Institute and Faculty of Actuaries

A practical guide to climate change for risk management actuaries

by R. Coertze, N. Debele, C. Garthwaite, M. Gayen, N. Junglee, C. Spence, C. Sutton, P. Telford and W. Walford

Pathways to Sustainability

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Introduction

The aim of this guide is to produce a practical guide that provides cross-practice guidance to support actuaries involved in risk management (RM) exercises. The primary audience will be risk management actuaries intending to manage climate change risk, though the content is expected to be of interest to actuaries working across all practice areas.

The Intergovernmental Panel on Climate Change's (IPCC) 2021 report on the physical impacts from climate change unequivocally attributes global warming to human activities. Emissions must reach net zero to stabilise temperatures and limit the irreversible human-induced effects on the climate system. The report clearly outlines warnings with greater conviction and certainty than any previous report on the subject. Without rapid, large-scale emissions reductions, outcomes aligned with the Paris Objective of limiting average global warming to levels of 1.5 °C or 2.0 °C will move beyond our reach of correcting back.

The report clearly outlines that physical risks from climate change, even with significant reductions to future emissions, are expected to continue to emerge. Therefore, risk management practitioners need to incorporate those considerations into their risk management framework and practices.

The size and scale of actions needed to try to limit global average temperature rise to 1.5 °C or 2.0 °C are potentially disruptive, particularly where action is delayed. Sustained changes across all aspects of the economy are needed alongside coordinated global responses. This unprecedented level of change will impact on firms' risk profiles and must be managed.

While there remains uncertainty over the range of ways that climate risks can emerge, economic projections that do not allow for the risks from a climate transition or emerging physical risks do not reflect the scientific evidence.

The risk management function can play a key role in developing an insurer's response to climate change. It can help build carbon literacy[1], a better understanding of the risks and opportunities, and identify appropriate lead indicators for monitoring trends. The risk management function can frame climate change risk and uncertainties within existing risk appetites. As well as the short-term impacts of climate change, the risk management function may help the business understand the potential impact on long-term business strategy.

The IFoA (in line with the IPCC's view) recognises that the climate is changing globally at an unprecedented rate as a result of human activity. The potential impacts of climate change are global and systemic. This change presents ecological, social, economic and financial risks. It is expected to result in highly disruptive physical changes that will have significant implications for the entire financial system. Further, the financial sector can impact on climate change through providing finance for and underwriting carbon intensive activities.

The actuarial profession specialises in risk management. Since climate change is one of the greatest risks facing our world today, mitigating this risk is therefore urgent. Future outcomes are uncertain, but the best value insurance premium that society can pay is to reduce our emissions today in order to avoid the irreversible consequences of unmitigated climate change tomorrow.

This guide focuses on the risks induced from climate change, however, broader sustainability risk will also impact on risk management and firms' responses to climate change. While these are not covered

[1] https://carbonliteracy.com/

in this guide, risk management actuaries will want to consider a proportionate approach to sustainability issues.

This guide contains the following sections:

Section 2 - Climate risk overview

Section 3 - Climate change risk management

Section 4 - Key concepts and challenges

Section 5 - Integration with the risk management framework

Section 6 - Assessing impact

Section 7 - Approaches to measuring climate risk

Section 8 - Climate impacts on business planning

Section 9 - Next steps

As with the climate itself, the overall state of understanding of the problem is changing rapidly. This includes developments in the understanding of climate change impacts for the world as a whole, but also in modelling, regulation and best practice governance for financial institutions. Climate change is also increasingly being seen as important by the general public - with a potential impact for financial firms in terms of reputation risk in case the firm is not proactively considering and addressing their position with respect to climate change risks. Actuaries may want to use this guide as a starting point for further activity and look to maintain an awareness of ongoing developments.

This guide is not intended to be formal guidance on this subject. This guide seeks to support actuaries in their work and in using their professional judgement when giving advice.

Climate change risk overview

The financial risks from climate change are generally categorised into the risks which arise directly from the changing climate and the risks driven by the actions taken to limit climate change. These may be defined as follows based on the Taskforce for Climate-related Financial Disclosure's (TCFD) definition[2]:

Physical risks: Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns. These risks potentially incur financial implications, such as direct damage to assets, and indirect effects via supply-chain disruption.

Transition risks: Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputation risk to organisations, through different rates of changing customer or community perceptions of an organisation's contribution to or detraction from the transition to a lower-carbon economy.

