRA can set a PRA Buffer (also referred to as Pillar 2B) which is determined as part of the supervisory review process. It can be used to mitigate against external factors such as the business cycle, or where the PRA assesses a firm's risk management and/or governance is significantly weak.

Insurance capital regime

The capital regime for UK insurers is based on the EU Solvency II regime, which adopts a ‘total balance sheet’ approach. Similar to the banking capital regime, Solvency II sets forward-looking, risk-based capital requirements. The regime is built on two key capital requirements: the solvency capital requirement (SCR); and the minimum capital requirement (MCR). Together, the SCR and MCR act as trigger points for varying levels of supervisory intervention.

The SCR is the quantity of capital that is intended to provide protection against unexpected losses, over the following year, up to the statistical level of 99.5% (or a ‘1 in 200-year event’). Some firms calculate their SCR using a ‘standard formula’ – a standardised calculation intended to capture the risk profile of most firms. Alternatively, firms may use an internal model to calculate the SCR, subject to prior supervisory approval. The MCR denotes a level of capital below which policyholders would be exposed to an unacceptable level of risk. It is calibrated to achieve a level of 85% probability of adequacy over 1 year.

A firm can propose or the PRA can impose a ‘capital add-on’ for significant deviations in a firm’s risk profile or governance from that expected under Solvency II.

HMT is, with input from the PRA, reviewing the UK’s application of the Solvency II regime which could result in changes in the next few years.

2. Key findings

Finding 1 – Capital can be used for the consequences, not the causes of climate change

This section explores the possible conceptual justifications for the use of capital frameworks to respond to climate change. Taking account of the PRA and Bank’s objectives and empirical evidence, it concludes that capital frameworks are useful to address the consequences but not the causes of climate change.

i. Capital frameworks are useful to address the consequences of climate change

The primary justification for the use of capital frameworks is to build resilience against prudential risks. Such use could be based on microprudential (firm-specific) as well as macroprudential (system-wide) considerations. Applied to climate, the use of capital for microprudential purposes could therefore be based on evidence that climate change alters in a material way the financial risks associated with specific

exposures or assets. This could result in an assessment that certain firms would need to hold more (or less) capital, to be able to remain appropriately resilient against future losses. The use of the macropudential capital framework could be based on an assessment that the system as a whole would require a different level of capital, and take account of interconnectedness and the potential systemic nature of climate-related financial risks.

These possible justifications align closely with the objectives of PRA set out in Part A of this report and the objectives of the FPC, both of which would be advanced if all material financial risks are captured by capital frameworks.

Whether this means that capital requirements need to change depends on whether current frameworks already capture these risks appropriately. If there are gaps in either the application or the design of current frameworks, and these gaps are material, regulators would need to consider mitigants. This question is explored further in Finding 2 below.

ii. Capital frameworks should not be used to address the causes of climate change

A number of external commentators suggest that regulators should introduce ‘carbon penalising factors’ and/or ‘green supporting factors’ for exposures to assets or counterparties that are respectively more or less carbon-intensive. The key rationale suggested for such interventions is to facilitate a quicker transition to a net-zero economy by channelling funding to more environmentally-friendly activities and by increasing the cost of business for carbon-intensive activities. Such interventions would be justified based on the externalities that are associated with financing of carbon-intensive activities, independent of the existence of a proven prudential risk differential.

As set out in Box A of Part A of this report, central banks and regulators do indeed have a role to play in supporting governments to achieve a transition to net-zero, where this is consistent with their objectives. For instance, in the UK, the Bank has set out plans to green its approach to investments via the Corporate Bond Purchase Scheme (CBPS) to incentivise companies to change their behaviours in meaningful and lasting ways that support orderly transition to net zero by 2050.

However, there are two key factors that suggest that the regulatory capital framework specifically, in contrast to other policy tools, is not an effective or appropriate way of achieving these policy objectives:

- First, capital requirements *seem unlikely to be the most effective* tool in reducing carbon-intensive activities unless calibrated at more extreme levels. This reflects the fact that capital requirements are only one of many components driving decisions by financial firms. They face other drivers of

costs and opportunities, which is why the PRA has focused its efforts on ensuring firms adopt a strategic approach to managing climate-related financial risks. Other more direct public policy interventions, for instance emissions regulations or carbon pricing, would offer better incentives for action across the wider economy. Most evidence appears to be consistent with this conclusion; for instance the Small and Medium Enterprise (SME) supporting factor under the EU's Capital Requirements Regulation (CRR), which reduced capital requirements for eligible lending, has been found to have a limited effect in influencing lending prices and volumes.³³ Other studies suggest that the calibration of climate-related supporting and penalising factors would need to be very large to have any meaningful influence.³⁴ Relatedly, it is challenging to differentiate capital requirements based on specific underlying activities (e.g. underneath the corporate name) which is where incentives are ultimately most efficient.³⁵ In particular, with regards to 'penalising factors', even if banks and insurance firms were to retreat from certain markets, other investors not subject to regulatory capital requirements are likely to fill the gaps, leaving the overall impact on emissions unchanged.

- Second, there could be important *unintended consequences* associated with the use of capital in this way – most crucially a deterioration of safety and soundness, as current measures of 'greenness' or the transition alignment of exposures are not necessarily reflective of the financial risk they pose, meaning capital calibrated on this basis could not be appropriately risk-based. This would make such use inconsistent with the Bank's and PRA's objectives. Particularly, 'supporting' factors could result in environmental considerations overriding (other) prudential risks. This could result in investments in 'green' (but otherwise risky) investments receiving too generous a capital treatment and/or an overall decrease in capital in the system (if not corrected elsewhere in the capital stack). This could threaten the safety and soundness of individual firms and may even have financial stability implications. On the other hand, 'penalising' factors, where not appropriately calibrated, might deprive finance for key services to consumers or businesses needed during the transition (e.g. certain types of insurance or lending to households). In addition, some business might not be green today but could become green in the future. Perversely, penalising factors could stop the financing of initiatives focussed on greening of businesses that are currently not (yet) green, despite such activity representing an important part of the transition.

