Grantham Research Institute on Climate Change and the Environment

Preventing a 'climate Minsky moment': environmental financial risks and prudential exposure limits

Exploring the case study of the Bank of England's prudential regime

Hugh Miller and Simon Dikau

Policy report

March 2022

The Grantham Foundation for the Protection of the Environment

LSE The London School of Economics and Political Science

The Grantham Research Institute on Climate Change and the Environment was established in 2008 at the London School of Economics and Political Science. The Institute brings together international expertise on economics, as well as finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute – Climate Change and Environment at Imperial College London.
www.lse.ac.uk/grantham

About the authors

Hugh Miller is a Research Assistant and **Simon Dikau** is a Research Officer at the Grantham Research Institute on Climate Change and the Environment.

Acknowledgements

This report is derived from Hugh Miller's LSE MSc dissertation. The authors would therefore like to first and foremost thank Professor Simon Dietz for supervising the dissertation and for his input, insight, and advice when it came to writing this report. The authors also thank Samuel Lanham, Lynnette Withfield and Mahmoud Fatouh of the Bank of England for their support, Alex Bowen, Katie Kedward, Danae Kyriakopoulou and Agnieszka Smoleńska for their review, comments and suggestions, and Pierre Monin and Irene Monasterolo for their helpful comments. The report was copy-edited by Georgina Kyriacou.

The authors acknowledge support from the Grantham Foundation for the Protection of the Environment.

This report was first published in March 2022 by the Grantham Research Institute on Climate Change and the Environment.

Suggested citation: Miller H and Dikau S (2022) *Preventing a 'climate Minsky moment': environmental financial risks and prudential exposure limits*. London: Grantham Research Institute on Climate Change, London School of Economics and Political Science.

Contents

Summary

It is an increasingly accepted reality that the transition to net-zero affects specific parts of the economy and the profitability of related financed activities. This exposes the financial sector to so-called 'transition risks'.

Changes in policy, technology and consumer preferences related to action to mitigate emissions will alter the future expected cash flows of relevant carbon-intensive assets. In some scenarios, this may result in a sudden revaluation of assets and cause financial risks to materialise. Therefore, it will become necessary to reduce the exposure of the financial sector to these transition risks by building resilience.

Sectoral analysis of companies within transition-sensitive industries suggests there is misalignment between (non-financial) companies and climate policy targets. Moreover, there are indications that companies are delaying their mitigation action until after 2040.

The analysis conducted in this report using the Transition Pathway Initiative (TPI) tool indicates that globally, 62% of 292 companies in transition-sensitive sectors are not aligned with the Paris Agreement temperature targets. Thirty-six per cent of the assessed companies are planning to align to climate policy target pathways only after 2040, leaving them exposed to near-term transition risk. The risk from the real economy will spill over into the financial sector, creating risks for banks and other financial institutions.

From a macroeconomic perspective, there is a strong argument that the global economy is heading for a disorderly transition to net-zero, which will exacerbate transition risks in the long term.

The global economy requires a 12.9% or 8.1% average annual reduction in carbon intensity until 2050 to meet targets of limiting warming to 1.5 or 2°C, respectively, according to PwC. Moreover, the UN Environment Programme finds that the updated climate pledges by countries for 2030 will amount to a 7.5% reduction in emissions, far short of the 30% cut needed for 2°C and 55% cut for 1.5°C. Consequently, drastic and imminent changes to policy are required to meet the current climate policy targets, which could in turn lead to significant policy-induced transition risk.

There is a role for financial policy in mitigating the risks from climate change. Central banks and financial supervisors, including the Bank of England, are ultimately responsible for ensuring the financial resilience of individual banks and the financial sector.

The Bank of England's remit changed in March 2021 to explicitly include climate change in both its Monetary and Financial Policy mandates. However, despite acknowledging the necessity for action, the Bank of England is yet to incorporate climate risks explicitly and directly into prudential requirements.

One instrument in the Bank of England's toolbox is the 'Large Exposures limit', which could be recalibrated to capture these transition risks.

The current regulation places limits on banks' exposures over 25% of their eligible capital to individual counterparties. The regulation could be adjusted to measure the transition risk component in banks' largest exposures. Exposure limits to certain economic sectors could be set by the Bank of England to incorporate the risk into the prudential regime.

This report proposes a 'transition-aligned Large Exposures framework' for the Bank of England that would introduce a 'soft' limit to individual banks, based on their largest exposures to transition-sensitive sectors.

As part of this approach, the Bank of England would map and assess commercial banks' large exposures to transition-sensitive sectors. **A 'soft limit' of 25% of eligible capital for aggregate large exposures to relevant economic sectors could be introduced.** If breached, banks would be

required to undergo a pre-defined climate-related disclosure process. The disclosure is focused on the climate mitigation strategies of underlying (non-financial) companies in banks' portfolio exposure as well as their risk management and governance processes on climate risk.

The proposal is written with specific reference to the Bank of England and the Prudential Regulation Authority rulebook but the identified risks and policy challenges, as well as the policy proposal itself, are applicable beyond the Bank; the analysis is therefore highly relevant for other central banks and financial supervisors, too.

Next steps and recommendations

Based on the discussion of the relevant transition risk factors in this report, the following recommendations and next steps emerge:

1. **The Bank of England should assess banks' large exposures to transition-sensitive sectors and explore the climate policy alignment of the underlying counterparties.** The Bank of England should conduct an assessment based on banks' large exposures reporting to measure the size of potential transition risks and create an evidence base to explore further policy action.
2. **The costs of the transition for underlying companies needs to be understood, to assess the policy impact.** Underlying companies will incur costs from transitioning, which will vary depending on the sector, and may cause policy-induced transition risk.
3. **The Bank of England should examine the exposure to transition-sensitive sectors in banks' exposures that are not defined as large.** This would explore whether substantial transition risk is present elsewhere in banks' portfolios and confirm if further prudential action beyond Large Exposure restrictions is needed to mitigate transition risks.

The proposed transition-aligned Large Exposures framework would necessitate several calibration adjustments of the Large Exposures regime:

- **Increase the understanding of climate-related risks to the real economy among sector-specific experts to enable the targeted recalibration of prudential measures.** Transition risk poses a threat to financial stability; it will originate in the real economy and spill over into the financial sector. Therefore, sector-specific expertise is necessary within the Bank of England to gain a holistic understanding of these risks and the best avenues through which to mitigate them.
- **Increase the required granularity of current sectoral reporting within the Large Exposures framework.** The use of 4-digit NACE codes is necessary for the accurate identification of exposures to transition-sensitive sectors. The reporting of NACE codes needs to be changed within the Large Exposures framework to require banks to submit a NACE code for each large exposure reported.
- **Ensure there are consequences for inadequate disclosure or risk management of banks' climate-related large exposures.** Three supervisory powers could be utilised:
    i. A climate risk awareness course could be required for senior management from the bank to attend. This tool could be most appropriate initially for banks with inadequate disclosure, to help address a potential knowledge gap.
    ii. Supervisors could request changes within the senior management structure, composition of the board or require hiring of senior management with existing climate knowledge; and/or impose limits on the capital distributions of dividends. Such action could be envisaged for banks with repeated inadequate management of their climate-related exposures.
    iii. Supervisors could impose a capital surcharge for consistent inadequate management and disclosure of climate-related risks. This avenue would focus more on the bank's risk management practices, which suits the overall framing of the policy.

1. Introduction

Scientific reports have provided ample evidence for the physical risks of environmental degradation and climate change as well as the necessary urgency for mitigating policy action. The 2021 report of the Intergovernmental Panel on Climate Change (IPCC) is a 'code red' for humanity to take drastic action to address climate change. The report reveals how perilously close to 1.5°C of warming the planet is, with imminent risk of hitting this threshold in the near term (IPCC, 2021). Policy action to respond to and mitigate the most severe impacts will inevitably substantially impact economies and all economic sectors, as carbon-intensive activities will have to be phased out or replaced with low-carbon alternatives.

Implications for the UK financial sector and the Bank of England

The UK's independent advisory body on climate, the Climate Change Committee, highlights the shortfall in efforts to adapt to climate change for the level of climate risk posed in the UK (CCC, 2021a), stressing that climate policy needs to be rolled out much more quickly than is currently happening (CCC, 2021b).

Climate change policies will have substantial impacts on the UK financial sector. According to a joint report by WWF and Greenpeace (2021), UK financial institutions have exposure to companies responsible for 1.8 times the UK's domestically produced emissions (805 million tonnes of CO_2 equivalent). Consequently, a low-carbon transition will adversely impact the expected future cash flow of certain financed activities and expose the financial sector to significant risks. Therefore, there is a strong and urgent need to build resilience in the financial sector to identify, assess and mitigate these risks. **In examining the potentially significant transition risk present in transition-sensitive sectors, the first aim of this report is to establish a firm basis for central bank supervisory action.**

In the UK, the Bank of England is ultimately responsible for the stability of the financial sector, achieved through ensuring the resilience of individual banks. The implications of climate-related financial risks for financial stability have been widely acknowledged by Governors and senior officials at the Bank (Carney, 2015; Breeden, 2021; Bailey, 2021). However, despite recognising the necessity for action (Prudential Regulation Authority [PRA], 2021a), the BoE is yet to fully incorporate climate risks into the prudential regime.

The adoption of a long-term risk horizon is crucial for preventing a rapid adjustment in asset prices and a so-called 'climate Minsky moment', which has been coined in this context by Breeden and Hauser (2019). While Hyman Minsky theorised a cyclical boom and bust cycle with tipping points that occur when speculative activity becomes extremely unstable, leading to rapid price deflation (Minsky, 1988; 1992), it is important to stress that these tend to occur in blind spots in the regulatory framework where risks are not yet recognised, identified or mitigated. A future potential 'Minsky moment' could take place as a result of climate risk.

This report focuses on the Bank of England because of the Bank's remit, and this is reflected in the terminology used throughout. However, the challenges highlighted, as well as the policy proposed in Section 4, are highly relevant to other central banks and financial supervisors around the world, too.

Box 1. Climate change and the role of the Bank of England

First and foremost, climate change is relevant for central banks' price stability mandates, due to its potential impact on supply chains and the overall price level (Villeroy de Galhau, 2021). Further implications can be addressed by central banks under two distinct approaches: first, **the risk-based approach**, which focuses on increasing banks' resilience to climate risks and ensuring financial stability; and second, **the promotional approach**, under which some central banks **support the scaling-up of green finance** by positively supporting finance for green sectors and a low-carbon transition as part of their secondary mandates (Berenguer et al., 2020; Dikau and Volz, 2021; Baer et al., 2021).

The role of any central bank is determined by its mandate, which differs in scope between central banks. The Bank of England's mandate is split between the Monetary Policy Committee and the Financial Policy Committee (MPC and FPC). The MPC is concerned with maintaining the inflation rate target and price stability, while the FPC concentrates on the stability of the UK's financial sector.

The FPC's current remit states that the risks from climate change are relevant to the primary objective of the Committee, which is ensuring financial stability (HM Treasury, 2021a). The FPC remit aligns with the risk-based approach to climate change action; therefore, any prudential measures should be grounded in risk. **This report focuses on this primary, risk-based approach to climate change and central bank action.**

The latest MPC remit update, detailed in the Bank of England's March 2021 MPC Remit Letter, explicitly includes the 'net-zero transition' as a government priority (HM Treasury, 2021b). The implied relevance of the scaling up of green finance prompted an immediate response from the Bank, signalling action to adjust the Corporate Bond Purchase Scheme (CBPS) "to account for the climate impact of the issuers of the bonds" (Bank of England, 2021).

Challenges to central bank action on climate

Despite the acknowledgement of the risks, there are several challenges hindering further central bank action globally, including for the Bank of England:

- A lack of data on climate-related risks severely reduces the ability of banks and supervisors to understand and measure those risks (NGFS, 2021a). While data availability on physical risks has greatly advanced (de Guindos, 2021), there is still limited progress being made on the disclosure of financial institutions' exposures (ECB, 2020), and that data is key to understanding transition risks.
- The unique characteristics of net-zero transition risks and physical climate risks, namely that they are forward-looking, non-linear, endogenous and deeply uncertain, currently make it difficult to fully capture climate impacts in quantitative terms. This inhibits supervisors' ability to incorporate climate-related risks into prudential frameworks and attach a financial measure of climate risk to individual exposures (Bolton et al., 2020; Chenet et al., 2021). Additionally, the endogeneity of these risks contribute to their uncertainty as the extent of their materialisation is reliant on the actions or inaction of policymakers.
- There are significant intra-industry differences in transition risk. Exposures to transition risk are expected to vary between different economic sectors (Breeden, 2021), but also between non-financial companies (Schoenmaker et al., 2015). Therefore, as argued in this report, the calibration of transition risk-sensitive prudential policy would need to be conducted at the corporate or asset level.

This report's second aim is to propose a policy change to adequately identify and mitigate the transition risk, overcoming the challenges introduced above. As such, the report develops a policy proposal that suitably incorporates climate-related transition risk into the prudential regime for Bank of England supervisors.

Outline of the report

The report is structured as follows:

- Section 2 discusses the relevant climate-related financial risks and challenges of the net-zero transition for all bank supervisors.
- Section 3 introduces assessment methodologies and approaches for the transition to a net-zero economy and conducts an example sectoral risk assessment exercise, building on the understanding of how central banks and supervisors could create the analytical evidence base.
- Section 4 introduces the Large Exposures regulation and outlines the proposed policy design of a 'transition-aligned Large Exposures framework' for the Bank of England.
- Section 5 examines implications and challenges of implementing the policy proposed in Section 4.
- Finally, Section 6 summarises and outlines policy recommendations.