In addition there is a third category of risk, sometimes referred to as liability risks, that captures the reputation risks and other franchise impacts these risks may carry from exposures to climate related litigation risks, regulatory censure, or adverse customer and other stakeholder perception of the enterprise.

The financial risks from climate change tend to materialise through changes to risks already captured in existing categories, resulting in higher losses to these business activities exposed to such risks. Here the existing risk management approach needs to be adapted to ensure that it captures these risk drivers appropriately. This may be through changes to the existing approach or requiring new data and metrics to express the exposure. Where climate risks change the risk profile of the long term strategic objectives, a more strategic and integrated approach may be needed to ensure these risks are well managed.

The uncertain nature of the risks from climate change, and the lack of historical data to support decision making, mean that there is a need to consider how risk management approaches may vary over short to long term and depending on the climate outcomes over that period and how this can be objectively embedded in the risk management approach.

[2] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

Climate change risk management

Climate change is a source of risk for financial institutions, through both physical risks as the climate changes around us and transition risks from the move to a net-zero carbon economy, or through impacts on the products that consumers demand. If the wide ranging risks from climate change are not managed, these risks could be the source of consumer harm and material financial loss for the firm.

An assessment of the risks should seek to capture both how climate risks and opportunities impact the company (also known as the outside-in risks) and how the company impacts on climate (the inside-out) perspective. This is sometimes referred to as 'double materiality'. Considerations should be given to how exposures are measured under both perspectives. The diagram below shows the associated stakeholders that could be considered.

Figure 1 – illustration of an ESG stakeholder universe

Source: https://www.thecroforum.org/wp-content/uploads/2021/11/CROF-Sustainability-WG_Mind-the-Sustainability-Gap.pdf

In addition to understanding the existing exposures to the financial risks from climate changes, firms are increasingly setting themselves ambitious carbon reduction targets. These will introduce additional risks for the enterprise. New strategic risks include the scope and coverage of the ambitions, alongside understanding what the objectives are. Given the extended time horizons of these targets are often out to 2050 and beyond, how progress will be monitored is important. Examples of considerations when setting targets include:

- The emission that the targets apply to (Scope 1, 2 and 3). For life insurers their scope 3 financed emissions will typically form the bulk of their emissions and should therefore be included for credibility.
- Clarity of the targets' objectives and how they will be incorporated within the firm's strategy.

- The risks of not achieving targets and their mitigations, including how progress will be measured and monitored.
- The uncertainty over evolving best practice, and how this may lead to changes in metrics and measurements over time.

A key risk management tool that has been used to understand climate risk exposures is scenario analysis. It is an important and useful tool used to explore and develop an understanding of the potential business implications of climate-related risks and opportunities. Modelling solutions used to support scenario analysis are uncertain and complex. Looking to distil multi-year climate pathways into a financial impact involves significant uncertainty, which is often represented through a range of potential outcomes. While these models can provide useful insights into climate risks, the model risks must also be understood to ensure that they are used judiciously with an understanding of the limitations in order to support decision making.

New skills are needed to ensure alignment with emerging best practice. The new data and modelling approaches require additional training and awareness to support the right behaviours. Our understanding of both what is needed and how this can be assessed and managed will continue to evolve. To respond effectively to this changing environment, risk management actuaries need to nurture, through lifelong learning, the necessary knowledge, skills, attitudes, and values for a sustainable society.

Key concepts and challenges

We are used to the idea of the interconnected nature of the financial and other systems within which organisations operate. In general, as the complexity of a system increases so does the interconnectivity, both between organisations and between different risks present within the system. This is true of climate risk in three ways:

- Climate risks are system-wide rather than being associated with a particular entity or component; i.e. they are *systemic* in nature.
- The climate risks in any organisation will be influenced by risk management and governance practices in other organisations.
- Climate risks are not independent of other risks that need managing.

The challenge of this interconnectedness[3] must be recognised by risk managers in financial firms.

Systemic risk

Environmental risks are system-wide rather than associated with a particular entity or component and are classic examples of systemic risks. This requires a broader system-wide approach to their risk management. While climate risks may impact directly on existing risk factors such as credit or underwriting risk, to manage an enterprise's exposure to climate risk, the interconnections between different risk factors needs to also be assessed. These connections can occur over time or across risks.

Business decisions made today impact on the risks faced in the future and the climate pathway that is realised. For example, providing funding for a new unabated coal power station will impact on the likelihood of remaining well below 2 °C (as stated in the 2021 IEA net zero aligned climate scenario[4] that no additional investment decisions should be taken for new unabated coal plants).