In light of these challenges, evidence to date suggests it would not be effective nor consistent with the

³³ For example, EBA [research](#) on the 'SME supporting factor' introduced as part of CRR found no evidence that it was effective in reducing pricing or increasing lending.

³⁴ See, for example, this recent [study](#) by I4CE.

³⁵ Entities might be involved in a combination of both 'green' and 'non-green' projects.

Bank's and PRA's objectives to attempt to internalise the social and economic cost of emissions through capital frameworks.

Finding 2 – Climate-related financial risks are partially captured by current frameworks, but there are gaps

As discussed in Finding 1, the use of capital frameworks might be appropriate to mitigate the impact of climate related-risks, but this requires interventions only to the extent that microprudential or macroprudential regimes currently fail to capture these risks in a material way. Determining whether this is the case is complex, not least as current capital regimes already capture *parts* of climate-related financial risks, as summarised in Table 1 (banking) and Table 2 (insurance) below.

In the UK, under SS3/19, the PRA already expects firms to capture and capitalise for climate-related financial risks where they are material, using current capital frameworks. There are a range of channels through which these risks could be reflected: e.g. through banks' probability of default (PD) and loss given default (LGD) credit risk assumptions in the internal ratings based approach, insurers' internal models, and the accounting regime. Banks can also propose add-ons under Pillar 2A where their material risks are not captured by Pillar 1, and the PRA can use capital add-ons or scalars in response to significant weaknesses in firms' risk management and governance. Insurers are required to assess through their ORSAs that they hold sufficient capital, but unlike banking the insurance regime does not have a Pillar 2A add-on.

However, the way current regimes capture these risks is likely incomplete, and the PRA has categorised the gaps into three broad groups³⁶:

1. **Capability gaps:** these cover hurdles to firms to capture risks fully *within current* frameworks. These exist mainly due to a lack of granular data or limitations in modelling techniques to reflect climate variables. These gaps are not unique to capital, and there are challenges related to climate-risk management and business planning more generally as described in Part A of this report.
2. **'Regime gaps' related to the microprudential regime:** due to the unique features and uncertainties of climate-related financial risks, there could be gaps fundamental to the way current regimes and current methodologies address firm-specific exposures, in particular the short-term calibrations based on historical data. This approach might understate the future risks associated with climate change.

³⁶ These gaps are not perfectly mutually exclusive and can have overlaps. This distinction was made solely for convenience.

3. **‘Regime gaps’ related to the current macroprudential regime:** possible gaps fundamental to the way the macroprudential capital regime currently addresses system-wide exposures to climate-related financial risks may exist, notably the fact that tools currently deal in only a limited way with risks that increase over time. The insurance framework does not include system-wide buffers.

Table 1: Illustration of climate-related financial risks captured in the banking regime, and possible gaps

Capital	Where captured (illustrative)	Possible gaps (illustrative)
Pillar 1 (minimum)	<p>Capital models: Existing risk types (notably credit and market) allow for elements of climate risk drivers to the extent that they are captured by firms under the relevant time horizons.</p> <p>Credit ratings: There is reliance on internal and external credit ratings, which are designed to incorporate future risks and increasingly include climate.</p> <p>Accounting treatment: The accounting values are the starting point for calculating capital to measure banks’ own funds against the Pillar 1 requirements. Where climate-related financial risk is considered material³⁷, firms must consider climate-related matters in preparation of their accounts. Loans (and the impact of climate-related financial risks on loan losses) and the fair value of</p>	<p>Capability gaps:</p> <ul style="list-style-type: none"> - Data limitations for modelling risk: lack of taxonomy and disclosure standards pose challenges. Current level of disclosures, particularly for indirect emissions from the value chain (i.e. scope 3) emissions, are poor. - Modelling variation: PRA analysis found significant variation between firms in translating climate science into targets and scenarios, on modelling climate-related market risk and capital modelling. - Lack of clarity on future outcomes: the scale and timing of both transition and physical risks, which are fundamental to estimating capital requirements, remain uncertain. <p>Possible regime gaps:</p> <ul style="list-style-type: none"> - Time horizon of 1 year (for the majority of capital requirements) which might result in future climate-related financial risks

³⁷ Information is material if omission, misstating or obscuring it could reasonably be expected to influence decisions of investors, lenders and other creditors made on the basis of those accounts.

	instruments that are marked-to-market are likely to be most impacted, where the climate-related financial risks are material, as these positions include a forward-looking element.	<p>remaining uncaptured.</p> <ul style="list-style-type: none"> - Reliance on historical data, which is not representative of future climate-related financial risks³⁸. - High-level 'bucketing' of assets, which overlooks climate-related financial risks that heavily impact certain sectors or geographies.
Pillar 2A (minimum)	Currently, firms should capture material climate-related financial risks if they are exposed to these risks and they are not (fully) captured in Pillar 1.	<p>Capability gaps:</p> <ul style="list-style-type: none"> - <i>Same as under Pillar 1</i>, although data and modelling gaps are likely less material (e.g. the operational risk methodology for Pillar 2 is an example of an approach where perfect data is not necessarily required). <p>Possible regime gaps:</p> <ul style="list-style-type: none"> - Current methodologies prescribed by the PRA use a time horizon of 1 year, and there is no specific climate module. However, in principle under Pillar 2A there is more flexibility with regards to time horizons than under Pillar 1.
PRA Buffer	<p>P2B is designed to reflect risks that firms become exposed to in the future over a three to five year time horizon under a severe but plausible stress.</p> <p>The Annual Concurrent Stress (ACS) test's severity (in the stressed scenario) could be argued to already capture at least some of the possible climate-related losses.</p>	<p>Possible regime gaps:</p> <ul style="list-style-type: none"> - Currently, no explicit module for climate in scenarios and buffer setting. - Currently, time horizons are longer than for minimum requirements, but still relatively short (3-5 years). - Risk Management and Governance (RMG) scalars could, in principle, be used for modelling / risk management deficiencies, as described earlier in the report. However, introducing separate climate-specific

