CHAPTER 2

The Impact of Climate Risks on the Insurance and Banking Industries

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Abstract  It is now largely recognised that the global climate has changed since the pre-industrial period. While the role of financial institutions in the transition to a low-carbon economy has received increasing attention over time, more limited has been the evidence on how climate change might affect financial institutions’ balance sheets. This chapter aims to redress this paucity of evidence by examining the impact of climate risks on the banking and insurance industries. To this purpose, it presents the main channels through which the physical, transition and liability risks of climate change might translate into financial risks for banks and insurance companies, along with the key data available to date. The extent

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to which climate risks might impair financial stability while causing new market failures is also discussed.

**Keywords** Banking · Climate change · Financial risk · Financial stability · Insurance · Market failure

### 2.1 Introduction

It is now largely acknowledged that the global climate has changed relative to the pre-industrial period. Nineteen of the twenty warmest years in history have all occurred since 2001, with 2016 ranking as the warmest year on record (NASA 2020). Although multiple lines of evidence exist that these changes have been affecting organisms and ecosystems, as well as human systems and well-being (IPCC 2018), more scarce has hitherto been the evidence on the impact that a changing climate might have on the financial system and its players. Until recently—at least before the Paris agreement was adopted in December 2015—the discussion around the link between climate change and financial institutions has tended to focus on the role they might play as catalysts for the transition to a low-carbon economy. Particular attention has been devoted to understanding how banks and other financial intermediaries might support a smooth and effective transition to a greener world in their function as providers of funds to the real economy. However, somewhat limited have been the efforts to uncover the financial risks that climate change might pose to financial institutions.

This dearth of evidence on the implications of climate risks for financial institutions may be problematic, as the COVID-19 pandemic that broke out at the beginning of 2020—as well as a number of other large-scale events—has vividly highlighted the negative effects that shocks external to the financial system might have for financial stability and the real economy. There is increasing recognition that severe weather events such as tornadoes, floods or droughts—whose frequency and magnitude have increased over the past years as a consequence of climate change—have the potential to translate into various financial risks for financial institutions, possibly undermining the overall stability and resilience of the financial system (Carney 2015).
Against this backdrop, this chapter aims to redress the paucity of dialogue about the implications of climate change for the financial sector by examining the effects of climate-related risks on insurance companies and banks. The chapter is organised as follows. Section 2.2 assesses the impact of climate risks on the insurance industry. It starts by providing an overall discussion about the various effects of climate change in this industry and then identifies the key risks and losses. It subsequently examines the challenges associated with insurers’ business models and the pricing of climate-related risks. This section also discusses the importance of third-party liability risks and concludes with an overview of climate risk reinsurance. Section 2.3 addresses the effects of climate risks on the banking industry. The first part of the section presents the main data available to date on the financial risks that climate change is likely to create for banks and other financial intermediaries. The second part reviews the empirical literature on the pricing of climate risks by banks, while the final part explains how these risks might affect financial stability and contribute to new market failures. Section 2.4 discusses the problem of measuring the exposure of insurance companies and banks to climate risks and summarises the key data that are currently available. The last section concludes with some recommendations.

### 2.2 Impacts on the Insurance Industry

Overwhelmingly, it is now acknowledged that climate change is a reality that is having significant direct and indirect effects on society. It appears that these may become even more prevalent in the future. With climate change comes an increase in climate-related risks, mostly associated with the uncertainty surrounding the full impact of climate change and the difficulty in measuring such risks. This is indeed a very serious challenge faced by the insurance industry. As argued by Hecht (2008), “if our society is to survive climate change without significant human costs, we must develop robust institutions and practices to manage these risks”.

The insurance industry provides a significant service to companies, individuals, investors and other firms in the financial sector. By enabling the pooling of risk and savings, insurers spread policyholder risks, something that, individually, individuals and businesses would not be able to do. This is undoubtedly an important service which increases resilience across the wider economy, as for a fixed premium, often linked to
long-term contracts, insurers provide certainty with respect to different financial outcomes, as noted by Swain and Swallow (2015).

One of the main purposes of the insurance industry is to match assets with liabilities, contributing to the financing of assets for infrastructure development and supporting the diversification across the financial system. It also provides income security to individuals through retirement products, income protection in case of unemployment and health care services. For instance, the industry paid over GBP5.7 billion in protection claims as per the Association of British Insurers (ABI 2019).

The abovementioned highlights the importance of the services provided by this industry across various sectors of the economy, providing an important contribution to economic growth. The role of insurers in supporting resilience across a range of economic activities is particularly important at a time of significant economic change. But it also stresses the impact that climate change can have on the efficiency of this industry and underlines some of its potential vulnerabilities, which, if not addressed properly, can impair the existence of this industry as we know it, with significant spillover effects to the wider society. Hence, it is important that an overview of the impact of climate change on the insurance industry considers both the implications to the industry with respect to the underwriting of climate change-related risks, investment activities, reporting and disclosure (CRO Forum 2019), as well as the economic and social role of the industry over the longer term (Bank of England 2015).

The above points also emphasise the significance of regulation in this matter. For example, this is the case of Solvency II—the European legislation Directive which came into force in January 2016. Summarily, Solvency II is a set of rules which should be adhered to by insurance companies and which focuses on how insurers should be funded and governed. It is based on three pillars (RIMES 2014):

- Pillar I covers requirements associated with the amount of capital an insurer should hold;
- Pillar II concentrates on governance, supervision and risk management requirements to ensure insurance firms are managed to, at least, a set standard;
- Pillar III addresses disclosure and transparency obligations, i.e. it sets out the necessary information that insurance firms need to disclose regarding their business.
This European Directive is particularly important in the context of ensuring the sustainability of financial institutions, namely insurers, and the strategic and operational decisions they take, as they face increased physical, transition and liability risks, as a result of the challenges climate change presents.

### 2.2.1 Types of Risks

Starting from the premise that insurance is, in essence, a mechanism for the transfer of risk in the context of the operation of markets, it is important to set out the main areas of risk for the industry: physical, transition and liability risks. In this subsection, we will focus on the first two areas of risk; we will address liability risks later in this chapter.