When considering interconnected risks it should be noted that actions by one financial institution (e.g. restricting insurance cover for buildings with increased risk of flood damage) will affect the risk profile of other firms (e.g. those holding mortgages on the same properties as assets).

This means that classic asset and derivative pricing models will be less suitable in the face of these risks unless they are corrected for interconnected risks[5]. Many post-2008 Global Financial Crisis case studies have added to the literature in this area. In particular, the systemic nature of this risk will shift focus from Value-at-Risk (VaR) to Conditional VaR type measures. Whilst VaR typically focuses on where the tail of the loss distribution begins, Conditional VaR explores what occurs once within that tail. With extreme and interconnected risks these conditional measures become more important.

Risk interdependence

The exposure to and significance of climate risks in any organisation, but particularly a financial institution, will be heavily dependent on exposures, actions taken, and risk management practices in other organisations. Examples of this include:

- Climate risk governance of credit risk for debtors or issuers of corporate bonds held

[3] For central banks and regulators this interconnected challenge is noted by Campiglio et al (2018)

[4] https://www.iea.org/reports/net-zero-by-2050

[5] The treatment of systemic risks in general is discussed by Eisenberg and Noe (2001) who propose a model structure.

- Environmental ratings of companies in which equity funds are invested
- Underwriting practices and pricing decisions of reinsurers
- Customers' sustainability expectations
- Transition preparedness of a distribution or joint-venture partner or supplier
- ...and many others

Risk management actuaries will therefore need to be aware of practices in these connected organisations and sources of risk[6]. Regulatory frameworks are adapted to capture the systemic financial risks from climate change. For example, the Bank of England (2019) stress test approach for banks and insurers anticipates this alongside the need to consider climate risks in the light of business model specifics that represent a risk to financial stability.

Value chain risk

It is therefore important that climate change risk management is incorporated across the business value chain. Through adopting a holistic assessment, both the different risk management actions and the interconnectivity of the actions that are taken can be understood and managed.

Figure 2 – illustration of a FI value chain

Risk management deep dive - Operational risk

Operational risk is the risk of loss arising from inadequate or failed internal processes, personnel or systems, or from external events. It will affect all aspects of a company's operations but will be specific to each company. Operational risks can be actively managed by working with the business to better understand, and manage, these risks.

It is worth noting that past operational risk experiences aren't necessarily a guide to the future, particularly for climate-related risks, but can support the development of a more robust risk framework, and therefore some case studies have been captured later in this section.

Operational Impact of Climate Change on Insurers

Physical Risks

Increasing frequency and severity of physical risks such as flood events, wildfires and droughts, will have an operational impact on companies. It is also important to consider potential knock-on effects these risks might have, such as additional IT threat exposure. Having robust disaster recovery and

[6] Further commentary on system-wide climate financial risk stress tests is given by Battiston et al (2017).

contingency plans will be key to ensuring the continued successful running of the company. Firms may consider adapting the physical structure of operational sites, moving operational facilities or creating backup facilities to which critical functions can be diverted to be more resilient to physical climate perils. Firms may also consider increasing relevant insurance and reinsurance cover. Physical risks may also impact a firm indirectly through companies across the firm's supply chain.

Whilst physical risks as a result of climate change may be having limited operational impact on companies currently, it is important to remember that decisions made, and plans put in place, today will see benefit in years to come.

Transition Risks

Transition risks arise from changes in technologies, markets and regulation as a result of society's response to climate change. Firms need to be clear on how transition risks might impact their operational resilience, as they can increase business costs, undermine the viability of existing products or services, and affect asset values.

Some companies may choose to sign up to pledges (e.g. Net Zero Insurance Alliance), but all firms should be clear on their timelines for reducing their carbon footprint and ensure that any pledges signed align with those timelines. The NZIA and other alliances have released guides, which can also be useful to firms who don't want to make a pledge but need some guidance on tangible steps to take.

To avoid getting caught out by policy changes or unexpected regulation, firms should closely monitor legislative, regulatory and market developments.

Litigation Risks[7]

Depending on the way companies put measures in place to protect customers against the impact of climate change and to reduce their own carbon footprint, there may be some climate-related litigation risks that arise, which may in turn also cause reputation damage and result in the loss of investment, customers and potentially staff.

When managing the company's operational carbon footprint[8], strong oversight is required, due to the varied quality of options available, and robust plans and processes are needed to deliver on commitments. Enhanced disclosure on plans will help internal stakeholders ensure plans remain on track and will show external stakeholders the steps being taken by the company to reduce carbon footprint.