³⁸ For example, market risk models calibrated to historical data do not allow for changes to correlations and/or volatility of assets due to the crystallisation of transition risk. Similarly, physical risks in the future are expected to be more frequent and severe than in the past.

		elements to the methodology may require further policy changes.
Combined Buffer³⁹	Climate-related financial risks are not currently explicitly captured within the macro-prudential regime.	Possible regime gaps: <ul style="list-style-type: none"> - No current explicit consideration of climate-related financial risks or tools designed specifically to address this risk. - Systemic buffers take account of firm's systemic impact but not specifically in relation to climate-related financial risks. - CCyB is cyclical in nature whereas climate-related financial risks are mostly not.

Table 2: Illustration of climate-related financial risks captured in the insurance regime, and possible gaps

Capital	Where captured (illustrative)	Possible gaps (illustrative)
SCR / MCR calculation	<p>Internal models: Existing risk types pick up some climate-related financial risks to the extent that they are modelled by firms under the relevant time horizons.</p> <p>Ratings: There is reliance on internal and external credit ratings, in particular with regard to Matching Adjustment calculations, which are designed to incorporate future risks and increasingly include climate.</p> <p>Accounting treatment: The accounting used in preparing financial statements has a less direct impact on capital coverage under Solvency II than under UK banking regulations.⁴⁰</p>	<p>Capability gaps:</p> <ul style="list-style-type: none"> - <i>Same as under banking Pillar 1</i> - Specific to general insurance firms, high-level resolution of physical risk data and assumptions on independence of perils can lead to underestimation of risks.⁴¹ <p>Possible regime gaps:</p> <ul style="list-style-type: none"> - Time horizon of 1 year which might result in future climate-related financial risks remaining uncaptured. - Reliance on historical data, which is not representative of future climate-related financial risks. - High-level 'bucketing' of assets and liabilities, which overlooks climate-

³⁹ This includes the following Basel buffers: CCyB, G-SII buffer, O-SII buffer and systemic risk buffer.

⁴⁰ Solvency II determines capital resources and requirements through the separately prepared Solvency II balance sheet, whereas for banks, key capital metrics are drawn directly from, or rely heavily on, accounting numbers. The Solvency II balance sheet shares some similarity with the accounting balance sheet, however there are some key differences. As a result,

		related financial risks that heavily impact certain sectors or geographies.
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As shown in Tables 1 and 2, most of the methodologies used as part of the microprudential frameworks are currently calibrated based on historical data to capture risks that crystallise over a short-term time horizon⁴². This reflects the notion that capital should be set in objective and quantifiable ways. This means that either one accepts that climate-related financial risks can only be capitalised where they arise over that period, or, if that approach leaves material gaps, that the microprudential regime is amended and/or new methodologies are introduced.

The banking macroprudential regime takes a more flexible perspective on time horizons⁴³, but does not currently incorporate an explicit recognition of the systemic impact of climate-related financial risks. As currently designed, it is also less suited for risks that increase gradually over a long period of time. The insurance regime does not explicitly require capital to be held for macroprudential purposes, in part reflecting the notion that historically insurers were less likely to be a source or amplifier of systemic risk. This view might usefully be revisited in the context of climate change.

Finding 3 – Estimating the materiality of these gaps raises fundamental questions

The need to take mitigating action, using either capital or non-capital interventions, ultimately depends on the PRA’s view on the materiality of gaps in current capital frameworks. Materiality is hard to estimate reliably because it depends on the PRA’s view of the relevant time horizons to consider, relevant scenarios, firm exposures and the identification and expected impact of other non-capital tools. Table 3 sets out some of the factors that would need to be considered in each of those areas.

changes in the way that climate risk is accounted for in financial statements may or may not be reflected in the Solvency II balance sheet and vice versa.

⁴¹ This [article](#) points out that reinsurers could be underestimating their own Natural Catastrophe exposures by about 50%. The industry’s ability to raise prices to offset such risks may not be sufficient or responsive enough.

⁴² This is particularly true for Pillar 1 in banking, and most of the regime in insurance. While there are a number of mechanisms, especially under modelled approaches, through which firms can capture longer-term judgements under current regimes, evidence suggests these aren’t currently used by firms to capture climate-related financial risks.

⁴³ The time horizon is not set but in many cases goes beyond 3-5 years.

Table 3: Fundamental questions and factors to assess materiality of gaps in current capital frameworks

Fundamental question	Factors to consider
<p>What is the relevant time horizon for capital setting in the context of climate change?</p>	<ul style="list-style-type: none"> - Capital requirements are updated frequently: there is reliance on the ability to increase capital as and when required. - The appropriate time horizons differ by exposure / product type, but developing methodologies to address this is challenging. - Unintended consequences should be considered, including the risks of deviating from objective and quantifiable approaches or undermining global standards. - There might be different answer for buffers compared to minimum capital requirements.
<p>What are the ‘severe but plausible’ scenarios relevant for that time horizon?</p>	<ul style="list-style-type: none"> - As shown by the wide range of scenarios chosen for stress tests globally, there is no consistent view on the most appropriate ‘plausible but severe’ stress scenario for climate change. - In the UK, CBES scenarios’ most severe stresses are beyond the immediate short-term. While this reflects current climate science⁴⁴, one could think of ‘plausible but severe’ scenarios more in the tail that would see shocks sooner. - Further clarity on government policy would reduce uncertainty in scenarios. With this clarity, regulators can better tailor the deployment of their toolkits, including the use of capital, to reflect those actions.
<p>How exposed are PRA-regulated firms or the system as whole to these scenarios?</p>	<ul style="list-style-type: none"> - Climate scenario exercises (including CBES in the UK) will give us more information on possible exposures but there are limitations posed by the specifications: for instance, for CBES, scenarios and losses are spread over 30 years making them hard to interpret for shorter-term capital setting. Another key limitation is the challenge of capturing feedback loops and second-order impacts, all of which could make exposures materially higher but are complex to calibrate. - Both direct and indirect exposures are relevant as climate change creates an economy-wide transition: all users are affected to some extent. Quantifying