2. The financial risks and challenges of the net-zero transition

There are underlying challenges related to the unique features of different climate risks, transition scenarios and sectoral changes. These can impede central banks' and supervisors' ability to address the relevant risks through a simple adjustment of their prudential policy frameworks.

In this section the discussion focuses on risks and challenges facing the Bank of England, but the risks and challenges also apply to other central banks and financial supervisors.

The net-zero transition as a source of financial risk

Generally, there are three distinct types of climate-related risk: physical, litigation and transition risks. Each has its specific impacts on the real economy and the financial system (EBA, 2021a, b; NGFS, 2021b; Monnin, 2018; PRA, 2015).

- **Physical risks** are those that may materialise in both the short and long term from acute and chronic changes in the global climate. Extreme weather events can cause unforeseen and substantial economic shocks, including significant hits to GDP. Meanwhile, incremental rises in average temperatures will have more predictable but still detrimental effects on economic growth.
- **Transition risks** arise from the transition to a net-zero economy and have implications for the real economy due to misalignment between the actions of companies and the factors driving the transition (FSB, 2020; NGFS, 2020a). Three primary drivers of transition risk are climate policy, technological advancements, and changes in consumer preferences (Bolton et al., 2020; Campiglio and Van der Ploeg, 2021). Transition risks manifest as financial risks, including credit, market and operational risk (PRA, 2018; Grünewald, 2020; Bolton et al., 2020). Beyond these, lesser-known types of transition risk can be identified, namely 'green risks' (Campiglio and Van der Ploeg, 2021) and transition pathway risk (Löyttyniemi, 2021). The transition pathway through which a net-zero economy is achieved heavily determines the size and materiality of these transition risks.
- **Litigation risks** can be understood as a subset of both the previous two risk types and may arise from those who seek compensation for the suffered damage from the effects of climate change (NGFS, 2021b) or wish to force a company or a government to take more action (see Setzer and Higham, 2021 for an overview of recent climate litigation trends).

In this report, transition risk is the primary risk type of concern. However, while transition and physical risks can be conceptually differentiated, they will materialise concurrently and have interactive qualities (FSB, 2020). Therefore, any assessment of an individual type of risk ought to consider the effect of the other type. Also, central banks need to consider physical risks and how to integrate them into prudential standards (ECB, 2021a).

It should be noted that transition risks will not necessarily increase continuously in the future. The distribution of transition risk drivers also has a 'tail', with a loss of or reduction in their impact if, for example, climate policy weakens or loses its credibility. However, for this report the assumption is made that the impact potential of these transition drivers will strengthen in the future, and the policy is proposed under this assumption.

Credit, market and operational risks and stranded assets

Changes in the drivers of the net-zero transition may damage borrowers' ability to repay their debts and depreciate the assets used for collateral. The reduced ability to repay debts due to decreased revenue or increased costs relates to the first main effect on (non-financial) companies, the *flow effect* (Campiglio and Van der Ploeg, 2021), and the change in valuation

of assets present on companies' balance sheets represents the second main effect, the *stock effect* (ibid.).

Financial portfolios that are not aligned with expected climate change mitigation pathways are expected to be substantially affected in the future by individual defaults and system-wide adjustments. Furthermore, changes in the three primary drivers of transition risk can alter the expected future cash flow from productive assets (Pointner et al., 2019), which reduces their profitability and can create 'stranded assets'. Research has found that a third of global oil reserves, half of gas reserves, and 80% of current coal reserves need to remain unused for the world to have a 50% chance of keeping warming below 2°C (McGlade and Ekins, 2015). Sudden revaluations may trigger fire sales of carbon-intensive assets, inducing stranded assets. Thus, transition risk will affect the banking sector from a micro- and macroprudential perspective, with individual banks facing defaulting counterparties and potential market revaluations that impact the entire financial system.

Operational risk arises from increased pricing of inputs such as energy, water and insurance (PRA, 2018), and can increase the overall operating costs for financial and non-financial companies. Additionally, inadequate understanding of climate risk within the senior management or governance structure of a bank may lead to operational risk.

Green risk and transition pathway risk

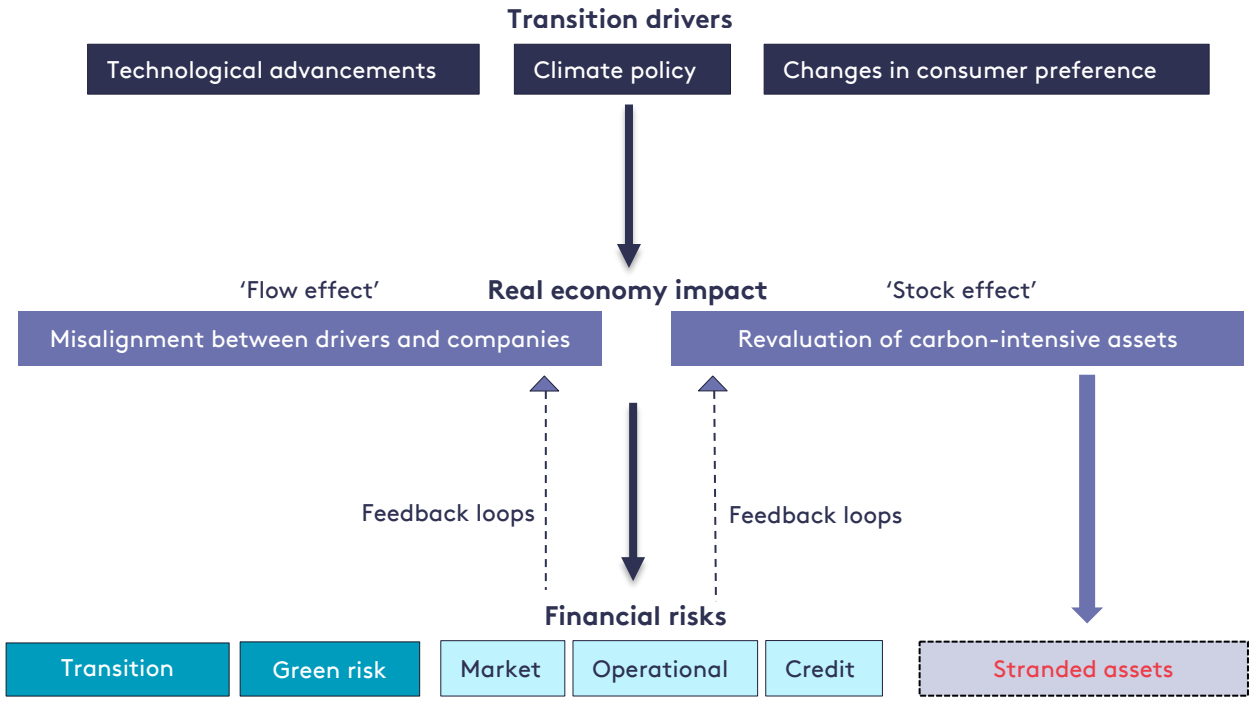
Green risk and transition pathway risk are two lesser cited potential risks resulting from transition risk. Green risks are risks that specifically affect typically 'green' sectors and technologies. They may originate from two sources, 'classical' and 'climate-related'. The former concerns macro-financial disruptions that originate from the overvaluation of green assets, and the latter regards risks that arise from the transition, affecting typically green sectors. For example, low-carbon technologies and sectors rely heavily on critical minerals, the extraction and production of which are highly concentrated, vulnerable to demand and supply risks, and may also create financial risks during the transition (IEA, 2021a; Dees et al., forthcoming) (see also Appendix).

Transition pathway risk emerges from certain moves made during the net-zero transition that have negative consequences (Löyttyniemi, 2021). This includes making abrupt changes or reversals in policy, and the creation of 'winners' and 'losers' through technological advancements, among other examples (see Appendix).

There is a need to implement prudential policy to mitigate transition risks in the financial sector. In this context, the divergence between the social discount rate and the private discount rate[1] has implications for policymakers (IPCC, 2007). The lower, 'social', discount rate used by policymakers encourages stronger mitigation action earlier but comes at a greater upfront economic cost. The private corporate discount rate is higher, and therefore incentivises companies to delay action (as the analysis in Section 3 demonstrates). This creates a misalignment between policymakers and private market participants, which leads to the potential materialisation of transition risks. The transmission of transition risks through the real economy and into the financial sector is visualised in Figure 1. The transition drivers will apply pressure on companies, creating risks for companies and assets that are not aligned to the trajectory of these transition drivers. Subsequently, financial institutions may suffer the consequences of these risks materialising through increased default rates and revisions to asset values.

[1] Social discount rates (SDRs) are used to put a present value on costs and benefits that will occur at a later date. In the context of climate change policymaking, they calculate how much guarding against future carbon emissions is worth to us now, weighing up the benefits future generations would experience against the costs that today's society would have to bear. SDRs can be used to determine how much today's society should invest in trying to limit the impacts of climate change in the future.

Figure 1. A stylised transmission channel of climate transition risks



Source: Authors

Data gaps, risk complexities and intra-industry differences

For bank supervisors seeking to take further action on climate risk there are several challenges that can impede efforts to integrate these risks into prudential standards. The policy presented in Section 4 attempts to overcome these challenges and satisfactorily incorporate transition risk into capital regulation from a risk-based approach.

First, there are significant gaps in the data on climate-related risks (NGFS, 2021a). This is particularly the case for forward-looking data, such as emissions pathways and companies' transition targets (ibid.), which are crucial pieces of information for assessing transition risks. The lack of data severely reduces the ability of banks and supervisors to understand, size and address relevant climate risks.

Second, due to the characteristics of climate risk, it is currently not possible to fully capture the impacts in quantitative terms. Therefore, the need to employ supplementary qualitative assessment approaches has been suggested (Chenet et al., 2021; NGFS, 2020a; Le Quang and Scialom, 2021). The inability to fully capture climate risk in quantitative terms hinders the ability of supervisors to integrate climate risk into certain capital requirements. Risk-weights, for example, are currently set using a purely quantitative measure of risk. However, it has been argued that the deep uncertainty presented by climate change requires qualitative supervisory judgement where quantitative risk measures cannot be derived (Chenet et al., 2021; Kay and King, 2020). Moreover, the long time horizon over which climate risks may materialise means that the current supervision horizon – assessing on an annual or three-to-five-year basis – does not fully capture these risks (PRA, 2021a, 2021b).

Third, the levels of transition risk differ between industries, based on their level of emissions prior to the start of the transition, but there are also significant *intra*-industry differences in exposure to transition risk (Schoenmaker et al., 2015). Therefore, to correctly size and adequately integrate the relevant transition risks into prudential standards, assessments would have to be conducted on an individual corporate basis, as opposed to a sector-level or economic activity basis.

3. Assessing and identifying relevant transition risks

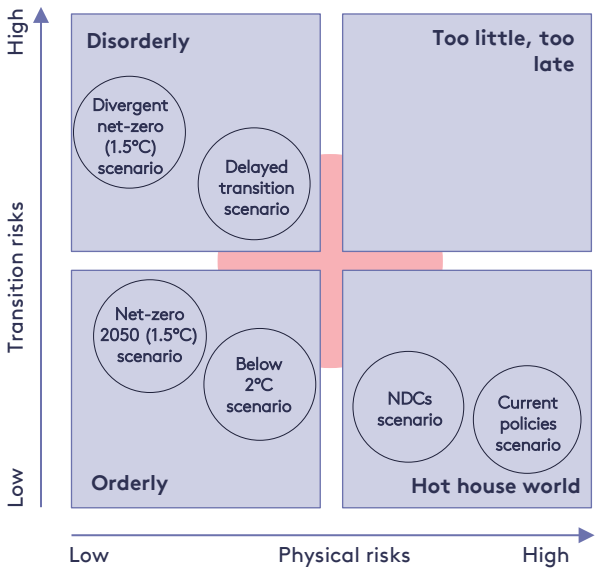
To overcome the challenges described in the previous section, different methodological approaches have been developed that can aid central banks and supervisors in mapping different future transition pathways and to identify transition-relevant economic sectors and activities. This is a necessary step for the incorporation of transition risks into prudential frameworks such as the Bank of England's Large Exposures Regime.[2] Transition risks have implications for all central banks and financial supervisors, and therefore all central banks must start to assess these risks.

Mapping the future: different scenarios for a net-zero transition

The analysis of the economic and financial impacts of climate change is subject to considerable uncertainty. Understanding how best to manage future climate-related risks requires a forward-looking approach. Scenario analysis has emerged as a leading tool to assess risks under a range of different possible future pathways. Focusing on several plausible outcomes, the Central Banks and Supervisors Network for Greening the Financial System (NGFS) has developed four main transition scenario narratives, created from its scenario framework:

- **Orderly scenario:** Results from early, ambitious action to a net-zero CO_2 emissions economy.
- **Disorderly scenario:** Results from action that is delayed or divergent, disruptive, sudden and/or unanticipated.
- **Hot house world scenario:** Results from limited action, leading to significant global warming and strongly increased exposure to physical risks as a result.
- **Too little, too late scenario:** Results from a late transition that would fail to contain the physical risks. While this narrative has not been detailed in full, worse physical risk outcomes than in the disorderly scenario might be expected.