**Physical risks** relate to an increase in losses from climate trends or extreme weather events (Regelink et al. 2017). Climate trends include rise in average temperature, sea levels and coastal erosion, while floods and hurricanes are classified as extreme weather events, the accelerated frequency of which contribute to new, emerging physical risk trends. These risks are important, not only because they cause damage to property and often loss of lives, but also because they have an impact, for example, on the supply of resources, business operations and supply chains.

**Transition risks** relate to those risks which result from an attempt to reduce the transformational physical risks arising from climate change. According to the Bank of England (2019a), this type of risk requires a number of policy, market and technological changes to support possible financial costs and economic dislocations which may result from the process of reducing emissions and transitioning to a low-carbon economy. Among the sectors that are most exposed to this type of risk are those which relate to the extraction or production of fossil fuels and those that tend to emit large amounts of Greenhouse Gases (GHGs).

In addition, transition risks, together with changes in social behaviour, are expected to have a more general effect on many of the services and products that use fossil fuels, such as the sale of non-electric cars, properties that require a lot of energy due to limited insulation or even restaurants that do not offer vegan options. Infrastructure-related and utility businesses that also rely heavily on fossil fuels will most definitely be impacted by bans, carbon pricing and declining levels of demand in the future.
Importantly, there are positive implications to transition risks—as a result of a shift towards the use of increased levels of renewable energy, new opportunities for employment and growth in various sectors will emerge, as well as health benefits for the population. But, as argued by the European Academies’ Science Advisory Council (EASAC 2018), there is “no silver bullet”—continuous research in new technologies requires large capital investments, can involve, in some cases, high investment risks and many of the new technologies also have significant limitations, such as high running costs. Adding to the impact of physical and transition risks are third-party liability risks. Their relevance for the insurance industry is paramount, but we will talk further about this in a separate subsection.

2.2.2 Uninsurable Risks and Losses

If we now concentrate on the impact that physical and transition risks can have on the insurance industry, we can clearly identify two areas that can shape the scenarios for which insurers need to prepare: one relates to the strength of response to the alleviation of climate change as per the Paris Agreement and the second concerns the pathway through which transition risks are being absorbed, i.e. how disruptive or smooth the transition to a low-carbon economy is established. The framework produced by the Network for Greening the Financial System (NGFS) and published by the UK Office for Budget Responsibility (2019) underscores the serious impact that these two types of risk can have for businesses and society at large, as can be seen in Fig. 2.1.

Specifically, the top right-hand corner box of this figure exacerbates the possible difficulty for insurers to insure certain risks properly and avoid significant losses. Indeed, it brings to the fore the potential for some risks to be regarded by the industry as non-insurable, in order to avoid very significant losses for the insurance business.

The latest developments regarding COVID-19 demonstrate how a virus has not only affected the health of so many individuals but has, in essence, shut down large parts of the world economy, with businesses closed, supply chains disrupted and a huge loss for both individuals and businesses. In such a case, the clauses associated with insurance contracts play an ever important role—for example, to what extent can an individual unemployment benefit insurance cover the damage caused by such a global, widespread health event?
The example of Flood Re, a publicly funded scheme in the UK, which was created to enable access to affordable insurance in areas prone to flooding also highlights the need for insurers to work closely with governments—it will continue to be the case (perhaps increasingly so) that some risks will be so expensive to incorporate in premiums that, unless governments are willing to bear some of the cost, insurance will not be a viable proposition in some areas and for some individuals and businesses.

More generally, physical and transition risks linked to climate change pose a number of very significant challenges to the sector. The Financial Stability Institute (FSI) of the Bank for International Settlements sets out a summary of these challenges (FSI 2019), which we present succinctly in five columns in Table 2.1 (related to insurance risk, market risk, credit risk, operational risk and liquidity risk) within the context of two examples.

### 2.2.3 Business Models and Pricing Adjustments

Given the fast developments that we are witnessing concerning the changes with the climate change and the resulting increased risks we have discussed earlier in this chapter, insurers and indeed the financial sector
Table 2.1  Challenges associated with physical and transition risks in the insurance industry

|                      | Insurance risk | Market risk | Credit risk | Operational risk | Liquidity risk |
|----------------------|----------------|-------------|-------------|------------------|----------------|
| Physical risk        |                |             |             |                  |                |
| Example:             |                |             |             |                  |                |
| Melting ice which    | Higher than    | Fall in     | Downgrade    | Physical damage  | Higher policy  |
| increases sea levels | expected       | equity values| of credit     | to insurers’     | cancellations  |
| and can cause        | insurance      | due to      | rating of     | premises,       | to supplement  |
| floods               | claims         | physical    | reinsurers,   | disrupting the | lost income    |
|                      | payouts        | losses and  | increasing the | operation of the |                |
| Transition risk      |                | business    | risk of       | business        |                |
| Example:             |                | interruptions| losses        |                  |                |
| Carbon tax, a        | Potential      | Investment  | Losses from   | Potential        |                |
| government policy    | undpricing of  | losses and   | corporate debt| increased        |                |
| to reduce GHG         | new insurance  | lower asset | investment     | exposure to      |                |
| emissions            | products       | values       |             | cyber risk       |                |
|                      |                |             |             |                  |                |
| Source               | Authors’        |             |             |                  |                |
|                      | elaboration    |             |             |                  |                |
|                      | based on FSI   |             |             |                  |                |
|                      | (2019)          |             |             |                  |                |
need to boost their climate readiness. This also means that their business models require reconsideration so that pricing of the products and services on offer can support insurers through the process of becoming more resilient within the context of emerging climate-related risks.

To be successful at identifying the key risks and opportunities for the sector and measure their effects appropriately, it is important that insurers work closely with policymakers towards an alleviation of climate risk exposure and collaborate with various other stakeholders to ensure that public policies which foster climate risk resilience are developed. In addition, insurers should also engage with rating agencies and experts in the field of environmental risk management to improve the accuracy of their pricing.