⁴⁴ Physical manifestations are clearly worsening, but, UK-facing banks and insurance companies are not deemed to be very directly materially exposed to increased floods or heatwaves in the next few years. As for transition risk, material adjustments to asset prices would primarily occur on the back of unanticipated bold government action – if such action is taken in the next few years it is likely to be less disruptive than when it is delayed to the next decade, as reflected by CBES scenarios. Hence, while there are transition risks on a near-term horizon they are generally considered less severe than those further in the future.

	the nature and scale of relevant exposures is therefore challenging.
What is the expected mitigating impact of non-capital tools ?	<ul style="list-style-type: none"> - Capital is not the only tool available to address these risks – regulators have to carefully consider whether risk mitigation aims can be achieved through other means. - Regulators should carefully consider how capital interacts with these tools, including other public policy interventions.

Ultimately, the PRA’s appetite to make changes is greater where there are material gaps in the frameworks. For the reasons set out in this section, this materiality is not easy to determine, and the size of the perceived gap will be impacted by the extent to which climate-related financial risk is captured in the accounting numbers that feed into the regulatory metrics (noting that this interaction is less direct for insurers).

In a world where there are so many ways of looking at this issue, regulators will need to make assessments based on available information and their risk appetite. The next section sets out the need to develop a better understanding and knowledge of these issues.

Finding 4 – More research is required on the materiality of any gaps, and options to address them

More analysis and research is required to assess whether the possible gaps in current capital frameworks are material (or might over time become material) and, if so, the suitability of various capital-related options to address them. The Bank is therefore putting out a ‘Call for Papers’ on this topic and will host a Research Conference in Q4 2022. Based on this internal and external work, the PRA expects to be in a better position next year to decide whether a different approach to capital should be considered (now or in the future) in the context of climate change.

The remainder of this section is the PRA’s contribution to early thinking in this area. The PRA recognises that there is no established approach as to how these issues should be approached as yet. The approach set out is therefore just one of many ways to consider these issues. The aim of including the below is to foster and contribute to a broader consideration of these issues by stakeholders, including (but not limited to) regulators, industry and academia. The forthcoming “Call for Papers” will seek to collate alternate and varying approaches from different stakeholders that will then be considered together.

In due course, if this work indicates the need for more specific policy measures to be taken, the PRA will follow its standard policymaking process prior to implementation, including through extensive further consultation. This could include a future Discussion Paper, for instance covering the framework for policy

proposals and next steps, in the same way that the Bank sought feedback from a wide range of external parties on the robustness and feasibility of the proposed framework for the CBES.

A potential approach for how the use of capital, or change in capital frameworks, could address relevant gaps

It is possible to map possible options to the specific gaps that were identified in Finding 2. There might be other ways to categorise and assess next steps, and the pros and cons of different frameworks will need to be studied further in the coming period.

1. ***Addressing capability gaps:*** this would include options that seek to address firms' risk mitigation and (capital) modelling deficiencies directly, for instance by promoting that firms more appropriately consider the entirety of the maturity of their exposures where regimes already allow this (e.g. internal ratings). Implementation and calibration of such options would depend on the evidence of firms' capital modelling capabilities. This evidence may be uncovered in the supervisory activity described in Part A of this report.
2. ***Addressing regime gaps related to the microprudential regime:*** this would include options that would amend the frameworks or methodologies themselves to allow them to better capture climate-related financial risks, for instance by introducing a more explicit forward-looking element. Implementation and calibration would ultimately depend on further robust evidence around future risks, which would be supported by clarity on future climate policy.
3. ***Addressing regime gaps related to the macroprudential regime:*** this would include changes to the macroprudential framework to more appropriately address the systemic dimensions of climate-related financial risks.

Table 4: Possible capital options for further exploration linked to the possible gaps identified

	(1) Address capability gaps	(2) Address microprudential 'regime gaps'	(3) Address macroprudential 'regime gaps'
Banking-specific capital tools to consider	<ul style="list-style-type: none"> • Pillar 1: develop more detailed guidance / expectations on relevant discretion • Pillar 2B: further use and/or development of RMG scalars 	<ul style="list-style-type: none"> • Pillar 1: improvements through BCBS or independently • Pillar 2A: develop PRA-led methodology for climate-related financial risks, e.g., similar to operational risk 	<ul style="list-style-type: none"> • Pillar 2B: develop climate scenario for PRA buffer • FPC tools: use existing macro-prudential tools or develop new ones, e.g., an 'escalating' climate buffer or scalar
Insurers – specific capital tools to consider	<ul style="list-style-type: none"> • Pillar 1: more detailed guidance / expectations on relevant discretions • CAO framework: further use and/or development of add-ons 	<ul style="list-style-type: none"> • Pillar 1: develop specific changes to calculation of SCR 	<ul style="list-style-type: none"> • Develop an 'escalating' buffer or scalar (likely first requiring the introduction of a 'buffer' regime in insurance)
Possible implementation signals	<ul style="list-style-type: none"> • Evidence of material lack of capital modelling capabilities with regards to climate-related financial risks 	<ul style="list-style-type: none"> • Increased clarity on policy interventions that might result in transition shocks • Worsening of physical impacts • Evidence of risk differential on specific exposures (e.g. 'green' housing) 	<ul style="list-style-type: none"> • Material risks arising from inaction
Possible implementation timeframe	Near term	Medium term	Medium term

These options, which are described in more detail below, would need to be considered in the context of

their proportionality, feasibility and the impact of other mitigating interventions, including non-capital tools. These factors would be considered formally as part of any follow-up policy-making process, which would include extensive engagement with stakeholders. For example, regulators need to consider whether any changes are best made internationally (e.g. through BCBS) before taking action domestically, which will depend on the part of the framework they target. Regulators also consider the impact of accounting on capital and the potential for double count. In addition, it is necessary to consider the relative benefits of using minimum capital versus buffers, which impacts amongst other things: usability in stress; the quality of capital; and perceptions or potential reactions of investors and rating agencies.