Figure 2. NGFS scenarios framework



Source: Recreated from NGFS (2020c)

[2] The Bank of England states: "An exposure is considered a large exposure if it is equal to or higher than 10% of a bank's eligible capital" (Chapman et al., 2020). In the EU framework, large exposure sits on top of the credit risk regime (CRR), and stands at 25% of eligible capital, requiring that "institutions shall have sound administrative and accounting procedures and adequate internal control mechanisms for the purposes of identifying, managing, monitoring, reporting and recording all large exposures and any subsequent changes to them, in accordance with the CRR" (EBA, 1994, 2021a, b).

The characteristics and financial impacts of transition risk are highly dependent on the transition pathway scenario. A sudden and disorderly transition scenario may exacerbate transition risk and could affect banks' exposure to systemic risk (Nieto, 2019; Giuzio, 2019; ESRB, 2016). In 2016 the European Systemic Risk Board acknowledged that a late and sudden transition is a plausible scenario based on current targets and pledges (ESRB, 2016). Extrapolating from current targets and pledges, this scenario has moved from being a possibility to a likelihood.

The IPCC's recent report states that the remaining carbon budget for a 67% chance of limiting global warming to 1.5°C is 400 gigatonnes (Gt) of CO_2 (IPCC, 2021). Current global annual CO_2 emissions are slightly above 40Gt (ibid.); continuing at that level, there would be less than 10 years until the remaining carbon budget was exceeded. An average annual reduction in carbon intensity of 12.9% until 2050 is required to limit warming to 1.5°C above pre-industrial levels, and of 8.1% to limit warming to 2°C (PwC, 2021). These stark figures expose the drastic measures that need to be taken to maintain a 1.5°C target. Moreover, countries' updated nationally determined contributions (NDCs) to the Paris Agreement for 2030, if fulfilled, would reduce emissions by just 7.5%, far short of the 30% cut needed for 2°C and 55% for 1.5°C (UNEP, 2021).

From a financial perspective, investment in low-carbon sectors is substantially below the required level, especially in emerging economies (IEA, 2021b). These figures show an apparent misalignment between the 'shared socioeconomic pathways',[3] such as Net Zero by 2050, and current policy action. The increased urgency for significant mitigation action strongly indicates a growing likelihood of a disorderly transition to a low-carbon economy and highlights the relative significance of transition risks. The rapid adjustment in asset prices from a disorderly transition may have substantial financial impacts and may lead to a climate Minsky moment (Breeden and Hauser, 2019).

The sectoral transition and the identification of 'Climate Policy Relevant Sectors'

Different economic sectors will be exposed to transition risk to different extents, with typically carbon-intensive sectors necessarily subject to greater exposure. Battiston et al. (2017) have developed a classification of economic activities to assess these transition risks across different sectors by defining a set of 'Climate Policy Relevant Sectors' (CPRS). Their proposed methodological classification of sectors takes account of transition risk beyond stranded assets and includes wider transition considerations. The classification provides a taxonomy of economic activities that are likely to be affected, either adversely or positively, by a transition to a low-carbon economy. This methodology captures 'green risks' as well as risks arising from carbon-intensive activities, offering a holistic risk-based approach.

While transition risk needs to be assessed at the corporate or asset level, a joint top-down and bottom-up approach would be appropriate to further improve the assessment. The CPRS methodology can be useful as an initial top-down approach to classify the sectors and companies that are most relevant for transition risks. However, this initial classification is a precursor to rather than a substitute for a corporate-level, bottom-up assessment. This is reflective of the European Central Bank's suggested approach in its 2019 *Financial Stability Report*, which states that sectoral analysis is a useful first approximation but further assessment is required to ascertain important differences within sectors (Giuzio et al., 2019).

[3] 'Shared socioeconomic pathways' examine possible changes to global society, demographics and economics over the next century and are used as inputs to climate models and to examine how societal changes might affect emissions (e.g. see Hausfather, 2018).

Under Battiston et al.'s classification system, Climate Policy Relevant Sectors are divided into six risk categories:

- Fossil fuels
- Utilities
- Energy-intensive
- Buildings
- Transportation
- Agriculture.

These categories were selected based on three criteria: sectors' direct and indirect contribution to greenhouse gas emissions; their relevance for climate policy implementation; and their role in the energy value chain.

The CPRS classification uses the Statistical Classification of Economic Activities in the European Community (NACE) for the identification of the relevant sectors. NACE contains four levels of granularity, from sector to individual economic activities. The CPRS methodology uses 4-digit NACE codes to identify transition-sensitive activities. The CPRS classification therefore offers a suitable framework to identify "financial risk stemming from the (mis)alignment to the climate and decarbonisation targets of [businesses] and sectors" (Battiston et al., 2017). Furthermore, it is used in the EU taxonomy for sustainable activities and will likely be used in the UK green taxonomy. Using the same classification system aids the harmonisation and understanding of different climate regulations. Here, we do not propose the EU or UK taxonomy as a classification methodology because it is not concerned with risks to capital or liquidity (Smoleńska and van't Klooster, 2021).

It is important to note that the policy impact from incorporating climate risk into prudential requirements will have a varying effect on transition-sensitive sectors, depending on their individual financial gearing.[4] Real economy sectors with high debt-to-equity ratios may find a more than proportional effect on their cost of capital and be more responsive to changes in prudential regulation than those with lower debt-to-equity. Moreover, taking corporate action to transition to a low-carbon economy is costly, and therefore supervisors should expect higher financial gearing from companies exposed to climate risks in the future, which in itself increases financial instability (Monnin, 2018). Thus, the CPRS categories exposed to higher transition risk, particularly fossil fuel companies, are likely to be highly geared due to their already substantial debt financing (ESRB, 2016). Rapid repricing of asset prices could lead to debt repricing and credit losses, exacerbating the effect on financial stability (Brunnermeier and Schnabel, 2015). Central banks' assessment of climate risk ought to reflect this.

The European Central Bank (ECB) and the Österreichische National Bank (OeNB) have conducted mapping exercises to observe banks' exposure to transition risk using the CPRS methodology (Giuzio et al., 2019; Battiston et al., 2020). Both these studies identify bank exposures to transition-sensitive sectors and reveal substantial exposures for some banks in absolute values. These studies demonstrate the CPRS methodology's ability to capture transition risks and provide a foundation for their use by central banks.

[4] Gearing refers to the relationship, or ratio, of a company's debt-to-equity and therefore measures a company's financial leverage by expressing the extent to which a company's operations are funded by lenders versus shareholders. When the proportion of debt-to-equity is great, then a business may be thought of as being highly geared, or highly leveraged.

Identifying transition risks in the CPRS risk categories

As an exemplifying exercise, this section outlines how the necessary evidence base for introducing a 'transition-aligned Large Exposures framework' could be created. The analysis aims to highlight companies' misalignment with transition pathways and, therefore, the existence of transition risks at the (non-financial) corporate level, which underlie banks' large exposures.

This analysis could provide central banks and supervisors with a starting point from which to create the necessary evidence base to justify adjusting their prudential frameworks. However, it is important to note that these results do not directly explore the climate risk at the company level but indicate the current capacity of companies within transition-sensitive sectors to handle the future challenges of climate change.

The example assessment in this section uses the TPI tool (see Box 2) and includes 468 companies from different regions across the globe that are categorised using the CPRS methodology. The analysis includes companies from outside as well as within the UK because the UK hosts a global financial sector, meaning a global perspective is required to assess and address the potential transition risks. The sector classification provided by TPI thereby enables the determination of companies' CPRS risk category classification and the assessment of inter- and intra-sectoral transition risks.

Based on a **three-fold assessment**, it is possible to explore the potential transition risk across and within different CPRS categories (agriculture is excluded due to the lack of disclosing companies from this sector).

Firstly, use of TPI's Management Quality scoring enables the assessment of the level and quality of disclosure. Subsequently, it is possible to observe the 'carbon performance' alignment and decade of alignment – i.e., the decade in which the company plans to align with one of three benchmarks, either 1.5°C, 2°C, or fulfilling the NDCs, based on its carbon intensity – to assess the (mis)alignment between companies and climate target pathways.

Box 2. The Transition Pathway Initiative (TPI) tool

The Transition Pathway Initiative (TPI) was established in 2017 to assess the preparedness of companies around the world for the transition to a low-carbon economy. Using publicly disclosed information provided by FTSE Russell, the tool explores companies' management of emissions, climate risks and opportunities. Moreover, it evaluates the future carbon performance of companies, thereby incorporating the forward-looking perspective, which is critical for examining transition risk.

Using the TPI tool, it is possible to explore and assess the potential risk in transition-sensitive sectors at the business level. However, it is important to stress that the instrument could also be subject to a selection bias because TPI only includes companies that disclose against the FTSE Russell, which may not wholly represent the sectors.

See www.transitionpathwayinitiative.org/.

i) Management of emissions and transition risks/opportunities

Our initial analysis examines the difference in TPI Management Quality ratings between companies, broken into the different CPRS risk categories (see Figure 3). TPI rates companies' 'Management Quality' across five different levels, shown in Table 1. 'Management Quality' is defined as "the quality of companies' management of their greenhouse gas emissions and of risks and opportunities related to the low-carbon transition".[5] An appraisal is conducted, and a company must fulfil all the criteria in a band to be considered 'adequate' and achieve a score above the threshold for that level. Companies that adequately undertake a strategic assessment achieve a Level 4 rating, or 4Star for fulfilling all the requirements under level 4.

[5] See **www.transitionpathwayinitiative.org/methodology**.

Table 1. TPI rating scale for assessing 'Management Quality'

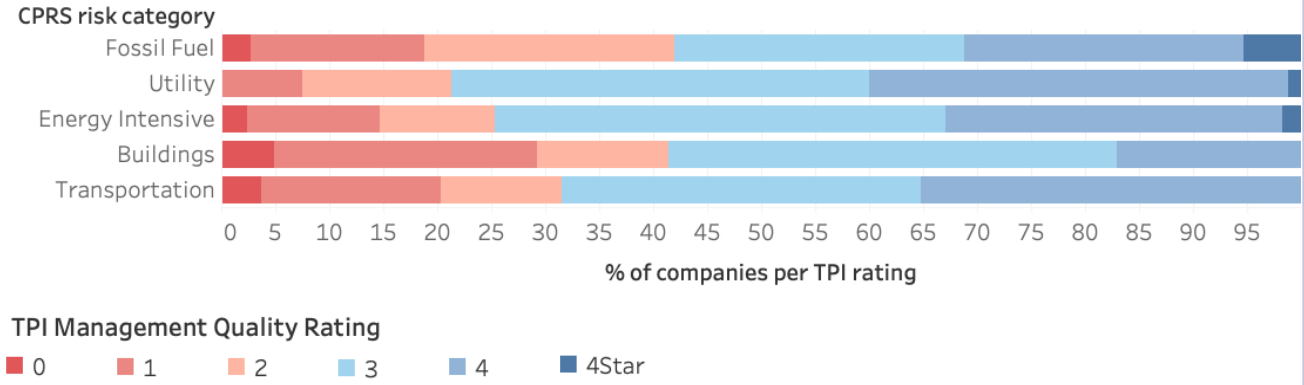
Level 0	Level 1	Level 2	Level 3	Level 4	4Star
Unaware of Climate Change as a Business Issue	Acknowledging Climate Change as a Business Issue	Building Capacity	Integrated into Operational Decision-making	Strategic Assessment	Complete Strategic Assessment

The results indicate that over 40% of companies in the 'Fossil Fuel' and 'Buildings' categories are classified as being at 'Level 2 – Building Capacity' or below, indicating that the companies are not adequately building capacity to understand and assess climate risks. Overall, 141 companies (30%) score a 'Level 2' or below, which highlights the extensive lack of sufficient disclosure of climate risks.

For each CPRS risk category, the single category containing the most companies is 'Level 3 – Integrated into Operational Decision-making'. While reaching this level is a positive initial step, it does not incorporate the forward-looking perspective imperative to improving management of emissions and risks.

Only 10 companies in this sample disclose an adequate strategic assessment on climate change, reaching 4Star. This highlights the widespread scarcity in adequate climate assessments within these transition-sensitive sectors.