When considering exposure to litigation risk, firms should also look at their supply chain. Companies could encourage their supply chain to reduce their carbon emissions via the procurement and supplier management process.

Measuring the Impact of Operational Resilience

Alongside the review of disaster recovery plans and outsourcing policies, firms should look to quantify the potential operational impact of climate-related risks. This analysis could be captured within the annual stress scenarios and reported on within the Own Risk and Solvency Assessment (ORSA), for firms in scope.

Companies should consider the perceived level of operational vulnerability to the physical and transition risks from climate change. Improved data and computing power means that potential sources of operational disruption can be modelled and better incorporated into overall risk management and business plans. Where climate considerations may lead to additional operational vulnerability from physical climate risks, firms should also consider how this may impact on the level of capital required to be held for operational risks.

Companies may choose to quantify the operational risk impacts using their own internal models, using vendor models or using more subjective quantification methods.

Companies should review their outsourcing policy and their approach to outsourcing management.

[7] https://www.lse.ac.uk/granthaminstitute/news/climate-change-litigation-cases-spreading-around-the-world/

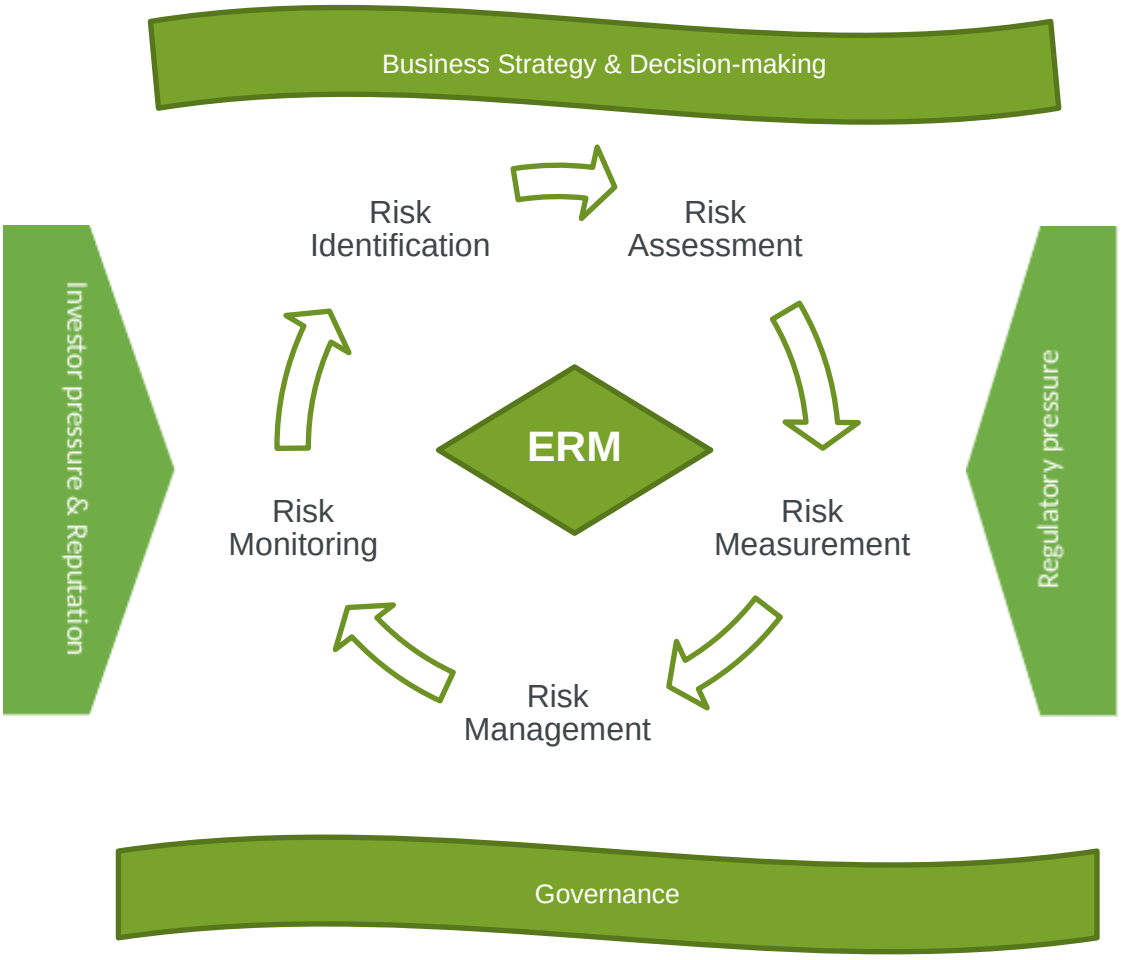
[8] Generally defined as the carbon emissions that are under the operational control of the entity. Generally Scope 1 and 2 emissions, although this may also include some scope 3 emissions, such as those associated with business travel.