1. Addressing capability gaps

Banks and insurers are already required to ensure they are appropriately capitalised for all material risks, including those related to climate. The challenge is that the difficulties in quantifying these risks could lead firms to conclude they are not material. Supervisory and regulatory interventions can be targeted to ensure firms perform more work in this area, and should also consider the importance of achieving consistent outcomes. The PRA is already prioritising this work through a mixture of its expectations of firms as set out in SS3/19, further initiatives such as the CBES, and use of the PRA's powers over auditors.

Regulators could publish further guidance for firms around capital modelling, for instance aimed at ensuring firms more appropriately consider the entirety of the maturity of their exposures (where the frameworks already provide this flexibility). On the banking side, this could include sharing best-practice on risk-weight calculations (e.g. the impact on PD / LGD metrics), or asset-level bucketing (recognising potentially heightened correlations driven by climate-related financial risk exposure and reducing diversification benefits). On the insurance side, this could include guidance on relevant considerations to include in internal model scenarios (such as giving a higher weighting to current climatic conditions where climate-related financial risks have already crystallised).

Capability gaps could also be partially addressed by publishing guidance to promote high quality and consistent accounting for climate-related financial risks. This would promote timely capture of climate-related financial risks in regulatory capital resources. The PRA will play an active role in promoting high quality and consistent accounting for climate change through its use of written auditor reporting and in supporting international efforts to promote reporting standards such as through the IFRS's International Sustainability Standards Board (ISSB).

As set out in Part A, one further option regulators could consider is the application of add-ons (for insurers) or scalars (e.g. under Pillar 2B in the UK banking regime) to those firms deemed to have significant weaknesses in their climate-related financial risk management and governance. This could help reinforce

existing supervisory expectations in this area and contribute to improving (capital) modelling capabilities over time. This could also be developed to include a methodology that allows for more consistent comparisons.

2. Addressing gaps in the microprudential regime

If the possible gaps in the microprudential regime were deemed material and could not be fully addressed through initiatives aimed at improving capabilities described above, regulators could explore specific amendments to the microprudential regime and/or develop new methodologies. Such actions could be informed by further evidence that specific risks or exposures are not properly captured by current regimes, for instance as a result of more robust evidence or predictions around future risks.

Options in this space could address the design features of the capital framework, either directly through amending specific design features or indirectly by developing new domestic methodologies. Such approaches should consider the overlap between accounting and capital and the risk for potential double count, in particular as accounting methodologies to capture climate change are evolving and as climate change becomes more material for accounting numbers.

On the banking side, the BCBS is already exploring the extent to which Pillar 1 captures risks, and the PRA will continue to contribute to these discussions. In this space, regulators could amend some of the overarching design-features of Pillar 1, such as the 1 year time horizon or reliance on historical data. This could be done by placing new requirements on firms (for example, by requiring them to consider forward-looking projections in their IRB models) or by regulators recalibrating existing supervisory values (for example, changing correlation factors in the IRB formula). Specific design changes could also enter through existing risk components, such as credit risk (e.g. treatment of securitisations, real estate, and collateral), or market risk (e.g. including exposures with climate-specific risks in exotic underlying exposures). As noted before, any changes to Pillar 1 would be time-consuming to deliver, so the costs of this approach would need to be assessed versus other available approaches.

On the insurance side, specific enhancements to the SCR framework could be considered. For instance, regulators could consider allowing for regular recalibration of prescribed shocks or factors within the standard formula, or by requiring internal model firms to include forward-looking projections of climate-change into their scenarios. In addition, amendments to diversification benefits could be made recognising potentially heightened correlations both within and across risk-components, recognising that climate-change could impact previously uncorrelated assets and liabilities (e.g. across market risk and non-life underwriting risk).

If the Pillar 1 amendments still left some material climate-related financial risks uncaptured, regulators could explore the development of a specific methodology to feed into Pillar 2. In the UK banking regime, the PRA could use Pillar 2A to develop and implement a methodology requiring firms to capturing specific climate-related financial risks that are not adequately incorporated into Pillar 1. This could be informed by ongoing and future work (such as the CBES) that help to highlight possible exposures and vulnerabilities. In the UK insurance regime, the PRA could explore developing a methodology to address material risks uncaptured by Pillar 1, similar to Pillar 2A in the UK banking regime.

3. Addressing gaps in the macroprudential regime

The macroprudential regime has a system-wide focus, including potential amplification mechanisms via feedback loops and spill-overs. Its objectives are macroeconomic: to ensure that the financial system can continue to support the real economy, prevent amplification of shocks to the system, and avoid boom and bust cycles in the supply of credit and liquidity.

Most commentators agree that climate change could become systemic, though research on the nature and quantification of the macroprudential climate-related financial risk channels is still evolving. That is one of the reasons why in the UK the FPC is undertaking the CBES. Climate-related financial risks could lead to different patterns in bank lending and reduction in coverage by insurance firms. As a result, certain sectors of the economy and groups of households could find it harder or more costly to access certain financial services, including to finance a transition to net zero or to adapt to the physical risks from climate change.

Another potential macroprudential concern from changes in lending patterns is that banks may not be able to (re)deploy capital quickly enough in the future to support low-carbon investment as the government's transition policy path becomes clearer. Interconnections between banks and insurers could amplify this transmission channel. For example, evidence suggests that a decrease in property insurance can impact house prices, increase credit risk for lenders, and reduce the provision of mortgages.