Figure 3. Companies' TPI Management Quality ratings, organised by Climate Policy Relevant Sector (CPRS)



Note: Agriculture is excluded due to the lack of disclosing companies from this sector.
Source: Compiled by authors, based on latest assessment by TPI, 2021.

ii) Alignment between disclosure and target pathways

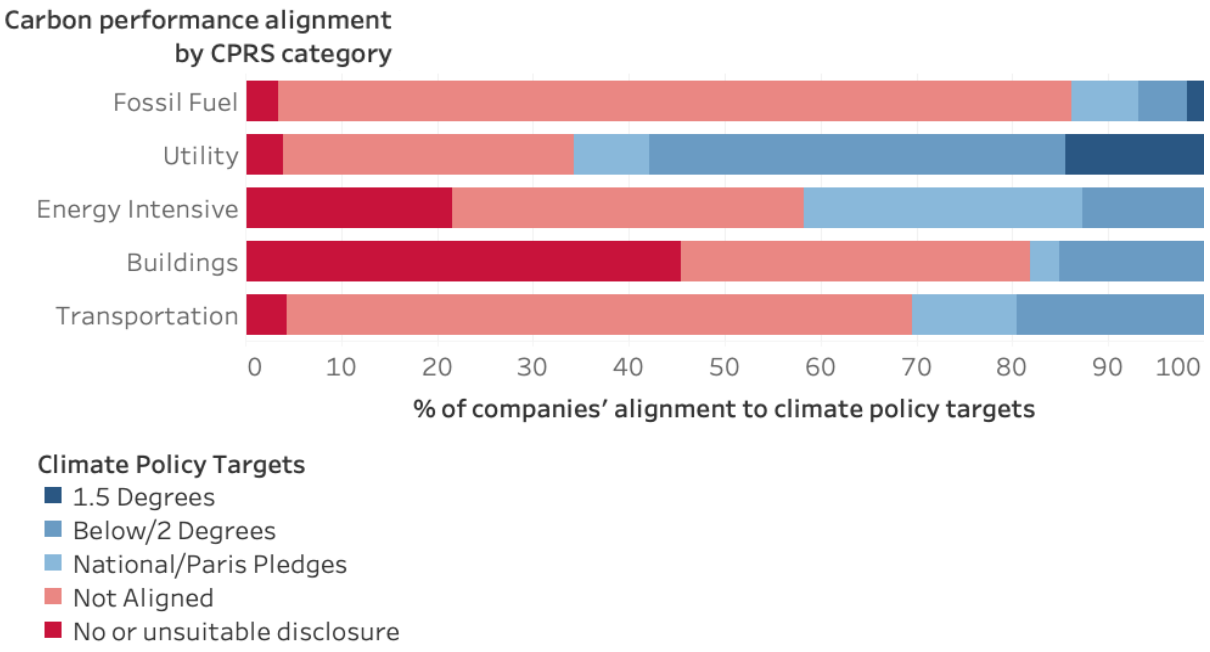
In a second step, the alignment between companies' disclosed carbon performance and climate policy target pathways is explored (Figure 4). Here, only 292 companies are included because forward-looking quantitative targets are not provided for all sectors. Under the TPI methodology, 'Carbon Performance Alignment' refers to companies' carbon intensity measured against industry benchmarks and whether this aligns with a pathway either to 1.5°C or 2°C or that is consistent with the emissions reductions pledged by countries as part of the Paris Agreement in the form of the first set of nationally determined contributions (NDCs) from 2015.

For every CPRS risk category except 'Utility', more than half of the companies – and over 80% in the 'Fossil Fuel' and 'Buildings' sectors – provide either 'unsuitable disclosure' or are not aligned to any climate policy target. In total, 181 out of 292 companies (62%) either do not offer suitable disclosure or are unaligned to any climate policy target. However, progress is being made in the 'Utility' category, where 66% of companies are aligned to some form of policy target pathway.

The widespread misalignment between companies and climate policy highlights these sectors' potential sensitivity to transition drivers and transition risk. Therefore, the future climate policy developments in these sectors necessary to achieving climate targets will likely have adverse impacts on these companies, which will translate into financial losses for banks. This is particularly relevant for the 'Fossil Fuel' sector, which is exposed to the highest transition risk category under the CPRS methodology.

The findings are aligned with the those of the recent report from the Science Based Targets Initiative (SBTi), which finds that only 20% of 4,215 companies in the G20 and only 6% of companies in the G13 (i.e. the G20 minus the G7) have climate targets that align with the Paris Agreement (SBTi, 2021). These findings support those presented here, which show misalignment between companies and climate policy target pathways. Consequently, companies in the real economy are exposed to transition risk drivers, which, if materialised, will spill over into the financial sector through financial institutions' exposure to non-financial companies.

Figure 4. Companies' alignment to different climate policy targets, organised by Climate Policy Relevant Sector (CPRS)



Note: Agriculture excluded, as before.
Source: Compiled by authors, based on latest assessment by TPI, 2021.

iii) Timing for mitigation and pathway-alignment action

Finally, the timing and targeted decade of companies' planned climate change mitigation and pathway-alignment action is assessed (Figure 5). This is the decade in which companies plan to align with a climate policy pathway, based on emissions intensity. Emissions intensity is used by TPI and enables assessment of a company's carbon performance against the TPI benchmarks; it refers to the total emissions over the economic activity or physical production of the company (Dietz et al., 2019).

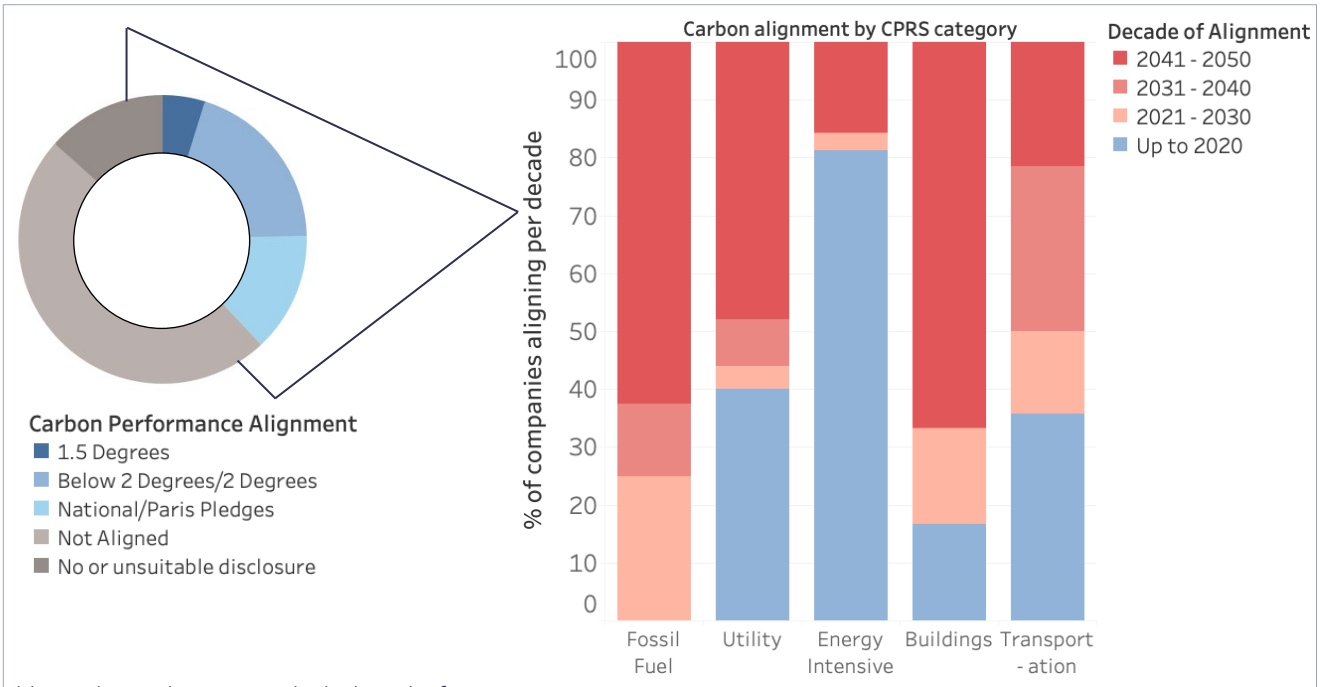
Out of the subset of the 111 companies that are aligned to one of the pathways, more than half of companies in the 'Fossil Fuel', 'Utility', 'Buildings' and 'Transportation' categories will become aligned after 2030. Over 60% of companies within the 'Fossil Fuel' and 'Buildings' sectors will only become aligned with a climate policy pathway after 2040.

Forty (36%) of the 111 companies will only become aligned to a policy pathway after 2040. Therefore, climate policy developments introduced prior to 2040 are likely to negatively affect these companies. Consequently, the companies may face higher costs and/or lower revenue,

which would impact their ability to meet their financial obligations. This in turn would create financial risks for banks and other financial institutions through higher default rates from struggling companies. The extensive backloading of alignment commitments accentuates the near-term risk within these 'transition-sensitive' sectors.

The need for prudential policy to mitigate these risks to the financial sector in the period 2020–2030 is evident from this analysis. The point becomes particularly significant when the near-term target of a 45% reduction in CO_2 emissions by 2030 to limit warming to 1.5°C is considered (IPCC, 2021). To achieve this target will require ambitious near-term climate policy, which in turn will impact businesses not aligned to this climate pathway. As the analysis shows, the backloading of decarbonisation commitments exposes these companies to near-term transition risk and highlights the urgent need for immediate action. Furthermore, it is worth noting that the analysis only considers companies with commitments that align to a climate policy pathway, which are therefore the 'best-in-class'; many more have not yet aligned at all.

Figure 5. Companies' disclosed alignment to climate targets and decade of alignment, organised by Climate Policy Relevant Sector (CPRS)



Note: Agriculture is excluded, as before.
Source: Compiled by authors, based on latest TPI assessment, 2021.

The analysis points towards there being a misalignment between transition drivers and companies within these sectors, which may translate into financial risks for individual banks as well as the entire financial sector in the future.

Key findings and summary implications

The three main findings from this example of transition risk analysis are:

1. A total of 141 companies out of 468 (30%) fail to disclose measures that integrate climate change into operational decision-making. **Only 10 companies (2%) disclose a fully adequate strategic assessment of climate change** that includes the necessary forward-looking perspective when considering climate risk.
2. **181 out of 292 companies (62%) fail to align their carbon performance with a climate policy target pathway**. The extensive misalignment across CPRS highlights the future transition risk present within these sectors. This is particularly significant for the 'Fossil Fuel', 'Buildings' and 'Transportation' categories.

3. For the 111 companies with a carbon performance aligned to a climate policy pathway, **36% only plan to become aligned after 2040, with over 50% of companies planning to align after 2030 in four out of five CPRS risk categories.** The backloading of carbon mitigation action leaves these companies susceptible to transition drivers in the coming decade.

The possibility of identifying these risks has strong implications for central banks and supervisors by contributing to creating the evidence base and foundation for the implementation of prudential policy to reduce the exposure of banks to transition risk arising from transition-relevant sectors. The build-up of exposure to misaligned non-financial companies within banks' portfolios, without sufficient prudential oversight, could lead to the rapid deflation of asset prices and ultimately to a climate Minsky moment. Misalignment between banks' portfolio exposure and the transition pathway announced for the UK financial sector (HM Treasury, 2021c) can serve as sufficient evidence for material risks (discussed further in Section 5).

4. Designing a transition-aligned Large Exposures framework for the Bank of England

Building on the assessment approaches and methodologies discussed in Section 3, central banks and supervisors would be able to conduct first analyses of transition risks and the related exposure of financial institutions and the financial system. Any identified materiality of transition risks would in turn have prudential implications.

This section outlines how the Bank of England could adjust its Large Exposures regulation to account for the relevant climate transition risks, subject to the establishment of the empirical evidence base by the central bank itself. While aimed at the Bank of England, the 'transition-aligned Large Exposures framework' outlined here is applicable to other central banks and supervisors as well.

Defining and mitigating conventional Large Exposures

Large Exposures regulation was initially introduced in the UK following the failure of Johnson Matthey Bankers in 1984 (Chapman et al., 2020). The purpose of the regime is to complement risk-based capital requirements and banks' losses in the event of a failure from a single counterparty. The Bank of England's current Large Exposures framework is part of the Capital Requirements Regulation (CRR), which is based on the Basel Standards (BIS, 2014). Under this framework, banks are not permitted to have exposures to a single counterparty or group of connected counterparties (GCC) that exceeds 25% of its eligible capital – hence the 25% of eligible capital proposed for a 'soft' limit.

Global Systemically Important Financial Institutions (G-SIFIs or G-SIBs – Global Systemically Important Banks) are subject to a more stringent limit of 15% of eligible capital for exposures to other G-SIBs. In this context, large exposures are defined as the aggregate exposures to a single counterparty (or group of connected counterparties) that exceed 10% of banks' eligible capital or a monetary value above €300m, gross (PRA, 2022a); see Box 3. NACE codes are already reported to classify the counterparty industry, but without the requirement for specific granularity.

Box 3. Groups of connected counterparties (GCCs) and economic interdependence

Under the Large Exposures framework, there are two conditions that define a group of connected counterparties (BIS, 2014; Chapman et al., 2020):

1. **A control relationship**, where one counterparty has direct/indirect control over the other; and
2. **Economic interdependence**, where if one counterparty encounters financial difficulties, the other would also encounter financial difficulties as a result.

The second condition may relate to companies that are economically interdependent based on climate transition risk drivers. For example, car manufacturers and suppliers to car manufacturers are exposed to the same transition risks regarding technological advances, climate policy and consumer preferences. Therefore, there is an argument to aggregate these exposures if the shared transition risks are seen to be idiosyncratic.

The condition could enable the inclusion of exposures that are *considered material* but not defined as 'large' (especially for large banks), based on economic interdependence and exposure to shared transition risks.

A transition-aligned Large Exposures framework

Identifying the exposure of banks to Climate Policy Relevant Sectors

In a first step, banks would have to identify their exposure to the relevant CPRS (see Section 3). Currently in the BoE's Large Exposures reporting, NACE codes are only included as a non-blocking validation rule, enabling banks to submit either their large exposure returns without NACE codes or just a sector NACE code for each large exposure. This has implications for using the CPRS methodology to map exposures to transition-sensitive activities. The proposed CPRS methodology relies on 4-digit NACE codes to determine the different risk categories. The BoE would have to strengthen the reporting requirements to be able to accurately map large exposures to transition-sensitive sectors.