Importantly, as detailed by Deloitte (2019), the following steps will certainly prove useful in instilling climate risk readiness:

- Embedding the importance of climate risk within the business by, for example, linking executive compensation to performance metrics which should be closely linked to sustainability;
- Making use of advanced data analytics and engaging with the climate and data science research communities to improve the assessment of climate risk through developments in risk selection and pricing;
- Developing a holistic approach to climate risk exposure, by incorporating it in the insurers’ enterprise risk management (ERM) framework. This will enable insurers to establish promptly correlations of certain impacts across both liabilities and investments.

In order to improve pricing strategies, firms will also be required to adjust their business models so that the input and output variables considered (as well as the way they are measured) incorporate the various scenarios as per the NGFS scenario analysis framework in Fig. 2.1. Specifically, with respect to the input variables, these should most definitely include macroeconomic variables, such as real GDP, inflation and unemployment rate and also financial variables which provide data on government bond yields, equity and commodity prices. However, central to the input variables is a set of climate variables that provides information on the expected frequency and impact of weather events, details carbon prices and provides a measure of emissions.

With respect to the output variables considered, firms need to work hard at sizing their risks and this certainly involves the development of
an improved method in valuing assets and liabilities as a result of climate risks. With respect to general insurers’ underwriting strategy, in particular, there are certain elements that are of utmost importance, such as knowledge about the location of the risk, the nature of the risk and the potential interconnection between risks—these are clearly central to their portfolio management.

Regarding life insurance, the specific combination of direct and indirect physical impacts as well as societal impacts needs to be addressed when dealing with these insurers’ level of business exposure. Heatwaves, storms and floods are examples of direct physical impacts on life insurance but so are air pollution, environmental degradation, diseases which may have an indirect impact on the business. More widely, the state of public health infrastructure and political (in)stability in a country or region of the world represent societal impacts which are relevant to life insurance. In fact, all these factors ultimately may impact levels of mortality and morbidity and, hence, should be incorporated in the premium formulation, claims expectations and in the analysis of insurability of various strata across populations.

With respect to insurers’ investment portfolios, two organisations, Investing Initiative (2II) and the ClimateWise Insurance Advisory Council have developed tools that focus on climate risk metrics. The latter, in particular, focuses on the quantification of transition risks for infrastructure investments, adopting the following steps: portfolio risk and opportunity exposure, asset impact identification and financial modelling analysis, as detailed in CRO Forum (2019).

In the meantime, insurers (general and life insurers) need to improve their modelling approach with respect to the assumptions used and advance data collection to improve forecasting. As per the World Bank (2016), climate change risks are often incorrectly priced due to mainly four factors: short-term approach to modelling of risks, inconsistent regulation across countries, asymmetric information, broad range of, for example, carbon prices across the world and lack of accurate data, which makes financial analysis very difficult and potentially less reliable.

Crucially, insurers need to recognise the challenges within their business models and ensure that management decisions and business models are aligned with the current expectations regarding the various climate scenarios (Bank of England 2019b).
Summarily, the insurance firms’ ability to adjust their pricing to climate-related risks will certainly depend on a combination of operational, business and structural factors. Operational factors deal with what is known as the catastrophe risk modelling—complex models normally dealing with existing risks. Business model factors focus on the diversification of a range of risks, the transferring of some of the risk to reinsurers for risk mitigation purposes and the inverse production cycle. Finally, structural factors considered in the process of pricing should embed regulatory capital requirements and accommodate details relating to the duration of contracts.

2.2.4 Third-Party Liability Risks

It was mentioned earlier that third-party liability risks constitute another type of risk which needs to be considered by insurers when addressing the effects of climate change. These risks are central to the operation of insurers because they can have long-lasting implications for their businesses. Liability risks relate to the effect that can emerge sometime in the future if parties who have suffered loss seek compensation from those they believe are responsible for the damage inflicted on them. These risks need to be central to insurers’ considerations when policies are formulated and sold because not only can they require a certain degree of speculation, but they can most certainly add to some disruption of the insurance business in the form of a potentially significant increase in claims over the longer term. This can present a serious financial problem for insurers, particularly if cover is proven for certain types of liability. For example, at the moment, insurers are dealing with serious liability challenges relating to the policies they have sold to businesses and individuals, as a result of COVID-19. Their response to events like these can lead to wider concerns for society and, in some cases, intensify the potential need to nationalise, to a certain extent, some physical and liability-related risks.

Third-party liability risks are often viewed as indirect risks as they relate to the impact that, for example, a flood can cause on certain business lines and the subsequent effect on third parties, who seek to recover losses from those they believe are responsible for these losses. For example, not only an extreme weather event may directly affect premises of a business and, if relevant, any products stored on-site, but it will contribute to financial loss and may have wider economic implications too—for example, it can affect one (or more) supply chain(s) and even cause displacement. Some of the
most common examples of contracts that address third-party liabilities are professional indemnity or director’s insurance contracts.

Generally, claims relating to this kind of risk in the context of climate change will focus on losses resulting from those who were insured and who failed to account for damage that they may have caused to the environment, known as “loss and damage” from climate change, where the impact of climate change has not been mitigated by taking the necessary steps to reduce, for instance, emissions, as per the United Nations Framework Convention on Climate Change (UNFCCC) Warsaw Agreement (UNFCCC 2014).

Third-party liability risks can also relate to a failure to comply with regulations. Claims due to asbestos use is one such example that has cost close to USD90 billion in claims in the United States alone. Another example is the long-term impact that pollution can have on various parties, such as individuals, past and current site owners of say potentially polluting businesses, impact on employees’ health, etc.

With increased climate risks, it is expected that insurers will require to allocate what is already a large proportion of their balance sheet provisions to future and uncertain claims, on the basis of third-party liabilities. As of 2014, approximately 39% of total provisions in the insurance industry were related to addressing claims related to this type of risk—the largest percentage of provisions, followed by motor claims. Moving forward, insurers will be required to carefully consider all aspects of liability risks, in order to mitigate the physical impact of climate change they are liable to pay, including being able to address potential liabilities related to failure of businesses to adapt, examples of which can include governance issues or failure of clients to disclose or comply with the relevant legislation.