Climate change might also result in an increase in risk premia for a range of financial assets leading to pro-cyclical behaviour of market participants (including banks and insurers). This could lead to asset fire sales from loss in value of assets, particularly in case of common exposures by several market participants, resulting in larger price movements with possible system-wide impacts.

Uncertainty on time and magnitude of impacts can amplify the strength of these transmission channels. The magnitude of these risks is hard to predict and depends on many factors, including the degree to which governments intervene to deliver on their net-zero commitments as well as consumer and investor views. These impacts on the financial system, if realised, would likely have real economy impacts associated with

them. For these reasons, it might be appropriate to apply a system-wide perspective and consider the use of macroprudential tools.

The macroprudential toolkit in the UK consists of a combination of capital and non-capital tools, some of which are within the formal powers of the FPC to implement directly, and some of which derive from international standards. The section below focuses on capital options only, and explores various options for how the macroprudential framework could address the unique systemic features of climate-related financial risks.

In the UK, one possible way to increase resilience of the system as a whole would be to impose a system wide rate or buffer. Any such tool may need to apply in relation to UK and non-UK exposures and apply in relation to a continuously increasing trajectory of climate-related financial risks. Therefore, it could be escalated over time based on a risk assessment on the materiality of future system-wide transition and physical risks associated with climate change.

Alternatively, options that seek to target the cross-section of banks or insurers most exposed to climate-change risk could be used. For banks, these include the use of scenario tests inputting into the PRA buffer (e.g. a modified ACS as standard, which would include adjustments to incorporate climate-related financial risks explicitly), through the use of Sectoral Capital Requirements where relevant, or through a new tool such as a climate-systemic buffer. Similar tools could be developed for insurers.

3. Next steps

A key finding of this report is that capital is not the right tool to address the causes of climate change, but that it should be used to provide resilience against its consequences. In fact, under the current prudential framework, capital already supports non-capital tools in mitigating climate-related financial risks. In particular, firms are already required to ensure they have sufficient capital to be resilient against all material risks including those stemming from climate change. Where they fail to demonstrate this appropriately, the PRA can use capital add-ons against significant weaknesses in risk management and governance.

Another key finding of this report is that current capital regimes likely do not yet capture the full extent of climate-related financial risks. The materiality of these gaps is not yet clear, but international efforts are ongoing to better understand and develop options to mitigate them. The PRA will continue to contribute to this work and also explore improvements to the parts of the capital framework that are specific to the UK.

Given the complexities it is important to proceed this work diligently yet quickly, to ensure firms and the system remain resilient and avoid unintended consequences. The Bank and PRA are therefore committing to undertake the following next steps:

- Over the coming year analysis will be undertaken to further explore whether the design features or methodologies of the microprudential capital regimes for banks and insurers might need to be enhanced:
 - for banking, the PRA will explore the balance between an internationally driven Pillar 1 approach and a more domestic Pillar 2 approach;
 - for insurers, the PRA will explore making specific changes to the SCR calculation.
- Over the coming year, further analysis on the macroprudential and systemic risks associated with climate change will be undertaken to help explore options that might more explicitly incorporate climate elements into the macroprudential capital regime.
- To complement internal work in this area, the Bank will put out a ‘Call for Papers’ and will host a Climate and Capital Conference in Q4 2022.
- The Bank will publish a follow-up report on the use of capital, including a plan on how future scenario exercises after CBES might guide further work on capital.

Conclusion

This report set out the key pillars of the PRA's response to climate change, including how it affects the firms we regulate and what policies we are putting in place to address the risks it poses. Our priority is ensuring firms (and the wider financial system) develop effective capabilities to identify, measure, manage, and where outside appetite, mitigate the financial risks from climate change so they are resilient to them. Our supervisory expectations, climate scenario exercise, and collaboration with industry will help drive improvements in these areas. In turn, this will help support the transition to a net-zero economy as better management of risks will also reveal opportunities.

Capital requirements are another key part of our supervisory and regulatory toolkit. They can help mitigate the financial consequences of climate change (financial risks), but are not the right tool to address the underlying causes of climate change (greenhouse gas emissions). We are already using the existing capital framework to ensure firms incorporate climate-related financial risks into their own assessment of capital adequacy and risks. In addition, where firms fail to keep pace with our supervisory expectations and demonstrate significant climate-related financial risk management and governance weaknesses, we stand ready to introduce capital add-ons or scalars where appropriate. However, determining whether broader changes are needed to the design, use or calibration of the capital framework to capture climate-related financial risks requires further work and research. This report helps set the groundwork for making that determination and supporting future work by the PRA, Bank, industry, academia, and other regulators on these issues.

As we look ahead to 2022, the PRA will continue to treat the financial risks from climate change as a priority. We will incorporate climate change into our core supervisory processes, actively engaging firms on climate change, supervising them against our expectations, and deploying our supervisory toolkit in response where appropriate. On capital, we will similarly be proactive in our work to assess whether changes to the framework are needed, putting out a call for research, hosting a climate change capital requirements conference, and continuing to participate in international discussions on these issues ahead of providing an update on our views.

Annex – Research Deep Dive on ‘Climate Change and Capital Regulation’

The growing importance of climate change as an issue for central banks and regulators has fuelled a debate about whether and how capital regulations for banks and insurers should be deployed in response. This Annex will review the literature in three key areas: prudential policy responses to climate-related financial risks in banks’ asset portfolios; the use of regulatory tools to encourage the transition towards a low-carbon economy; and the challenges for insurance regulators from heightened climate risks.

Dealing with climate-related financial risks in asset portfolios

One argument for incorporating climate-related financial risks in capital regulation is to ensure that individual firms have sufficient capacity to absorb losses. This requires a reliable methodology to measure these risks for individual firms.