Figure 6. Example of the mismatch between NACE reporting requirements and the reporting needed to enable the identification of CPRS

Company name	Sector	Reported NACE code	Economic activity	4-digit NACE code
X	Mining and quarrying	B	Extraction of peat	B8.92

Current reported large exposures

Reporting needed for CPRS methodology

If a bank only reports the NACE-sector code, as shown in Figure 6, it is not possible to determine whether it should be classified under either Fossil Fuels, Energy-intensive, or as a non-CPRS exposure. Under current reporting standards, it is therefore not possible to accurately determine a bank's exposure to transition-sensitive activities using CPRS. Adjustments to the Large Exposures reporting framework regarding NACE are thus a prerequisite to including climate transition risk.

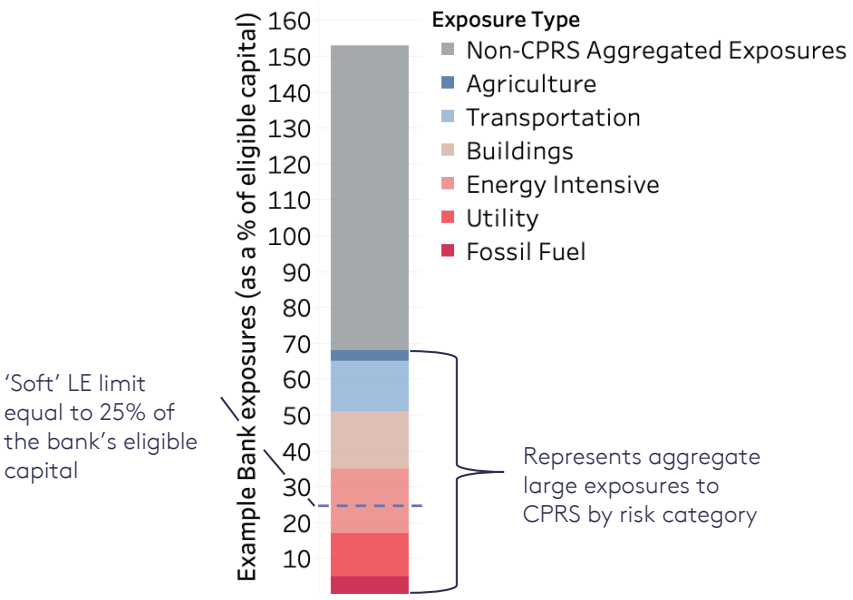
Moreover, it is difficult to identify non-financial companies that are conglomerates under a single 4-digit NACE code. Consequently, thresholds need to be conceived to establish if an economic activity is substantial or significant in the context of the company's overall activities, and therefore if it can be classified under that economic activity. This is particularly important for companies whose activities fall partially under the CPRS methodology for determining their classification.

Establishing a 'soft' large exposures limit

Building on a comprehensive (CPRS and NACE code-based) financial risk and exposure assessment, as exemplified in the previous section, financial institutions' large exposures could be assessed to gauge the exposure to transition risk. Under the BoE's Large Exposures framework, individual banks could be subjected to a 'soft' Large Exposures limit where their aggregated exposure to CPRS must be equivalent to or below 25% of their eligible capital. If banks exceed this soft limit, they could be asked to engage in additional disclosure requirements. The disclosure would provide details on their risk management of the relevant transition risk and justify the concentration of their exposure to the relevant 'high-risk' sectors.

Figure 7 illustrates the proposed 'soft limit' for a bank's reported large exposures. In this scenario, the bank has exceeded the soft limit of 25% and would therefore be subjected by the BoE to additional disclosure requirements.

Figure 7. Stylised example of a bank breaching the soft 25% limit for large exposures



Source: Compiled by authors

The proposed soft limit reflects the European Banking Authority's (EBA) guidelines on exposure to shadow banking entities (EBA, 2016), with which the BoE still expects banks to attempt to comply (PRA, 2022b). Under these guidelines banks are asked to identify their individual exposures to shadow banking entities and the potential related risks, and are tasked to set limits on their exposures to shadow banking entities. If banks fail to comply with the guidelines or cannot achieve effective oversight, their aggregate exposures to shadow banking entities are subject to the typical limits on large exposures (EBA, 2016).

The proposed soft limit reflects the approach of the guidelines on shadow banking entities. However, the proposal would envision the soft limit to be determined by the BoE rather than internally by banks. Additionally, exceeding the limit would subject banks to additional disclosure requirements, which may lead to supervisory sanctions if requirements are not met, rather than to a conventional, hard large exposures limit.

A benefit of this proposed approach is that from a microprudential perspective a 'soft' large exposures limit would identify the banks with the greatest potential exposure to transition risk for their level of eligible capital. The advantage of using a 'soft' limit is that it avoids burdensome reporting for banks that are not exposed to transition-sensitive sectors, while capturing the banks with material transition-related financial risks. This approach would enable the BoE to be mindful of the trade-off between financial stability and the Financial Policy Committee's secondary objective, namely promoting competition within the financial sector. Therefore, the BoE needs to implement a policy that balances mitigating the risk of climate change with the burden of reporting, particularly for smaller banks with less capacity to report the risks. However, this should not be at the expense of ensuring the financial stability of the sector or the resilience of individual banks.

The initial regulatory reporting of banks' large exposures to CPRS could also be used by the BoE to inform its macroprudential policy. By aggregating all large exposures to CPRS, the BoE would be able to observe the banking sector's overall exposure to different transition-sensitive sectors. This would be important to understanding the potential systemic risk to financial stability posed by the aggregate misalignment with a given climate transition scenario. Moreover, the BoE could use the macroprudential perspective to monitor the total exposures to an individual counterparty by different banks. This would enable the monitoring of the overall impact of the failure of one counterparty to financial stability.

Implementing additional disclosure requirements if the 'soft' limit is exceeded

Under this proposal, if a bank exceeded the proposed 'soft' limit of 25%, it would be subjected by the BoE to additional disclosure requirements. Banks could be required to create and disclose their own climate strategy extending to 2050, based on three primary components:

1. The identification of exposure to main climate-related risks or scenarios
2. The projection of portfolio exposure alignment to climate policy targets using scenario analysis
3. A forward-looking strategy to mitigate risks and align portfolio exposure

The climate disclosure requirements would extend beyond the guidance on climate change set out in the BoE's Supervisory Statement SS3/19 (PRA, 2019), assessing both the quantitative and qualitative aspects of climate risk, over a longer time horizon. These climate disclosure requirements reflect the proposal set out by Frank Elderson in his speech on mandatory transition plans (Elderson, 2021). The requirements would be used within the supervisory assessment and could be used to alter capital requirements under Pillar 2b.

The BoE could focus primarily on two aspects to assess banks' transition strategies: first, the absolute monetary exposure to different transition-sensitive sectors and the portfolio alignment to NGFS climate scenario pathways; and second, the risk management and governance practices implemented to consider the climate risk attached to these exposures. The first aspect is to establish the materiality and indicate the significance of the transition risks within the portfolio. The second aspect would enable the BoE to overcome the challenge of measuring the financial value of climate risk, by examining whether a bank's policies mitigate these transition risks.

While acknowledging the overall time horizon of the transition, the supervisory assessment would be concerned primarily with risks likely to occur in the next three to five years. For example, green risks are likely to occur within this timeframe because it will be necessary to transition 'into' low-carbon technologies before it is possible transition 'out of' carbon-intensive activities (Dees et al., forthcoming). Longer time horizons are necessary to assess banks' forward-looking strategic plans and to ensure they will be capable of tackling the risks that will arise over the course of the transition to a net-zero economy.

In the first component of the disclosure, the BoE could require banks to identify the future climate-transition risks to which they are most exposed, based on current exposures. This would enhance the understanding by banks of the conditions and sectors that are most at risk and exposed to transition drivers. In the second component, banks would be required to use the NGFS or similar scenarios to determine the conditions under which they would face the greatest adverse impact on their portfolio through stress testing.

Moreover, due to the inherent uncertainty, the BoE could consider additionally including a climate-related reverse stress test to complement the traditional climate stress test, for banks whose failure has profound implications for financial stability. A reverse stress test requires banks to identify the scenario in which the bank is no longer able to continue business activities (PRA, 2021c). The reverse stress test could be compared against banks' stress tests using the NGFS scenarios to assess the possibility of bank failure.

In the final component, banks would be required to state their current risk management processes and governance to monitor and assess climate and environmental risks. Where banks are not aligned to climate policy targets, they could be asked to develop operational changes for the alignment of their portfolio exposure and to propose these to the supervisor.

The predominant focus would be on the climate transition-related disclosure of the underlying companies reflected in the asset and therefore banks' portfolio exposure. The data of companies' future quantitative emissions targets and transition pathways are crucial to assessing the transition risk for banks, due to the potential misalignment between companies' actions and

transition drivers. Considering the underlying companies' transition pathways would enable the transition risk to be examined at a business level and expose intra-industry differences.

Operationally, the most appropriate avenue for the BoE's microprudential policy could be to focus on banks' climate-risk management and underlying companies' transition pathways. This is the case because climate risk cannot be quantitatively assessed accurately at an asset level due to the radical uncertainty (Chenet et al., 2021; Kedward et al., 2020) and non-linearity of these risks. Therefore, a precautionary approach should be adopted when assessing these risks (ibid.). Due to the heterogeneity of transition risk, effective disclosure practices would have to consider the sector, region and jurisdiction of the counterparty. Moreover, the disclosure should include all relevant types of risks, including green risks and, where possible, rely on forward-looking quantitative metrics.[6]

Finally, the BoE would require banks to submit an updated climate strategy disclosure every time the 'soft' large exposures limit is breached. Banks would be accountable if current exposures do not align with previously submitted climate strategy. From the supervisory assessment of this disclosure, the BoE could enforce restrictions on banks that do not adequately manage their exposure to climate-related risks. Initially, supervisors could require banks' senior managers to attend an independent climate awareness course to increase their understanding of climate-related risks. The NGFS suggests a variety of measures for supervisors if they find an institution's climate-related factors excessively high, including risk mitigation tools in the form of guarantees, limiting, or prohibiting certain categories of activities, and requiring business model adjustments within a longer-term perspective (NGFS, 2020a). These requirements are most appropriate for banks with inadequate corporate planning and risk management processes for assessing climate risk over the course of the transition.

Banks that persistently fail to publish adequate disclosures, with exposures that pose a significant threat to their resilience due to the climate risk, may be required to hold additional capital. However, the use of capital should be restricted to only banks with significant exposure to near-term climate risks and inadequate risk management processes in place. This capital 'surcharge' could be implemented through the Pillar 2b PRA buffer framework.

[6] See Appendix for more information on consideration of the sector, region and jurisdiction of the counterparty, and potential disclosure characteristics.

5. Implications and policy challenges

Building on a risk exposure analysis that could follow along the lines of the exemplifying analysis in Section 3, this section discusses the implications and challenges for the implementation of a transition-aligned Large Exposures framework relating to disclosure regimes, risk management approaches and the way in which a net-zero transition is priced in the market. While these policy challenges are framed in the UK context for the Bank of England, they are widely applicable outside the UK.

Rationale for using the Large Exposures framework

To create effective climate policy, the financial impact from transition risks needs to be balanced against the policy impact and cost. There is a necessary trade-off between prudential rigour to mitigate risk and the burdensomeness of the policy requirements.

There are two aspects that need to be considered regarding policy impact.

First, for banks, while climate change may pose significant risks to the financial sector, the transition risk will vary between banks due to their different sectoral and regional exposure, given differing stringency in climate policy. Moreover, larger banks will have a greater capacity than small banks to monitor and report on transition risks, in the face of the data-intensive nature of climate risk. Therefore, climate prudential regulation ought to account for these considerations. This directly relates to the secondary objective of the Financial Policy Committee: to maintain effective competition within the banking sector (HM Treasury, 2021a). Implementing blanket climate prudential policy for all banks might be overly burdensome for smaller banks with limited transition risk exposure, and therefore undermine this secondary objective.

Second, for the real economy, the data-related requirements for adequate climate risk disclosure may be particularly onerous for small and medium-sized enterprises (SMEs) within transition-sensitive sectors. The disclosure requirement heavily relies on the forward-looking climate strategy and quantitative targets of the underlying companies. If all exposures are included, SMEs in transition-sensitive sectors might be unable to produce the necessary climate disclosure. Consequently, the policy may have the unintended impacts of raising the cost of capital for SMEs, increasing financial exclusion for these companies, and undermining a 'just transition'.

Therefore, effective prudential policy must adequately mitigate the risks while considering the proportionality of impact. From a financial stability perspective, the Large Exposures framework is selected for the following reasons:

- Conventional large exposures have potential implications for financial stability (hence Large Exposures regulation). Therefore, large exposures with unobserved climate risk pose a substantially greater threat to financial stability. As noted by the ECB, large exposures are potentially the most important exposures in terms of concentration and systemic impact with regard to transition risk (Giuzio et al., 2019).
- The sectors considered under the proposed policy adjustment are typically concentrated with a small number of large companies that comprise most of the market share of emissions (see Appendix). Hence, it is assumed exposures to these companies are typically sufficient in size to be included within the Large Exposures reporting framework. Material exposures to transition-sensitive sectors that are not defined as large but are still considered substantial in size could also be included through the second condition for groups of connected counterparties (GCCs) (see Box 3).