Finally, we will turn to another area of business in the insurance industry—reinsurance.

### 2.2.5 Reinsurance of Climate Risks

When we consider climate risks, we most certainly have to bear in mind the significant function played by reinsurance firms—their role in providing underwriting, pricing, claim management and general consultancy to primary insurance firms is of prime importance in absorbing shocks impacting the insurance industry (Upreti and Adams 2015). Among the concerns for reinsurers, climate risk has been recently ranked third in the Insurance Banana Skins ranking, as detailed in the latest report
Climate change is indeed challenging the current reinsurance models due to two main factors: on the one hand, the risk of increased natural disasters will lead to significant claim charges and, on the other hand, it can impact the industry’s reputational risk as they may, in fact, not be able to cover against, at least, some of emerging climate risks and hence reinsurers may no longer be in a position to offer certain solutions which could be instrumental to businesses in certain circumstances.

In essence, the above presents critical challenges to both sides of reinsurers’ balance sheets (Swiss Re 2020). On the asset side, if reinsurers are to sustain their profitability, they need to carefully assess their investments in infrastructure funds and corporate bond holdings, as they may potentially become more exposed to certain physical and transition climate risks and, on the liability side, if they rely on existing models which are based on historical data, they may underestimate the premiums they have charged.

Therefore, in order to remain a sustainable industry, reinsurance firms need to invest in increasingly more sophisticated forward-looking business models, which consider all the relevant aspects to the socio-economic, technological, political and regulatory landscape and associated factors. Such models should also dynamically track the impact of climate change and, in particular, a warmer climate and, consequently, the derived additional exposures and vulnerabilities that result for the reinsurance industry.

### 2.3 Impacts on the Banking Industry

#### 2.3.1 Lack of Data on the Impact of Climate Risks

The implications of climate risks for the banking industry have received increasing attention over the last decade, particularly since the adoption of the Paris Agreement in December 2015. Following the famous speech by Mark Carney—Governor of the Bank of England and former Chairman of the Financial Stability Board—on “Breaking the Tragedy of the Horizon” in September 2015 (Carney 2015), it is now largely accepted that climate change poses a number of financial risks for banks and other financial intermediaries. Many of these risks exhibit new characteristics, including
greater scale, likelihood and interconnectedness (CCSF 2016). Collectively, these characteristics contribute to making climate risks more central in the current risk management agenda of banks and other financial institutions, as will be discussed later in this section and elsewhere in this book.

There tends to be agreement in the literature that risks associated with climate change do not represent a new category of risk for banks (Aubert et al. 2019). On the contrary, climate risks have the potential to manifest as types of risk already faced by banks and other financial intermediaries, namely credit, market and operational risks (Bank of England 2018). Table 2.2 provides an overview of the main ways in which climate risks, defined according to the taxonomy originally proposed by Carney (2015) and summarised in Sect. 2.2.1 above—i.e. physical, transition and liability risks—might translate into different types of financial risks for the banking industry.

Climate change might affect the quality of banks’ credit portfolios through its effects on the ability of households and firms to repay their debts or meet their obligations. For example, physical risk arising from climate-related events such as droughts or long-term changes in precipitation could harm borrowers’ income through decreased production capacity, translating into a higher probability of default and loss given default on loan books (Bolton et al. 2020). Credit risk might also increase as a result of the fall in collateral values and the write-off of assets located in regions at high climate risk. In turn, the transition towards a low-carbon economy could have a bearing on the riskiness of credit portfolios via changes in property values, which might stem from tighter energy efficiency standards or similar climate-related policy interventions (Monnin 2018). At the same time, the shift away from carbon-intensive sources of energy might imply that some assets could become stranded, impairing the value of banks’ loan portfolios. This might be the case for corporate clients with business models that are not aligned with a 2 °C scenario (e.g. carbon extractors and emitters), whose earnings and business operations are likely to be the most affected by the transition—in particular if it happens lately and disorderly (Bank of England 2018). Although physical and transition risks can be regarded as the major sources of credit risk for banks and other financial intermediaries in relation to climate change, the quality of credit portfolios might also be weakened by greater liability risk. Insofar as compensation costs for climate-related losses or damages worsen borrowers’ financial situation, liability risk on the part
Table 2.2  Main climate-related financial risks for the banking industry