Measuring transition risks in asset portfolios

The existing literature proposes several approaches for estimating banks’ capital shortfalls under a transition stress scenario. The first approach is to build climate stress testing around technologically plausible scenarios and carbon price paths which are consistent with climate goals, as proposed by Batten, Sowerbutts and Tanaka ([2016](#), [2018](#)) and recommended by the NGFS ([2020](#), [2021a](#)). A second approach is to estimate capital shortfalls for banks arising from ‘stranding’ of specific sectors. Using granular data on individual firms, [Battiston et al \(2017\)](#) carry out a climate stress test of 50 large EU banks in which they include second round effects deriving from the revaluation of exposures to shocked institutions. They find that 15 banks would suffer losses that exceed 10% of their equity in a stress scenario where the equities of all firms in the fossil fuel and utilities sectors are wiped-out. A third approach consists of building market-based measures of banks’ exposures to transition risks. [Jung, Engle and Berner \(2021\)](#) perform a climate stress test of 27 large global banks by computing the ‘climate beta’, i.e. the sensitivity of their equity prices to the return on “stranded asset portfolio”. They then use the climate beta to compute expected capital shortfall under a climate stress scenario (‘CRISK’). They find that, under a stress scenario of a 50% fall in the value of the stranded asset portfolio, the amount of capital that large UK banks would have needed to raise to restore their capital ratios to 8% in 2020 ranged from around US\$40bn to US\$160bn.

There is also some (limited) empirical evidence for specific markets that low carbon assets have lower default risk. For example, [Guin and Korhonen \(2020\)](#) find evidence that home energy efficiency is a relevant predictor of mortgage defaults in the UK. For a sample of investment grade bond issuers, [Capasso et al \(2020\)](#) find a negative relationship between firms’ distance to default and both the level of CO₂ emissions and the carbon intensity (the ratio between carbon emissions and sales).

Measuring physical risks in asset portfolios

Physical risks in asset portfolios are harder to quantify than transition risks. [Leaton \(2020\)](#) argues that, while catastrophe models can incorporate the increasing frequency and severity of extreme weather events in the future, they cannot predict which specific region will actually experience an extreme weather event. [BCBS \(2021a\)](#) acknowledges that limited progress has been made in capturing banks' exposures to physical risks, due to lack of data about the geographical locations of the physical assets underlying their financial exposures, and uncertainty about their ability to insure against prospective losses. Moreover, [BCBS \(2021b\)](#) recognises that there are large uncertainties over the location, frequency and severity of climate-related events and that these uncertainties can be exacerbated by tipping points and non-linearities in the impact of climate change. In general, climate models are difficult to validate, as past data may not contain meaningful information about the future trajectory of key climate variables; and non-linear models can give rise to radically different predictions about future climate outcomes.

Implications for capital regulation

Setting capital requirements or buffers based on market-based climate risk measures, such as CRISK and carbon betas, is likely to be problematic for two reasons. First, these measures are likely to be directly influenced by the market reaction to regulators' actions. Second, market-based measures provide reliable signals of transition risks only to the extent that investors price these risks. While there is some evidence that financial markets are starting to price transition risks ([Bolton and Kacperczyk \(2020\)](#)), regulators may lack analytical tools to ascertain whether they are accurately priced.

By contrast, setting capital requirements or buffers based on specific climate scenarios is conceptually no different than basing these on other types of stress scenarios, as long as all major banks and insurers have sufficiently granular data to map the scenarios to losses. But in practice, the regulators may not be able to validate firms' data and models, especially for physical risks. Several central banks and regulators have either concluded or are planning climate stress tests in the near future ([NGFS 2021b](#)). [Baudino and Svoronos \(2021\)](#) note that the predominant view in the official sector is that it is premature to require banks to have additional capital based on climate stress tests given the high level of uncertainty around their results. [Baranovic et al. \(2021\)](#), however, argue that supervisory measures, including Pillar 2 requirements, and macroprudential policies to address the challenges and risks to the banking sector posed by climate change could both play a role.

Green prudential tools

Another argument for calibrating capital requirements to climate-related financial risks is that they can ultimately destabilise the financial system, and thus the regulators should use these requirements to incentivise banks and insurers to support an early and orderly low-carbon transition.

This gave rise to several proposals for green prudential policies. Among these, the most widely proposed are green supporting factors (GSF), i.e. lower risk weights for green assets, and brown penalising factors (BPF), i.e. higher risk weights for brown assets. [Campiglio \(2016\)](#) argues in favour of green supporting financial regulations, as a carbon tax might not provide enough incentive to stimulate profitable low-carbon investment when banks constrain credit to protect their balance sheets. [D’Orazio and Popoyan \(2019\)](#) argue that GSF can have a destabilising effect and suggest a set of alternative tools: countercyclical capital buffer (calibrated to climate risks), sectoral leverage ratios, minimum credit floors (for green investments), maximum credit ceilings and large exposure limits (for brown investments). [Esposito, Mastromatteo and Molocchi \(2019\)](#) propose several ways to compute environment-risk weighted assets. The environmental corrections applied to risk weights are based on deviations from national average of some measures of externality. The measures considered include CO2 emissions and sectoral external costs.

A strand of the literature has investigated the impact of green prudential regulations on financial stability using structured models. [Dunz, Naqvi and Monasterolo \(2021\)](#) develop a macroeconomic stock-flow consistent model and find that even reducing risk weights for green loans to zero will result only in a small increase in the share of green capital goods in the economy. A GSF could also lead to an increase in the ratio of non-performing loans of brown firms due their lower profits, as they compete with green firms which face better credit conditions.