Large exposures are used in the European Central Bank's assessment of transition risk in its 2019 *Financial Stability Report* (Guizio et al., 2019). While further prudential measures, with a scope beyond large exposures, may be required in the future, these exposures present the greatest threat to the resilience of individual banks, and are therefore an appropriate starting point for climate risk assessments.

Addressing the environmental risk challenges

The transition-aligned Large Exposures framework proposed in this report would address several of the environmental risk-related challenges by enabling the Bank of England to begin incorporating transition risk into the prudential regime. The joint top-down and bottom-up approach would enable companies' risk to be assessed individually and accounts for intra-industry differences.

It is important to note that the proposal relies in part on the disclosure practice and requirement from underlying non-financial companies, which enables transition risk to be more accurately identified. The success of this policy is highly dependent on sector-wide climate-related disclosure of companies. Without this disclosure from the underlying non-financial companies, the disclosure requirement is mainly irrelevant because the data availability is greatly reduced. However, several recent announcements help mitigate this issue: the mandatory disclosure upcoming in 2025 from the Task Force on Climate-related Financial Disclosures (TCFD) for large companies (HM Treasury, 2020) and mandatory transition plans for large companies and financial institutions (HM Treasury, 2021c) could help improve the data availability for climate-related disclosure. Moreover, by incorporating climate-related data collection into the assessment of banks' transition risk, supervisors can overcome these issues.

The main challenges and how they can be addressed are described below.

Limitations to quantifying climate risk

There are considerable limitations to the quantitative determination of climate-related risk, which has previously hindered attempts to incorporate the risk into the prudential regime. However, the proposed approach would be a first step to overcoming this challenge, as it would lead a twin approach to a focus on the risk management behaviour of banks and their aggregate exposure to transition-sensitive sectors instead of the quantitative risk value in each exposure. This twin approach could be utilised to integrate transition risk into capital requirements similarly to the Prudential Regulatory Authority's risk management buffer assessment. The PRA risk management buffer is set based on three assessments: the 'stress' impact – an assessment of capital required to withstand a severe stress scenario; 'risk management and governance' processes – an assessment of whether firms have risk management and governance weaknesses; and 'supervisory judgement' – a supervisory assessment of any additional information (PRA, 2021b). The scenario analysis of banks' climate transition exposure enables supervisors to assess the capital required to withstand a severe climate scenario. The risk management and governance criteria in the additional disclosure succinctly aligns with the second criteria for the PRA buffer. Therefore, financial supervisors would be able to integrate transition risk into capital requirements similarly to their current calculation of the PRA risk management buffer.

Lack of long-term planning

The lack of long-term forward-looking planning has been previously highlighted as a key shortcoming that hinders the assessment of transition risk (Aglietta, 2021; Carney, 2015). The proposed approach would contribute to addressing this by requiring banks to create a long-term mitigation strategy for their portfolio exposure based on their exposures to underlying companies if a soft Large Exposures limit is exceeded. The proposed policy encourages banks to make business decisions based on a longer time horizon and to incorporate the relevant transition risks. The assessment of the PRA buffer would need to be altered as well to account for this extending time horizon if capital additions were to be implemented. Furthermore, the requirement to disclose such information would incentivise banks to gather the relevant climate-related data from their exposed non-financial counterparties, which would help reduce the current data gaps. The policy shifts the burden of collecting the data onto the banks as part of their risk management assessment, which enables supervisors such as the BoE to assess banks' transition risk through their risk management practices rather than relying on incomplete data.

Assessing and mitigating environmental risks

Assessing and mitigating environmental risks is challenging because they are subject to uncertainty and fat-tailed distributions. The proposed large exposures adjustment could offer a first step towards incorporating transition risk because it focuses exclusively on a risk-based approach and can assess the risk from both a micro- and macroprudential perspective. This approach ensures banks identify the risks to which their portfolios are most vulnerable, determine the potential transition path scenarios based on their findings, and adequately incorporate transition risk into their business operations. Moreover, compelling banks to identify their most significant climate-related risks also obliges them to account for the uncertainty in these risks and their fat-tailed distributions with respect to their own portfolio.

Incorporating 'green' risks

An additional challenging dimension of environmental risk are so-called 'green risks' that specifically affect typically 'green' sectors and technologies. It could be argued that including green risks in the analysis undermines the low-carbon transition by dissuading banks from lending to green sectors if the policy includes them because of the costs associated with the disclosure requirement. Fundamentally, however, some risks may impact 'green' activities in the future, and due to the scope of climate-related risks, the policy should include these risks. Exclusion of these risks would undermine the prudential regime's ability to ensure financial resilience. Moreover, if unchecked, these risks may materialise in the future and undermine investor confidence in green sectors, hampering the transition. Therefore, banks' disclosure must consider these risks. The ECB has already explicitly included green risks within its climate stress test methodology (ECB, 2021b).

Financial supervisors and their role in determining transition risks

The threat and materialisation of transition risk is highly dependent on the implementation of climate policy, which speaks to the endogeneity in transition risk. Therefore, it would be important to consider the Bank of England's role in potentially causing transition risk as well as in identifying, monitoring and mitigating risks to the resilience of the UK financial system (HM Treasury, 2021a). While BoE policy may impact the realisation of transition risks, its inaction would not necessarily prevent the materialisation of transition risks, which are primarily caused by government legislation and climate policy. In this context, prudential policy could be introduced in a fashion minimising its own contribution to causing material transition risks and instead focus on mitigating the transition risks caused by central government legislation.

For example, the UK government has introduced legally binding carbon budgets with a net-zero by 2050 target (UK Government, 2019) and has committed to publishing a transition pathway for the UK financial sector to reach net-zero by 2050 (HM Treasury, 2021c). The financial supervisors could use clear policy signals like these as a basis for assessing transition risks in the UK. While the credibility of the UK government's climate policy may be called into question to justify central bank inaction, it would implicitly create a conflict with the Financial Policy Committee's secondary objective to support the Government's economic policy. For international exposures and to be prudent, supervisors should assume the announced climate policy to be the expected pathway for the region, unless there is clear evidence to support alternative assumptions.

Limitations to the approach itself

Finally, it is important to highlight two limitations of the proposed approach. First, and similar to other climate risk assessment frameworks, such as the NGFS climate reference scenarios, the analysis and incorporation of the transition risk dimension of environmental risks is the primary focus. The proposed policy concentrates on transition risk for banks while the approach is less well-suited to incorporating physical risks that are expected to have considerable impacts on the real economy, particularly in regions more exposed to extreme weather events. The impacts of physical risks are likely to affect all bank exposures, regardless of size. Therefore, limiting the scope of physical risk to large exposures is an inappropriate course of action. Hence, the soft Large Exposures limit policy should be implemented in conjunction with other climate-related

policies that have a more in-depth focus on the physical and liability elements of climate-related financial risk.

Second, while the policy only focuses on large exposures, as opposed to all exposures, it should be viewed as a starting point for integrating transition risk into the prudential regime. It is necessary to start with the exposures that pose the greatest threat to the financial resilience of individual banks as well as the financial stability of the UK banking sector.

Introducing a 'soft' versus a 'hard' exposure limit

The proposed transition-aligned Large Exposures framework focuses on a 'soft limit' for large exposures to transition-sensitive activities, which, if breached, would trigger an additional climate-related disclosure requirement for banks. However, a more rigorous approach that focuses on a 'hard' exposure limit, with a capital charge comparable to a 'dirty penalising factor', previously proposed for exposures to carbon-intensive companies (D'Orazio and Popoyan, 2019), could also be discussed. Arguably, this approach would enable a more robust regime, with a greater deterrent for banks to inadequately manage their transition risk. However, there are several reasons why the 'soft' limit approach could be preferable for the Bank of England and other supervisors.

In recognising that climate policy is one of the primary drivers for transition risk, it is necessary to consider the consequences of the climate policy in question and its potential impact on the real economy. The introduction of the policy might be 'too sudden' an approach and generate a disorderly low-carbon transition. A 'hard limit' may force banks to sell-off their carbon-intensive assets over a short time, devaluing assets, which could in turn increase financial instability through a fire sale. This could potentially also lead to carbon-intensive 'bubbles' building up outside the regulated banking sector.

Any hard limit may hinder carbon-intensive companies' ability to transition to a low-carbon company by increasing their cost of capital. This would reduce the speed of a low-carbon transition and may increase the likelihood of a disorderly scenario. A disorderly scenario is likely to broaden the scope of businesses and assets affected by the transition. Furthermore, the increased cost for businesses may reduce their ability to repay their debts (Campiglio and Van der Ploeg, 2021), and therefore forcibly reducing banks' exposure to particular economic sectors might increase transition risk to the overall economy. However, this could be partially offset if companies raise finance through alternative avenues, such as green bonds, which typically offer a lower cost of capital due to their so-called 'greenium' (a premium for green bonds) (Agliardi and Agliardi, 2021).

Furthermore, a 'hard' limit would be solely based on banks' current exposures to transition-sensitive sectors. This approach ignores the distinct characteristics of climate-related financial risk, which the disclosure requirement assesses under the current approach. Without this additional assessment, it is not possible to distinguish the intra-industry differences in transition risk; nor is it possible to size the climate risks concerning these characteristics. Moreover, a 'hard limit' would attach the capital charge to specific exposures instead of banks' risk management, whose risk differential cannot be defined in quantitative terms (as shown in a study by NGFS, 2020b).

The proposed 'soft' limit approach can be understood as a principles-based method with flexibility and proportionality in assessing transition risk. This more delicate approach encompasses the characteristics of climate risk in the disclosure requirement and accurately incorporates transition risk into the prudential regime without inducing the risk to materialise. Thus, a 'soft' limit would be a more appropriate avenue for mitigating transition risk in the financial sector. The possibility of a 'hard limit' could be considered in the future if the proposed soft limit is insufficient to ensure banks implement effective risk management processes to mitigate transition risks. However, this would be contingent on greater availability of transition-related data to implement a risk-based approach and the ability to assess the risks in quantitative terms.

6. Next steps and recommendations

This report's exploratory analysis of transition risk shows how the relevant sectors are greatly misaligned to current climate policy targets and possess inadequate ambition to meet these targets in the future. These sectors will thus be susceptible to transition drivers over the coming decade. There is a strong case for the alignment of prudential instruments to further the assessment, mitigation and reduction of these transition risks.

Activating the transition-aligned Large Exposures framework proposed here could overcome the current challenges for financial supervisors and incorporate transition risk into the prudential regime, from both a macro and a micro perspective. The proposed policy identifies transition-sensitive exposures and assesses the risk at the company level with a complementary disclosure regime. Activating the policy would ensure transition risk were adequately incorporated into the prudential regime with a 'soft' large exposures limit by adopting a risk-based approach.

Next steps and calibration of a transition-aligned Large Exposures framework

Based on the exposure assessment analysis and the outline of the proposed policy change, several next steps for the Bank of England as well as for other supervisors could emerge:

1. **It is essential to improve the understanding of the exposure of the banking sector as well as the real economy to climate-related transition risks.**
    - The materiality of transition risk to the UK financial sector should be measured, as a prerequisite to the implementation of a transition-aligned Large Exposures framework. A Bank of England assessment, similar to the European Central Bank's 2019 *Financial Stability Report*, is necessary to determine the banking sector's exposure to transition-sensitive sectors.
    - Companies will incur costs in the transition to a net-zero economy. It is necessary to understand the cost of transition for different Climate Policy Relevant Sectors to assess policy impact and potential policy-induced transition risk.
    - Banks may have substantial exposure to counterparties in Climate Policy Relevant Sectors in exposures that are not defined as large. The Bank of England should assess the materiality of transition risk within these 'non-large' exposures to determine whether further policy action beyond the Large Exposures framework is necessary.
2. **The proposed transition risk-aligned calibration could be implemented as a second step, to establish an effective transition-aligned Large Exposures framework.**
    - The quality of NACE reporting within the Large Exposures framework needs to be improved by financial institutions. Four-digit NACE codes are necessary for the accurate identification of CPRS exposures. The reporting of NACE codes needs to be changed within the Large Exposures framework to become a 'blocking validation rule'. This would require banks to submit a NACE code for each large exposure reported.
    - The nature, size and complexity of transition risks vary, depending on the sector of origin. Therefore, the hiring of 'sector experts' within the Prudential Regulation Authority is fundamental to the understanding and adequate assessment of transition risks.
3. **A framework should be established to formalise the consequences for inadequate disclosure or risk management of banks' climate-related large exposures, as a final step.**
    - Supervisors initially could require senior employees from the bank to attend an independent climate awareness course. This tool could be most appropriate for a 'first-time offence' to address a potential knowledge gap.

- Further to this, supervisors may demand changes within senior management or composition of the board, place limits on capital distributions, and use other similar measures. This course of action could be envisaged for banks that repeatedly mismanage their climate-related exposure.
- Where greater impact is necessary, supervisors could impose a capital surcharge for consistent inadequate management and disclosure of climate-related risks. The capital surcharge could be incorporated into the PRA's risk management buffer. This avenue would focus more on the bank's risk management practices, which suits the overall framing of the policy.