|                        | Credit risk                                                                 | Market risk                                                                 | Operational risk                                                                 |
|------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| **Physical risk**      | • Increase in default rates due to borrowers’ declining revenue              | • Re-pricing of sovereign debt as a result of severe weather events          | • Impact on business continuity (e.g. branches, infrastructure and staff) as a consequence of severe weather events |
| Direct losses caused   | • Reduction in collateral values as a result of damages to property          | • Re-pricing of securities and derivatives due to tighter climate-related    |                                                                                  |
| by climate-related     | • Write-off of assets situated in high-risk areas                            | policy                                                                        |                                                                                  |
| events                 |                                                                              |                                                                              |                                                                                  |
| • Acute (e.g. storms   |                                                                              |                                                                              |                                                                                  |
| and floods)            |                                                                              |                                                                              |                                                                                  |
| • Chronic (e.g. higher |                                                                              |                                                                              |                                                                                  |
| average temperatures   |                                                                              |                                                                              |                                                                                  |
| and rising sea levels) |                                                                              |                                                                              |                                                                                  |
| **Transition risk**    |                                                                              |                                                                              |                                                                                  |
| Economic and financial |                                                                              |                                                                              |                                                                                  |
| consequences associated|                                                                              |                                                                              |                                                                                  |
| with the transition to |                                                                              |                                                                              |                                                                                  |
| a low-carbon economy   |                                                                              |                                                                              |                                                                                  |
| • Changes in property |                                                                              |                                                                              |                                                                                  |
| exposures as a result   |                                                                              |                                                                              |                                                                                  |
| of stricter energy     |                                                                              |                                                                              |                                                                                  |
| efficiency standards   |                                                                              |                                                                              |                                                                                  |
| • Decline in value of  |                                                                              |                                                                              |                                                                                  |
| loan portfolios due to |                                                                              |                                                                              |                                                                                  |
| stranded assets        |                                                                              |                                                                              |                                                                                  |
| • Borrowers’ losses    |                                                                              |                                                                              |                                                                                  |
| arising from disruptive |                                                                              |                                                                              |                                                                                  |
| technology             |                                                                              |                                                                              |                                                                                  |
| **Liability risk**     |                                                                              |                                                                              |                                                                                  |
| Liabilities arising    |                                                                              |                                                                              |                                                                                  |
| from claims on climate |                                                                              |                                                                              |                                                                                  |
| related losses or      |                                                                              |                                                                              |                                                                                  |
| damages                |                                                                              |                                                                              |                                                                                  |
| • Increase in default  |                                                                              |                                                                              |                                                                                  |
| rates due to borrowers’|                                                                              |                                                                              |                                                                                  |
| rising costs for climate|                                                                              |                                                                              |                                                                                  |
| change-related         |                                                                              |                                                                              |                                                                                  |
| compensation           |                                                                              |                                                                              |                                                                                  |
| • Fines or penalties   |                                                                              |                                                                              |                                                                                  |
| related to the         |                                                                              |                                                                              |                                                                                  |
| consequences of climate|                                                                              |                                                                              |                                                                                  |
| change                |                                                                              |                                                                              |                                                                                  |
| • Reputational risks   |                                                                              |                                                                              |                                                                                  |
| stemming from a       |                                                                              |                                                                              |                                                                                  |
| perceived inadequate   |                                                                              |                                                                              |                                                                                  |
| response to climate    |                                                                              |                                                                              |                                                                                  |
| change                |                                                                              |                                                                              |                                                                                  |

Source: Authors’ elaboration based on Aubert et al. (2019) and Bank of England (2018)

of borrowers might transmit to banks’ credit risk through an increase in default rates.

Together with their impact on credit risk, physical and transition risks have the potential to increase the market risk faced by banks and other
financial intermediaries. Severe weather events such as hurricanes or floods could slow economic growth, for instance through large and sustained damage to national infrastructure. Greater levels of sovereign risk might lead to a re-pricing of national or local government’s debt, possibly lowering the value of securities held on banks’ balance sheets (Bank of England 2018). Market risk might also materialise as a consequence of stricter policies aimed at facilitating the transition to a low-carbon economy, which could cause a re-pricing of equities, corporate bonds and derivatives related to energy and commodities. Banks whose balance sheets are hit the hardest by credit and market risks could find it difficult to refinance themselves in the short-term, possibly facing liquidity risk and generating tensions in the interbank lending market (Bolton et al. 2020).

A third major category of bank risk that might be impacted by climate change is operational risk. Severe weather events such as storms or higher average temperatures are likely to disrupt business by causing damages to office premises and IT infrastructure or lowering staff’s productivity and well-being. Additional impact on business continuity could be induced by higher volatility in the prices of inputs, including energy, water and insurance (Bank of England 2018). Another source of operational risk for banks and other financial intermediaries is tied to changes in policies and technologies as part of the adjustment towards a low-carbon economy. To the extent that this adjustment sparks a changing sentiment towards climate-related issues, such as increased pressure to divert capital away from fossil fuel companies and greater demand for green loans, climate change could represent a source of reputational risks for banks (TCFD 2017). These risks might be material if banks are perceived to be contributing to climate change or failing to manage climate-related risks, prompting claims by those who have suffered the losses or damages.

Although there is currently a good understanding of the channels whereby climate risks might affect banks and other financial intermediaries, a quantification of the likely impact of the physical, transition and liability risks of climate change on the banking industry is still underdeveloped (Summerhayes 2019). For instance, limited empirical data is available to date on the relationship between climate change and credit risk. Advancements in this area are hampered by a lack of historical data that banks can employ to evaluate the impact of climate risks on credit losses. For this reason, the quantification of physical, transition and liability risks tend to rely primarily on insights from climate scenarios and make the best use of expert judgements (Colas et al. 2018).
Theoretical support for the physical effects of climate change on the banking industry is provided by Dafermos et al. (2018), who establish that climate change is likely to increase the rate of default of corporate loans and threaten the stability of the banking system by destroying the capital of firms together with their profitability and liquidity. In addition, some preliminary evidence exists for the physical costs associated with climate-related events such as droughts and hurricanes having a negative impact on both equity and debt instruments through lower payoffs and higher non-performing loans (Campiglio et al. 2019).

In parallel to these studies, the last few years have witnessed a growing strand of research on the economic and financial consequences that the transition to a low-carbon economy might entail for the banking industry. Although this research is confronted with important data gaps and the need to rely on a number of assumptions, it offers some useful insights into the impact of transition costs on banks and other financial intermediaries.

One of the pioneering contributions is made by Battiston et al. (2017), who illustrate how their methodology can be used to perform a climate stress test of the banking system based on individual bank-level data. Their major conclusion, drawn from data for the top 50 listed European banks by total assets, is that banks would not default solely as a consequence of their loan exposures to firms in the fossil-fuel and utilities sectors. However, climate policies might cause significant volatility of large portions of banks’ assets relative to their capital. A similar approach is taken by DNB (Vermeulen et al. 2018) for the Dutch banking sector, with their stress tests revealing that banks’ losses are likely to reach 3% of total stressed assets in a disorderly energy transition. A large part of these losses is due to the interest rate effect associated with holdings of government bonds carrying longer maturities. It is also found that the regulatory capital (CET1) ratio of banks might fall by approximately 4% in a combined policy and technology shock scenario. These results are corroborated by a more recent study by Roncoroni et al. (2020), who develop a climate stress test framework to quantify the direct and indirect impact of a late and disorderly transition to a low-carbon economy. Focusing on the Mexican financial system as a laboratory, they find that an adverse scenario will generate systemic losses ranging between 2.5 and 4% of initial total assets—a sizeable amount.
2.3.2 Possible Pricing Adjustment Strategies