Several recent studies use agent-based models due to their flexibility in analysing a combination of policies. They typically conclude that green prudential policies will need to be supported by other policies to have the desired effect. [Dafermos and Nikolaidi \(2021\)](#) find that GSF and BPF reduce the pace of global warming and thereby decrease the physical risks. At the same time GSF increases bank leverage because it boosts green credit and the BPF increases loan defaults since it reduces economic activity. A mix of green fiscal policies and BPF is potentially synergic, as the former reduce the transition risk brought by the latter. [Lamperti et al \(2021\)](#) investigate green capital requirements alongside green credit guarantees and carbon-emission adjustments in credit ratings. They find that each of these policies fails to produce significant mitigation effects in isolation. In particular, carbon emission adjustments weaken the performance of the economy and increase banks’ failure rate. Instead, a policy mix comprising all three policies allows the economy to enter a virtuous cycle in which emission growth is dampened significantly, growth is higher, and bank stability is enhanced. [Lamperti et al \(2019\)](#) find that climate-dependent capital requirements can counterbalance excessively high or low credit provision, as they account for the impact of

climate damages on firms' solvency. A counter-cyclical capital buffer could help address climate physical risks, even though it proves ineffective when damages surge. Overall, macroprudential regulation alone is only partially able to attenuate the financial costs brought by climate change.

There are important additional concerns over green prudential policies, as highlighted in [Campiglio et al \(2018\)](#). First, unlike carbon tax, capital requirements are not sufficiently granular to target carbon-intensive activities. Thus, they may fail to achieve their intended aims, and at worst discourage investment needed for low-carbon transition, for example if they cannot discriminate those companies that engage in low-carbon investments within brown sectors (e.g. oil companies investing in solar energy). Second, unless those policies are implemented across major jurisdictions, brown firms can bypass them by raising funds on international financial markets.

Ultimately, whether a GSF will be effective in stimulating green investment is an empirical question. For example, there is mixed evidence on the SME supporting factor introduced in January 2014 across EU. [Mayordomo and Rodríguez-Moreno \(2018\)](#) show that it was effective in alleviating credit rationing for medium-sized firms that were eligible for the application of the SF but not for micro/small firms, while [EBA \(2016\)](#) suggests this did not lead to any increase in access to finance for SMEs relative to large firms. [BCBS \(2018\)](#)'s literature review also suggests that, while there is some empirical evidence that sectoral capital requirements may limit loan growth in the targeted sectors, their effectiveness depends on the context and they can give rise to unintended spillovers to untargeted sectors and other jurisdictions.

Regulating insurers

Although insurers typically hold longer term assets than banks, issues related to assessing climate-related financial risks on their asset portfolios are in essence similar to those for banks discussed above. [Braun, Utz and Xu \(2019\)](#) discuss how transition risks in insurers' asset portfolios could be reflected in capital. The paper proposes an adjustment to Solvency II capital charges to reflect insurers' exposures to carbon risk, as measured by the sensitivity of their stock excess return to carbon prices ('carbon betas'). As discussed above, however, basing solvency requirements on market-based metrics is problematic.

But unlike banks, insurers are particularly exposed to climate-related physical risks on the liability side of their balance sheets. According to the recent [EIOPA \(2021\)](#) report, since non-life insurers commonly re-price contracts annually, they implicitly adjust to long term trends such as climate change gradually over time. However, [Tesselaar, Botzen and Aerts \(2020\)](#) analysed the impact of climate change on EU flood insurance markets and concluded that insurance premiums would rise following large disasters and thus reduce insurance affordability. Using data on U.S. property insurers' supply decisions from 1992 to 2012, [Aseervatham et al \(2017\)](#) find evidence that insurers exit or reduce business after natural catastrophes,

with the effects more pronounced after extreme hurricane years. They argue that supply distortions are driven by the correlated losses and call for regulators to focus on measures that encourage risk diversification.

Batten et al ([2016](#), [2018](#)) also highlight that, while withdrawal of insurers from covering weather-related risks would help protect them from losses, this does not necessarily represent an efficient outcome for the financial system or the economy. If more of the weather-related risks become uninsured, the post-disaster reconstruction is more likely to experience delays and risks to banks' credit exposures will increase. It could also increase the need for fiscal authority to step in *ex ante* (to reduce insurance premiums) or *ex post* (to bail out uninsured victims). Hence, any policy which could increase the cost of natural catastrophe insurance will need to take these effects into account.

Insurers are also exposed to climate-related liability risks, which arise from parties that have suffered losses due to climate change and seek compensation from another (insured) party that might be deemed to be responsible for causing these losses. There is little research on quantifying these risks, but the challenges associated with gauging these are similar to those for physical risks, as the claims ultimately originate from the same events. In addition, there is legal uncertainty around how these claims would be treated in courts.

[Cleary et al. \(2019\)](#) surveyed 18 insurance supervisors and noted that capital requirements currently do not explicitly capture climate risks. This is both because there is still inadequate understanding of the nature of climate risks on the part of the supervisors and because data needed to calibrate the requirements are often missing. The authors also note that it is currently unclear if capital is the right mitigant for climate risks.

Conclusions

Overall, research in the areas covered by this Annex is still at an early stage. For example, the existing literature does not discuss specific implementation questions about how to incorporate climate-related financial risks in capital regimes for banks and insurers. That includes whether climate-related financial risks should be incorporated in risk weights or in buffers; and whether the time horizon covered by the capital stack is appropriate for climate-related financial risks. While further supporting evidence would be needed to guide any policy actions, some broad lessons can be drawn based on this nascent literature.

First, calibrating capital requirements based on a scenario-based stress testing is in principle possible, but there are serious practical challenges for regulators. While data gaps could be filled and more sophisticated models could be developed over time, the most fundamental challenge is that models cannot be validated

even with the best data given the uncertainty around the path and impact of climate change. Thus, any policy action based on such scenario-based stress testing will need to ultimately rely on regulators' judgement. By contrast, calibrating these to market-based measures is problematic given endogeneity and potential for mispricing of risks.

Second, the existing literature cautions that GSFs could potentially destabilise the financial system and may not, on its own, be effective in stimulating low carbon investment. A combination of policies, including fiscal policies to support the transition to a low-carbon economy, may need to be implemented to mitigate these problems. Finally, forcing insurers to increase capital against their physical risks on the liability side could increase the problem of underinsurance, which in turn could adversely affect financial stability.

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