Policy action beyond a risk-based approach

This report has adopted a risk-sensitive approach to incorporating climate considerations into the prudential regime because the primary purpose is to ensure financial stability. Therefore, any climate-related prudential policy should exclusively consider climate risk; otherwise, it is inappropriate for the purpose for which it is designed. A promotional approach to prudential policies risks undermining the prudential regime and financial stability of the banking sector. However, to ensure the transition to a low-carbon economy, a risk approach alone is insufficient. Further action by central banks as monetary policy authorities is necessary to achieving a low-carbon economy in the limited timeframe available to limit warming in line with the Paris Agreement.

Based on its updated remit letter, and to fulfil its mandate, the Bank of England could have to play a role in employing policies to support the scaling-up of activities that will enable the net-zero transition. However, for now, this discussion primarily relates to the BoE's monetary policy operations, the objective for which has been updated in the context of the net-zero transition through the aforementioned Monetary Policy Committee remit letter. The BoE has already started to respond to the updated remit with changes to its Corporate Bond Purchasing Scheme (CBPS) to include green criteria (BoE, 2021). In the monetary policy context, 'green criteria' have been proposed for collateral requirements (Dafermos et al., 2021) and central bank portfolios.

Additionally, direct monetary instruments could be employed during future crises. Similar to the Coronavirus Business Interruption Loan Scheme (CBILS) introduced during the COVID-19 crisis (British Business Bank, 2020), government-backed loans could be introduced to priority green sectors. In the period of the decarbonisation pathway from now until 2050, there is a high likelihood of further crises occurring. These crises might undermine the speed and scope of the UK's transition to net-zero, particularly for nascent green sectors. Providing government-backed loans can support these sectors and ensure crises do not hinder the pace of the transition.

References

Agliardi E, Agliardi R (2021) Corporate Green Bonds: Understanding the Greenium in a Two-Factor Structural Model. *Environ Resource Econ* 80: 257–278. https://doi.org/10.1007/s10640-021-00585-7

Aglietta M (2021) 'Panel G. How should financial stability, regulation and supervision be considered in the context of increasing climate-related risk?', The Green Swan Conference 2021, 3 June 2021, Bank of International Settlements (BIS).

Baer M, Campiglio E, Deyris J (2021) *It takes two to dance: Institutional dynamics and climate-related financial policies* (Working Paper No. 356). London: Grantham Research Institute on Climate Change and the Environment. https://www.lse.ac.uk/granthaminstitute/publication/it-takes-two-to-dance-institutional-dynamics-and-climate-related-financial-policies/

Bailey A (2021) *Laying the Foundations for a Net Zero Financial System*, Speech by Andrew Bailey at COP26. https://www.bankofengland.co.uk/speech/2021/november/andrew-bailey-speech-at-cop26-laying-the-foundations-for-a-net-zero-financial-system

Bank for International Settlements (BIS) (2018) *The treatment of large exposures in the Basel capital standards – Executive Summary*. https://www.bis.org/fsi/fsisummaries/largeexpos.htm

Bank for International Settlements (BIS) (2014) *Supervisory framework for measuring and controlling large exposures*, Basel Committee on Banking Supervision, April, https://www.bis.org/press/p140415.htm

Bank of England (2021) *Greening our Corporate Bond Purchase Scheme (CBPS)*. https://www.bankofengland.co.uk/markets/greening-the-corporate-bond-purchase-scheme

Battiston S, Guth M, Monasterolo I, Neudorfer B, Pointner W (2020) 'Austrian banks' exposure to climate-related transition risk', *Financial Stability Report 40*, Oesterreichische Nationalbank (ONB), November.

Battiston S, Mandel A, Monasterolo I *et al.* (2017) A climate stress-test of the financial system. *Nature Climate Change* 7: 283–288. https://doi.org/10.1038/nclimate3255

Berenguer M, Cardona M, Evain J (2020) *Integrating Climate-related Risks into Banks' Capital Requirements*, I4CE and WWF, Paris.

Bolton P, Despres M, Pereira De Silva L A, Samama F, Svartzman R (2020) *The green swan: Central banking and financial stability in the age of climate change*, Bank for International Settlements and Banque de France.

Breeden S (2021) *Climate change – Plotting our course to Net Zero*, speech by Sarah Breeden given at the University of Edinburgh and Environmental Association for Universities and Colleges webinar, May 2021. https://www.bankofengland.co.uk/speech/2021/may/sarah-breeden-managing-the-impact-of-climate-change

Breeden S, Hauser A (2019) A climate Minsky moment. In: *Global Public Investor Report by the Official Monetary and Financial Institutions Forum,* OMFIF.

British Business Bank (2020) *Coronavirus Business Interruption Loan Scheme (CBILS)*. https://www.british-business-bank.co.uk/ourpartners/coronavirus-business-interruption-loan-scheme-cbils-2/

Brunnermeier MK, Schnabel I (2015) *Bubbles and Central Banks: Historical Perspectives*, working paper, OMFIF.

Campiglio E, van der Ploeg F (2021) *Macro-Financial Transition Risks in the Fight Against Global Warming*, 1 June, SSRN, http://dx.doi.org/10.2139/ssrn.3862256

Carney M (2015) *Breaking the Tragedy of the Horizon – climate change and financial stability*, Speech by Mark Carney to Lloyd's of London, 29 September.

Chapman D, Miller H, Pascarella K, Withfield L (2020) Don't put all your eggs in one basket': protecting banks from the failure of individual counterparties, *Quarterly Bulletin 2020 Q2,* Bank of England. https://www.bankofengland.co.uk/quarterly-bulletin/2020/2020-q2/dont-put-all-your-eggs-in-one-basket-protecting-banks-from-the-failure-of-individual-counterparties

Chenet H, Ryan-Collins J, van Lerven F (2021) Finance climate-change and radical uncertainty: Towards a precautionary approach to financial policy. *Ecological Economics* 183: 106957.

Climate Change Committee (CCC) (2021a) *Independent Assessment of UK Climate Risk* for the UK's third Climate Change Risk Assessment (CCRA3). CCC, London.

Climate Change Committee (CCC) (2021b) *Progress in reducing emissions*: *2021 Report to Parliament*. CCC, London.

Cripps P (2021) Environmental Investing Pioneer Sounds Green Asset Bubble Warning, *Environmental Finance*, 12 February.

D'Orazio P, Popoyan L (2019) Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies? *Ecological Economics* 160: 25-37. https://doi.org/10.1016/j.ecolecon.2019.01.029

Dafermos Y, Gabor D, Nikolaidi M, Pawloff A, van Lerven F (2021) *Greening the Eurosystem Collateral Framework: How to Decarbonise the ECB's Monetary Policy*. New Economics Foundation. https://neweconomics.org/2021/03/greening-the- eurosystem-collateral-framework

Dees S, Dikau S, Miller H, Svartzman R (2022, forthcoming) *Critical Minerals, Green Risks and Transition Realisation Risk,* Grantham Research Institute on Climate Change and the Environment Working Paper.

De Galhau V (2021) *The role of central banks in the greening of the economy*. BIS. https://www.bis.org/review/r210211g.pdf

De Guindos L (2021) *Shining a light on climate risks: the ECB's economy-wide climate stress test*. European Central Bank. https://www.ecb.europa.eu/press/blog/date/2021/html/ecb.blog210318~3bbc68ffc5.en.html

Dietz S, Jahn V, Nachmany M, Noels J, Sullivan R (2019) *Methodology and indicators report*. Transition Pathway Initiative. https://www.transitionpathwayinitiative.org/publications/65.pdf

Dikau S, Volz U (2021) Central bank mandates sustainability objectives and the promotion of green finance, *Ecological Economics* 184. https://doi.org/10.1016/j.ecolecon.2021.107022.

Elderson F (2021) *Overcoming the tragedy of the horizon: requiring banks to translate 2050 targets into milestones*. Keynote speech by Frank Elderson to the Financial Market Authority's Supervisory Conference, 20 October. https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp211020~03fba70983.en.html

European Banking Authority (EBA) (2021a) *Management and supervision ESG risks credit institutions and investment*. https://www.eba.europa.eu/eba-publishes-its-report-management-and-supervision-esg-risks-credit-institutions-and-investment

European Banking Authority (EBA) (2021b) *EBA Guidelines*. https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Guidelines/2021/EBA-GL-2021-09%20GL%20on%20large%20exposure%20breaches/1019615/Final%20Report%20on%20Guidelines%20on%20large%20exposures%20breaches%20and%20time%20and%20measures%20to%20return%20to%20compliance.pdf

European Banking Authority (EBA) (2016) *Guidelines: Limits on exposures to shadow banking entities which carry out banking activities outside a regulated framework under Article 395(2) of Regulation (EU) No 575/2013* **https://www.bankofengland.co.uk/-/media/boe/files/paper/2020/december/guidelines%20on%20limits%20on%20exposures%20to%20shadow%20banking.pdf**

European Banking Authority (EBA) (1994) *Capital Requirements Regulation (CRR), Part 4, Article 395*. https://www.eba.europa.eu/regulation-and-policy/single-rulebook/interactive-single-rulebook/101506

European Central Bank (ECB) (2020) *ECB report on institutions' climate-related and environmental risk disclosures*. https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.ecbreportinstitutionsclimaterelatedenvironmentalriskdisclosures202011~e8e2ad20f6.en.pdf

European Central Bank (ECB) (2021a) *Climate-related risk and financial stability,* ECB/ESRB Project Team on climate risk monitoring. https://www.ecb.europa.eu/pub/pdf/other/ecb.climateriskfinancialstability202107~87822fae81.en.pdf

European Central Bank (ECB) (2021b) *Climate risk stress test*. https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.climateriskstresstest2021~a4de107198.en.pdf

European Systemic Risk Board (ESRB) (2016) Too late too sudden: Transition to a low- carbon economy and systemic risk, *Reports of the Advisory Scientific Committee* No.6, February.

Financial Stability Board (FSB) (2020) *The Implications of Climate Change for Financial Stability*. Financial Stability Board, 23 November.

Giuzio M, Krusec D, Levels A, Melo AS, Mikkonen K, Radulova P (2019) Climate Change and Financial Stability, *Financial Stability Review May 2019*, European Central Bank. https://www.ecb.europa.eu/pub/financial-stability/fsr/special/html/ecb.fsrart201905_1~47cf778cc1.en.html

Grünewald S (2021) Climate Change as a Systemic Risk in Finance: Are Macroprudential Authorities Up to the Task? In: Busch D, Ferrarini G, Grünewald S (Eds.) *Sustainable Finance in Europe,* EBI Studies in Banking and Capital Markets Law, Palgrave Macmillan. https://doi.org/10.1007/978-3-030-71834-3_7

Hausfather Z (2018) Explainer: How 'Shared Socioeconomic Pathways' explore future climate change. *Carbon Brief,* 19 April. https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change

HM Treasury (2021a) *FPC remit and recommendations letter*. https://www.bankofengland.co.uk/-/media/boe/files/letter/2021/march/fpc-remit-and-recommendations-letter-2021.pdf?la=en&hash=3C5B23BE764387498155F61CAF255417E665CCE8

HM Treasury (2021b) *MPC remit and recommendations letter*. https://www.bankofengland.co.uk/-/media/boe/files/letter/2021/march/2021-mpc-remit-letter.pdf?la=en&hash=C3A91905E1A58A3A98071B2DD41E65FAFD1CF03E

HM Treasury (2021c) *Fact Sheet: Net Zero-aligned Financial Centre*. https://www.gov.uk/government/publications/fact-sheet-net-zero-aligned-financial-centre/fact-sheet-net-zero-aligned-financial-centre

HM Treasury (2020) *Chancellor sets out ambition for future of UK financial services*. News story, 9 November. https://www.gov.uk/government/news/chancellor-sets-out-ambition-for-future-of-uk-financial-services

International Energy Agency (IEA) (2021a) *The Role of Critical Minerals in Clean Energy Transitions*. IEA, Paris. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

International Energy Agency (IEA) (2021b) *Financing clean energy transitions in emerging and developing economies*. IEA, Paris. https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies

Intergovernmental Panel on Climate Change (IPCC) (2007) *Climate Change 2007: Synthesis Report. Contribution of Working Groups I II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team: Pachauri RK and Reisinger A (eds.)]. IPCC, Geneva, Switzerland.

Intergovernmental Panel on Climate Change IPCC (2018) Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways in the context of strengthening the global response to the threat of climate change sustainable development and efforts to eradicate poverty* [Masson-Delmotte VP et al. (eds.)].

Intergovernmental Panel on Climate Change IPCC (2021) Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte VP et al. (eds.)]. Cambridge University Press.

Kay J, King M (2020) *Radical Uncertainty: Decision-making for an unknowable future*. The Bridge Street Press, London.

Kedward K, Ryan-Collins J, Chenet H (2020) *Managing nature-related financial risks: a precautionary policy approach for central banks and financial supervisors*. UCL Institute for Innovation and Public Purpose Working Paper Series (IIPP WP 2020-09). https://www.ucl.ac.uk/bartlett/public-purpose/wp2020-09

Le Quang G, Scialom L (2021) *Better safe than sorry: macroprudential policy, Covid 19 and climate change*. Working Paper, January. http://www.chair-energy- prosperity.org/category/publications/

Lóyttyniemi T (2021) *How should financial stability regulation and supervision be considered in the context of increasing climate-related risk?* Speech by Timo Löyttyniemi to the Green Swan Conference, 3 June, Bank of International Settlements.

McGlade C Ekins P (2015) The geographical distribution of fossil fuels unused when limiting global warming to 2°C, *Nature* 517: 187-190.