Insofar as climate change causes financial risks of the sort described in the previous subsection, it is important for banks and other financial intermediaries to account for these risks in their pricing strategies. As the Bank of Canada points out (Bank of Canada 2019, p. 29), “[l]imited understanding and mispricing of climate-related risks could potentially increase the costs of transitioning to a low-carbon economy”. According to Thomä and Chenet (2017), the mispricing of climate risks has the potential to create a “carbon bubble”—i.e. an overvaluation of fossil fuel reserves and related assets that will materialise if the objective of containing climate change to well below 2 °C above pre-industrial levels is to be achieved (Schoenmaker and van Tilburg 2016). Moreover, if climate-related financial risks are being underestimated, capital is likely to be over-allocated to activities with higher risk. Alongside exposing creditors to potentially large losses, the underestimation of climate risks could result in central banks accepting collateral of insufficient credit quality (Monnin 2018). It follows that correctly pricing financial risks arising from climate change might support a more efficient allocation of capital by banks and other financial intermediaries, while ensuring they are not overexposed to risk (Chenet 2019).

Mispricing can occur for a variety of reasons, including limited data on carbon exposures, challenges of accounting for uncertain events in the future and discrepancy in time horizons—which means that households and firms that produce GHG emissions currently have no direct incentive to shift towards a low-carbon technology as they do not bear the damages or losses caused by their pollution (Thomä and Chenet 2017). For example, the lack of detailed and accurate information on climate risk at the level of individual assets and portfolios may hinder banks’ ability to price risk and allocate capital properly (e.g. Monasterolo et al. 2017; Summerhayes 2019), implying that the efficient market hypothesis might not hold when it comes to climate change (Thomä and Chenet 2017). The consequences of incomplete information and ensuing mispricing of assets by banks and other market participants are summarised well by the Task Force on Climate-related Financial Disclosures (TCFD 2017, p. 1):

[I]nadequate information about risks can lead to a mispricing of assets and misallocation of capital and can potentially give rise to concerns about financial stability since markets can be vulnerable to abrupt corrections.
Campiglio et al. (2019) review the literature available to date and conclude that the impact of climate change on future financial asset performance will depend critically on the extent to which physical and transition costs are reflected in current asset prices. As Litterman (2011, p. 10) strongly emphasises in relation to pricing carbon emissions:

> Climate risk is not being priced. It should be priced immediately at a level that appropriately reflects fundamental uncertainty about catastrophic risks and a high level of societal risk aversion.

There is initial evidence in the literature to suggest that banks and other financial intermediaries have started to price in climate-related financial risks, yet not fully. Drawing on US data over the period 2001–2010, Cortés and Strahan (2017) show that small banks respond to local shocks created by exposure to natural disasters by increasing credit in affected areas and taking credit away from other areas. Small banks are found to mitigate the effects of credit reduction in connected markets by raising deposit rates in these markets to help finance additional lending. Further evidence from the US is provided by Jiang et al. (2019), who examine whether the risk associated with sea level rise has a bearing on the pricing of bank loans. They establish that the spreads for long-term loans—that is, loans with maturity longer than five years—go up with the sea level rise risk of the county where the borrower is located. In turn, Ouazad and Kahn (2019) identify a mispricing of assets vulnerable to natural disaster risk, i.e. guarantee fees associated with mortgage securitisation. They contend that the mispricing of mortgage risk carried in securitisers’ balance sheets can represent a source of unhedged and unanticipated systemic risk.

Support for mispricing of climate-related financial risks in the banking industry also exists in relation to transition risk. Using the Clean Air Action launched by the Chinese Government in 2013 as a quasi-experiment, Huang et al. (2019) show that the loan spread charged to high-polluting firms increased by 5.5% after the policy implementation—compared with an increase of 50% in the default risk of these firms. This evidence suggests that banks may be pricing in climate-related transition risks, though not sufficiently. In a similar vein, Delis et al. (2019) focus on the syndicated loan market to investigate whether banks price in firms’ polluting activities, i.e. stranded fossil fuel reserves. They find evidence consistent with banks charging significantly higher loan spreads to fossil
fuel firms with greater exposure to climate policy risk, but only in the period after the Paris Agreement.

Further evidence that climate-related risks are not yet fully reflected in banks’ prices is offered by a survey of 28 financial institutions in the Netherlands conducted by DNB (Regelink et al. 2017). The survey discovered that virtually none of these institutions were of the opinion that transition risks are adequately priced, indicating the potential for a sudden downwards shock in the banking industry arising from the introduction of new, low-carbon measures and technological developments.

Overall, the empirical evidence available so far concurs with the concern expressed by the NGFS that “there is a strong risk that climate-related financial risks are not fully reflected in asset valuations” (NGFS 2019, p. 4). For this reason, TCFD-style disclosure should be promoted further, as it is likely to help banks and other financial intermediaries adjust their pricing strategies in order to correctly account for climate-related risks.

### 2.3.3 Systemic Impact and Market Failures

The review of the literature presented in the previous subsection suggests that banks who fail to account for climate risks in the construction of their portfolios are pricing their holdings based on a misspecified model. To the extent that such mispricing has a bearing on the assets held by systemically important banks and other major financial intermediaries, there could be consequences in terms of systemic risk (Alessi et al. 2019). The link between mispricing of climate-related financial risks and the aggregate level of risk in the economy is corroborated by a recent analysis by the ECB (Giuzio et al. 2019). This analysis reveals that climate risks have the potential to become systemic for the euro area, particularly if banks and other financial institutions are not fully pricing in these risks.

According to a study by the ESRB (2016), an adverse scenario—whereby the transition to a low-carbon economy occurs late and abruptly—could have implications for systemic risk via three main channels: (i) lower energy supply and higher energy costs harm macroeconomic activity; (ii) banks and other financial institutions are negatively affected through their exposure to assets that are subject to a revaluation
(e.g. carbon-intensive assets); (iii) the frequency and intensity of physical shocks (e.g. natural catastrophes) associated with climate change increase.

Climate risks may be regarded as systemic by nature, as they tend to impact the whole planet and are therefore non-diversifiable (Aglietta and Espagne 2016; DNB 2018). The unprecedented scale of these risks is such to have the potential to cause another major financial crisis (Saha and Viney 2019). In fact, one could argue that climate catastrophes are even more serious than most systemic financial crises, since they might pose an existential threat to humanity (Bolton et al. 2020).

Financial risks related to climate change have a number of distinctive elements, which are bound to give rise to considerable challenges for the banking industry. Among these elements is that they are far-reaching in breadth, that is, they will affect all economic agents (i.e. households, firms and governments) across all sectors and geographies (NGFS 2019). Therefore, their overall impact on the financial system is likely to be greater than other types of risks, while being potentially non-linear, correlated and irreversible (Bank of England 2018). Furthermore, despite uncertainty surrounding the precise outcome, there is a high degree of certainty that financial risks from climate change will occur sometime in the future (NGFS 2019). To use an expression introduced recently by the BIS (Bolton et al. 2020, p. 6), climate change can be viewed as “green swan” events:

[C]limate change represents a green swan: it is a new type of systemic risk that involves interacting, nonlinear, fundamentally unpredictable, environmental, social, economic and geopolitical dynamics, which are irreversibly transformed by the growing concentration of greenhouse gases in the atmosphere.

Empirical evidence on the implications of climate-related financial risks for bank soundness and financial stability already exists in the literature. Building on a sample covering 160 countries over the period 1997–2010, Klomp (2014) uncovers a positive relationship between natural disasters and the likelihood of a bank’s default. Their analysis indicates that natural disasters may pose a substantial threat to the liquidity, yet not

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1 Although the carbon bubble alone is unlikely to be a source of systemic risk (Weyzig et al. 2014), it could combine with other sources of financial instability and create important destabilising effects for the financial system.
directly to the solvency, of the commercial banking sector. Similar results are obtained by Noth and Schüwer (2018), who investigate the effects of weather-related disasters on bank stability in the US between 1994 and 2012. They provide evidence that weather-related disasters indeed harm bank stability, as captured—among others—by significantly lower Z-scores, larger probabilities of default and higher non-performing asset ratios. The extent to which climate-related damages influence the stability of the banking system is explored further by Lamperti et al. (2019) using an agent-based climate-macroeconomic model. Their results show that climate change will lead to an increase in the frequency of banking crises (between 26 and 248%), with an additional fiscal burden of around 5–15% of GDP per year. It is estimated that approximately 20% of such effects will stem from the weakening of banks’ balance sheets caused by climate change.

There is some preliminary evidence to suggest that bank stability might also be impacted by transition risk. Safarzyńska and van den Bergh (2017) establish that investments in renewable energy may lower interbank connectivity and lead to higher probability of bank failures. According to their analysis, financial stability may be hampered by a too quick transition to a low-carbon economy because the costs of financing investments in expensive renewable power plants may offset the enhanced profitability associated with existing gas power stations.

Besides its implications for bank soundness and financial stability, the literature available to date indicates that climate change might spawn new market failures. In fact, it could be maintained that climate change is itself the result of a market failure to account for the cost of GHG emissions to society (Fang 2018).

Drawing on US data during the 1990s, Garmaise and Moskowitz (2009) find that properties with greater exposure to hurricane risk are likely to receive less bank financing than other properties in the same zip code. This outcome translates into reduced provision of credit, limited participation of less wealthy investors and slower neighbourhood revitalisation in disadvantaged areas. Similar results for hurricane risk are presented by Brei et al. (2019), who show that deposit withdrawals together with a dry-up in non-deposit funding explain the contraction in bank lending that occurred in the two quarters following a hurricane in the Eastern Caribbean. At the same time, Duan and Li (2019) use mortgage origination as a laboratory to assess whether beliefs about climate change have a bearing on the decision-making of agents, establishing that
abnormally high local temperatures reduce mortgage approval rates and loan amounts by 6.7%.

Additional evidence on the negative effects of weather-related disasters on bank lending is available for flood risk. Collier et al. (2013) collect data from a microfinance intermediary in Peru that is vulnerable to El Niño-related flood risk and conclude that loan losses caused by a natural disaster lead lenders to contract credit after the event—which in turn slows economic recovery for the affected area. These conclusions are confirmed by Choudhary and Anil (2017), who employ unprecedented flooding in Pakistan during 2010 as a natural experiment and show that banks disproportionately cut back on lending to new and less-educated borrowers following an exogenous shock to bank funding. They provide evidence consistent with this reduction in credit being driven by adverse selection and not being compensated by more lending by less-affected banks. Similarly, Faiella and Natoli (2019) investigate bank lending to non-financial firms at risk of flooding in Italy and find that banks tend to ration credit to firms with greater exposures to climate risk. Taken together, these results suggest that a rise in intermediation costs due to climate change-related events has the potential to create new market failures (or at least to amplify pre-existing ones).

2.4 The Problem of Measuring the Exposure to Climate-Related Risks

There tends to be agreement in the literature that well-designed and effective climate-related disclosure is central to ensuring an orderly transition to a low-carbon economy (e.g. Batten et al. 2016). In June 2017, the TCFD published a set of recommendations concerning the voluntary disclosure of climate-related risks and opportunities by firms across all sectors, including insurance companies and banks. The rationale behind TCFD-style disclosure is encapsulated in the following statement accompanying the recommendations (TCFD 2017, p. ii):

One of the essential functions of financial markets is to price risk to support informed, efficient capital-allocation decisions. Accurate and timely disclosure of current and past operating and financial results is fundamental to this function.
Although a growing number of financial institutions have made efforts to understand and implement the TCFD recommendations, a comprehensive assessment of their exposures to climate risks represents one of the most critical measurement gaps in relation to climate change (Giuzio et al. 2019). A survey by DNB (Regelink et al. 2017) revealed that transition risks are not yet fully incorporated into financial institutions’ risk management frameworks, primarily because of scarce and incomplete information on their exposures to sectors with high levels of CO₂ emissions as well as on the energy labels of their real estate exposures. While sectoral analysis can offer a first approximation of financial institutions’ exposures to climate risks, it abstracts from important differences in production processes and technologies within sectors (Giuzio et al. 2019). These problems might be compounded by the lack of granular data on the geographical location of their exposures. In addition, even if spatial data on their real estate exposures exists, it might not be systematically available in financial institutions’ information systems (Aubert et al. 2019). All these factors contribute to making financial institutions’ exposures to climate-related risks considerably hard to measure.