Minsky H (1986) *Stabilizing An Unstable Economy*, Yale University Press.

Minsky H (1992) *The Financial Instability Hypothesis*, The Jerome Levy Economics Institute of Bard College Working Paper No. 74, May.

Monnin P (2018) *Central Banks and the Transition to a Low-Carbon Economy*. Council On Economic Policies Discussion Note 2018/1 1, March. http://dx.doi.org/10.2139/ssrn.3350913

Nauman B (2021) 'Green bubble' warnings grow as money pours into renewable stocks, *Financial Times,* 19 February.

Network for Greening the Financial System (NGFS) (2021a) *Progress report on bridging data gaps*. NGFS technical document, May.

Network for Greening the Financial System (NGFS) (2021b) *Climate-related litigation: Raising awareness about a growing source of risk* NGFS technical document, November. https://www.ngfs.net/sites/default/files/medias/documents/climate_related_litigation.pdf

Network for Greening the Financial System (NGFS) (2020a) *Guide for Supervisors: Integrating climate-related and environmental risks into prudential supervision*. NGFS technical document, May.

Network for Greening the Financial System (NGFS) (2020b) *A status Report on Financial Institutions' Experiences – from working with green non green and brown financial assets and a potential risk differential.* NGFS technical document, May.

Network for Greening the Financial System (NGFS) (2020c) *NGFS Climate Scenarios for central banks and supervisors*. NGFS technical document, June.

Nieto M (2019) Banks climate risk and financial stability. *Journal of Financial Regulation and Compliance* 27(2):243-262. DOI 10.1108/JFRC- 03-2018-0043

Pointner W, Ritzberger-Grünwald (2019) *Climate Change as a risk to financial stability: Financial Stability Report* 38, Österreichische Nationalbank (OeNB), December.

Prudential Regulation Authority (PRA) (2022a) *PRA Rulebook 'Large Exposures – Application and Definitions', 1.2 qualifying exposure*. https://www.prarulebook.co.uk/rulebook/Content/Chapter/211539/06-02-2022#211549

Prudential Regulation Authority (PRA) (2022b) *Interpretation of EU Guidelines and Recommendations: Bank of England and PRA approach after the UK's withdrawal from the EU,* Statement of Policy. Bank of England. https://www.bankofengland.co.uk/-/media/boe/files/paper/2021/interpretation-of-eu-guidelines-and-recommendations-boe-and-pra-approach-sop-jan-2022-dec-2021.pdf?la=en&hash=58F1B98E0F32FF23A788321831FC7E0467C9229F

Prudential Regulation Authority (PRA) (2021a) *PRA Climate Change Adaptation Report 2021 – Climate-related financial risk management and the role of capital requirements*. Bank of England. https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/publication/2021/october/climate-change-adaptation-report-2021.pdf?la=en&hash=FF4A0C618471462E10BC704D4AA58727EC8F8720

Prudential Regulation Authority (PRA) (2021b) *The PRA's methodologies for setting Pillar 2 capital*. Bank of England, April.

Prudential Regulation Authority (PRA) (2021c) *The Internal Capital Adequacy Assessment Process (ICAAP) and the Supervisory Review and Evaluation Process (SREP), Supervisory Statement SS31/15*. Bank of England, December. https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/supervisory-statement/2020/ss3115-update-dec-2021.pdf?la=en&hash=427D016ADE146A15CA43673B2F9AB405F7A67BBF

Prudential Regulation Authority (PRA) (2019) *Enhancing banks' and insurers' approaches to managing the financial risks from climate change, Supervisory Statement SS3/19*. Bank of England, April. https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/supervisory-statement/2019/ss319.pdf?la=en&hash=7BA9824BAC5FB313F42C00889D4E3A6104881C44

Prudential Regulation Authority (PRA) (2018) *Transition in thinking: The impact of climate change on the UK banking sector*. Bank of England, September.

Prudential Regulation Authority (PRA) (2015) *The impact of climate change on the UK insurance sector*: *A Climate Change Adaptation Report by the Prudential Regulation Authority*. Bank of England, September.

PwC (2021) *Net Zero Economy Index 2021*. https://www.pwc.co.uk/services/sustainability-climate-change/insights/net-zero-economy-index.html

Raval A (2021) A $140bn asset sale: the investors cashing in on Big Oil's push to net zero, *Financial Times*, 6 July. https://www.ft.com/content/4dee7080-3a1b-479f-a50c-c3641c82c142

Schoenmaker D, van Tilburg R, Wijffels H (2015) *What role for financial supervisors in addressing systemic environmental risks?* Sustainable Finance Lab Working Paper 14, April.

Scientific Based Targets Initiative (SBTi) (2021) *Taking the Temperature: unlocking breakthrough climate action in the G20*. https://sciencebasedtargets.org/news/g20-companies-neglecting-science-when-setting-climate-targets

Setzer J, Higham C (2021) *Global trends in climate change litigation: 2021 snapshot*. London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science. https://www.lse.ac.uk/granthaminstitute/publication/global-trends-in-climate-litigation-2021-snapshot/

Smoleńska A, van 't Klooster J (2021) *A Risky Bet: Should the EU Choose a microprudential or a Credit Guidance Approach to Climate Risk?* European Banking Institute Working Paper Series 2021 - no. 104. http://dx.doi.org/10.2139/ssrn.3949541

UK Government (2019) The Climate Change Act 2008 (2050 Target Amendment), Order 2019 No. 1056. https://www.legislation.gov.uk/ukdsi/2019/9780111187654

United Nations Environment Programme (UNEP) (2021) *Emissions Gap Report 2021: The Heat Is On – A World of Climate Promises Not Yet Delivered*. UNEP, Nairobi, Kenya.

WWF UK, Greenpeace (2021) *The Big Smoke: The Global Emissions of the UK Financial Sector*. https://www.wwf.org.uk/updates/uk-banks-and-investors- responsible-more-co2-emissions

Appendix

1. Green risks and transition pathway risk

'Climate-related' green risks: a case study of critical minerals

Risks to green sectors might be born from the pressures of a global low-carbon transition. An example of this is the critical minerals sector. As highlighted by the International Energy Agency rapid deployment of clean energy technologies is likely to cause an increase in demand for minerals (IEA 2021a).

In the case of lithium-ion batteries, overall costs have reduced by 90% over the past decade, which means the raw materials account for between 50 and 70% of the cost. This makes them very sensitive to changes in the price of raw materials (ibid.). High geographical concentration of mining and processing makes them highly exposed to climate risks. Further issues include long project development lead times: the IEA's analysis suggests that it has taken on average over 16 years to move mining projects from discovery to first production. The IEA says: "These long lead times raise questions about the ability of suppliers to ramp up output if demand were to pick up rapidly. If companies wait for deficits to emerge before committing to new projects this could lead to a prolonged period of market tightness and price volatility" (ibid.). In terms of resources concerns relate to quality rather than quantity. The IEA says: "In recent years ore quality has continued to fall across a range of commodities. For example the average copper ore grade in Chile declined by 30% over the past 15 years. Extracting metal content from lower-grade ores requires more energy exerting upward pressure on production costs greenhouse gas emissions and waste volumes" (ibid.).

Transition pathway risk

At the 2021 Green Swan Conference, Timo Löyttyniemi, CEO of Finland's State Pension Fund, was a speaker on 'Panel G: How should financial stability regulation and supervision be considered in the context of increasing climate-related risks?'. He outlined 'transition pathway risk' and how it may affect financial assets. Given the uncertainty in the transition pathway to a low-carbon economy, there might be mistakes along the pathway, due to future uncertainty, which cannot be known *a priori*. Mr Löyttyniemi outlined four potential sources of transition pathway risk:

1. Investment risks in new tech/investments (winners and losers in new technological developments).
2. Risks in policy mitigation – governments make changes in policy and are not always consistent, e.g. granting subsidies for fossil fuels.
3. Discounted pricing risk – markets might misprice future risks, e.g. in an IT boom. There are certain additional risks from market pricing, especially for equities.
4. Metric risks – there are various carbon intensity measures and it can be difficult to choose the most appropriate.

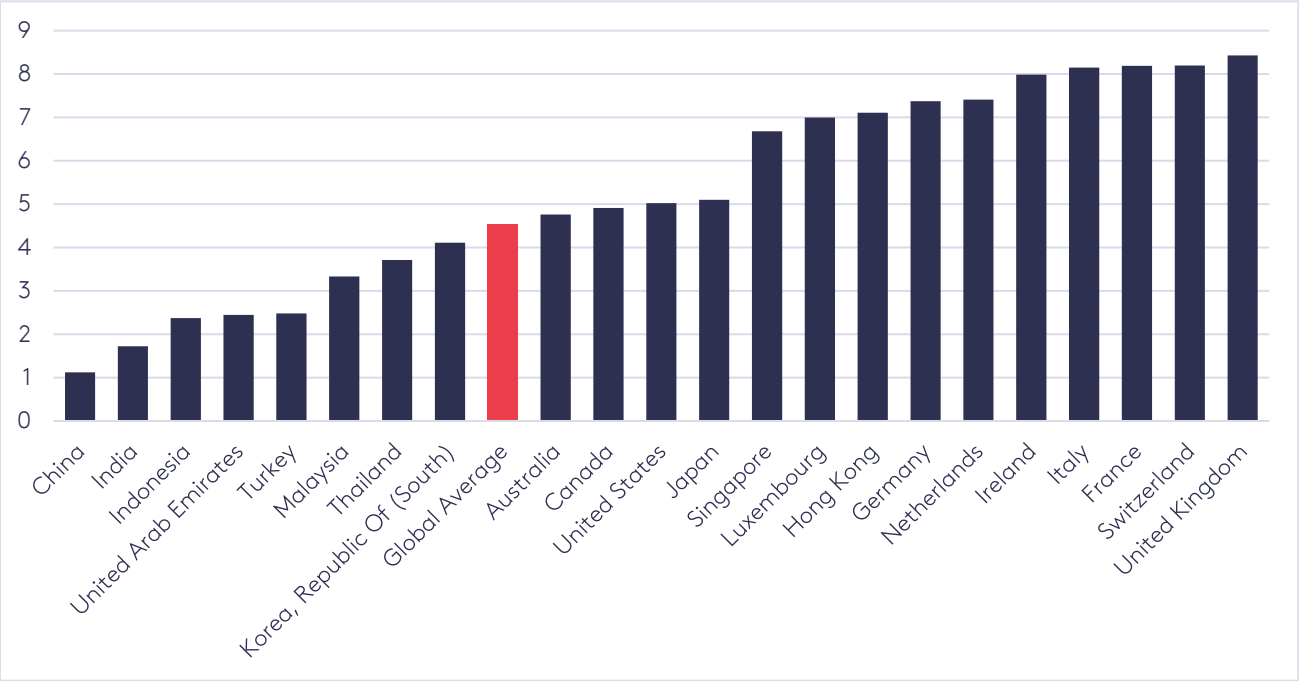
2. Non-financial companies' market share for carbon-intensive sectors

Many of the economic sectors of concern contain a small concentrated number of businesses that have a dominant percentage of the market share. Reports by the Science Based Targest Initiative (SBTi) and the Climate Disclosure Project (CDP) have identified a substantial proportion of emissions to be attributed to a small subset of global companies. Across the G7 SBTi finds that 10% of companies are responsible for at least 48% of all indexed emissions (SBTi 2021). CDP's report identifies that 100 companies are responsible for over 70% of carbon dioxide and methane emissions (CDP 2017).

3. Country-level transition risk

Countries have differing timescales for transitioning to a low-carbon economy as well as distinct exposure to both transition and physical climate risk. This needs to be accounted for in banks' climate-related disclosure. Figure A2 shows the 'carbon transition scores', as rated by Bloomberg Terminals for 25 countries (Bloomberg Terminals, 2021).

Figure A2. Carbon transition scores for 25 countries



Note: Bloomberg's carbon tranisiton scores indicate countries' preparedness and ability for the transition to a low-carbon economy. The higher scores indicate a greater level of preparedness out of 0 to 10.

4. Disclosure attributes based on climate-related transition risk characteristics

Below we outline disclosure characteristics that banks ought to include in their climate-realted disclosure, based on the risk characteristic present in climate risk.

Risk characteristic	Disclosure characteristics
Non-linearity	• Cannot overly rely on historical data for future pathway. • Qualitative measures alongside quantitative exposures are necessary to identify and manage risk.
Forward-looking	• Require banks to proactively estimate the future risks to portfolios based on current exposures. • Includes an assessment of current policy technology and consumer preferences as well as future developments. • Require banks to justify current exposures and the assumptions about future developments of risk using scenario analysis. • The disclosure should include different time horizons (5, 10 and 30 years) to account for short- and long-term materialisation of climate-related risks.
Breadth and scope of impact transmission channels	• Require banks to examine exposures across their entire portfolio not just in sectors most affected by the transition. • Banks must identify channels through which the risk may transmit and the potential contagion between assets. • Employ the 'look-though' approach to identify similar exposure to climate-related risks in the supply chains of different assets. • Must consider regional differences in climate-related transition risk.
Deep uncertainty	• Ensure banks employ a precautionary approach when examining climate-related risk. • Banks need to consider transition pathway risk and green risks.
Endogeneity	• Double materiality ought to be considered to the extent that financed emissions through new exposures may cause exacerbated future physical risks.