Nevertheless, the FSI has recently published a climate risk assessment with respect to the insurance industry (FSI 2019), based on a survey conducted by the Prudential Regulation Authority (PRA) to large insurers (including both life and non-life insurers) to establish to what extent they were exposed to two main risks: physical risks arising from climate change and other risks resulting from the transition to a low-carbon economy.

According to the PRA, the selected insurers were asked to comment on the impact of three scenarios on their models and also the effect of these on their asset valuations. The three scenarios considered were: A—a disorderly transition to a low-carbon economy as per the IPCC Fifth Assessment Report published in 2014; B—a long-term transition, with a maximum increase in temperature below 2 °C as set in the Paris Agreement and C—no transition, with a rise in temperature of approximately 4 °C above pre-industrial temperature levels by the year 2100. The results are presented in Tables 2.3 and 2.4.

Tables 2.3 and 2.4 provide some striking figures, particular with respect to Scenario C, where the impact on both insurers’ liabilities and investments increases exponentially.

The even more limited evidence on climate risks available for the banking industry is somewhat concerning, given the significant size of financial institutions’ exposures to these risks. Weyzig et al. (2014) find
Table 2.3 Impacts of physical risks on general insurers’ liabilities

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

Source Authors’ elaboration based on FSI (2019)

that total equity, bond and credit exposures of EU banks to high-carbon assets corresponded to EUR460–480 billion (1.4% of their total assets) at the end of 2012, with corporate loans to fossil fuel companies contributing to almost two-thirds of this value. In a similar vein, DNB (Regelink et al. 2017) assesses Dutch financial institutions’ exposures to transition-sensitive sectors (i.e. those that are responsible for the bulk of CO₂ emissions) and shows that 11% of their balance sheet was tied to carbon-intensive sectors in early 2017. This evidence is corroborated by the results of another study by DNB (Vermeulen et al. 2018), which conducts a climate stress test on over EUR2200 billion of assets held
Table 2.4  Impacts of risks on insurers’ selected investments

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

*Source* Authors’ elaboration based on FSI (2019)

by Dutch banks, insurers and pension funds and concludes that banks are the most exposed to carbon-intensive industries—with a total exposure of 13% against a figure of 5% for insurers and 8% for pension funds. Moreover, the ECB (Giuzio et al. 2019) establishes that Euro area banks’ exposures to firms contributing to carbon emissions are sizeable, with the 20 largest emitters accounting for approximately 20% of total large exposures (1.8% of total assets of the sample banks). Data from the Banque de France (Aubert et al. 2019) also indicate that total exposure of the largest banking institutions in France to sectors that are most important GHG emitters reached 12.2% of total credit risk exposures at the end of December 2017, while banks’ exposures to climate policy-relevant sectors represent a portion of loan portfolios comparable to their capital (Battiston et al. 2017)—raising serious concerns if a substantial part of these portfolios ends up as stranded assets.
2.5 Conclusions

The evidence reviewed in this chapter suggests that climate change might represent a source of significant financial risks for insurance companies and banks and that these risks are likely to increase in the years ahead. Since the literature indicates that risks associated with climate change have the potential to become systemic, it is critical for insurance companies and banks to identify, price and manage these risks appropriately.

There is now growing awareness on the part of financial institutions about the importance of correctly quantifying climate-related risks. It is encouraging to see the results of surveys by central banks and other financial authorities showing that an increasing number of insurance companies and banks are addressing climate risks at the group strategy level, rather than simply as a concern of their CSR function (e.g. Aubert et al. 2019; Bank of England 2018). Survey results also reveal that insurance companies and banks have started to assess the opportunities that might be brought about by the transition to a low-carbon economy, including the development of new products and the support to customers throughout the transition period (APRA 2019).

However, the long-term horizon that distinguishes climate-related risks makes it extremely challenging for insurance companies and banks to identify, measure and monitor these risks. These challenges are compounded by considerable data gaps, particularly in relation to financial institutions’ exposures to the physical, transition and liability risks created by climate change. For example, there is evidence that transition risks are not yet fully incorporated into financial institutions’ risk management frameworks, largely because of limited information on key aspects of their portfolio exposures such as the levels of CO$_2$ emissions and the energy labels of real estate properties (Regelink et al. 2017).

It follows that more efforts need to be made to mitigate the potential impact of climate risks on financial stability, while ensuring that financial institutions’ practices are aligned with the target of limiting global temperature rises to well below 2 °C. The complex nature of climate change requires coordinated actions by a multitude of players, including financial institutions, the private sector and financial authorities. It is recommended that insurance companies and banks integrate financial risks from climate change into their risk management frameworks and discuss them at the board level. Climate-related financial risks should be identified and addressed at the earliest possible stages in order to reduce
their effects on financial institutions’ balance sheets. Insurance companies and banks should be supported in this endeavour through better availability and comparability of data on their exposure to climate-related risks. To this end, disclosure in line with the TCFD recommendations should be encouraged further. In turn, financial authorities such as central banks and other supervisors have a major role to play in ensuring that climate risks are effectively taken into account by insurance companies and banks. Since climate change presents a number of financial risks that are relevant to supervisory authorities, greater emphasis might be placed on strengthening current approaches to supervision through the integration of climate risks into prudential regulation requirements. The debate on whether financial institutions should be required to hold additional capital in view of their climate risks is one that is likely to attract continued interest in the time to come.

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