Integration with the risk management framework

One of the key objectives of having an enterprise-wide risk management framework (RMF) in place is to be able to make forward-looking strategic decisions while having a holistic view of the organisation's risks. As a result, enterprise risk actuaries need to ensure that climate-related risks are identified and managed as part of a firm's broader RMF.

The following section highlights some of the material considerations for climate risk when looking across the risk management framework.

Figure 3 – a schematic of an ERM framework



Business Strategy and Decision Making

The impacts from climate change can have implications for firm's strategy, these should be understood and incorporated through a strategic response to managing climate risk.

To enable effective decision making it is critical that a firm's risk taking tolerances are understood with clear delegations and oversight. These risk appetites and tolerances should reflect considerations from climate change.

How the business strategy and decision-making frameworks are updated should reflect the enterprises business structure and may be as a specific risk or through the impact that climate may have on other existing risks.

Governance

It is important that there be an effective governance framework in place to ensure that appropriate focus is given to climate-related risks and that the right people are being held accountable.

The Board is ultimately responsible for the organisation's resilience and should have oversight of climate-related risks and opportunities. A clear top-down message from the Board serves not only to guide key strategies and decision-making processes but also to ensure that the right risk culture and attitude to climate change is in place to promote transparency in climate strategy and reporting across the organisation. The risk function can support this oversight through considering how climate considerations are captured within the governance frameworks and identifying areas that may require additional strengthening to ensure full oversight of the financial risks from climate change.

Risk Appetite

The physical and transition risks are likely to influence an organisation's long-term strategic objectives. The impact of these risks may be influenced by factors such as regulatory requirements, policies, and investor pressure and are likely to affect the organisation not only through the risks that they are exposed to but also may also affect the market where a business is operating.

Therefore, the organisation's risk appetite will need to be reviewed and updated to include climate risk. This revised risk appetite needs to be integrated within the organisation's long-term strategic objectives. Ideally a top-down approach will be adopted with oversight and sign-off from the Board.

The risk appetite statement(s) coupled with risk limits and tolerances should be reviewed and updated to include climate-related risks. A key challenge that an organisation may face is that risk appetite statements and forecasts are usually implemented over the budgeting/planning period which, unless explicitly allowed for, may not fully capture the systemic nature of the risks, or the extended time horizons associated with climate change.

Although this can be challenging, businesses can make use of either qualitative metrics or scenario analysis coupled with publicly available pathways to help them in formulating complete, coherent, and comprehensive risk appetite statements over the appropriate time horizon.

Risk Identification

Due to the systemic nature of climate risk, it manifests itself through other existing risks such as insurance risk, credit risk, market risk, economic risk. Therefore, a key decision-making point would be whether to consider climate risk as a stand-alone risk or within existing risk categories. This will be highly company-specific and will be dependent on the organisation's long-term risk management strategy.

Key stakeholders, together with risk actuaries, should incorporate climate change within their risk identification process. Climate considerations will include both how climate change may impact on existing risks and may introduce new risks, generally these new risks will be in relation to strategic changes such as climate related commitments or from new products and asset classes. Existing risk taxonomies should be updated to incorporate both aspects from the risk identification process. These risks will require regular review and revision to reflect the changing risks that the organisation is exposed to alongside changing external environment.

Risk Assessment

Scenario analysis is currently the preferred approach to assessing climate risk for effective decision making. This is particularly due to the uncertain nature of the risk coupled with the limitations of using

historical observations to inform decisions on potential future climate pathways. TCFD has issued guidance[9] on scenario analysis and the scenario analysis falls into the following steps:

1. Defining a risk measure
2. Choosing impact assessment tools
3. Assessing financial impacts and financial metrics.

These are described in more detail in Section 6.

Risk Management and Monitoring

As understanding of and the global response to the risks from climate change develop, so to must the risk management. The evolving nature of these risks and our understanding of their management will need to be continuously reviewed. This should be supported through regular monitoring of both the internal risks and the external environment that triggers further review and updating of the RMF. The following table shows how climate change risks could impact different risk categories in a typical RMF.

Risk Class	Physical risks	Transition risks	Legal / Reputational risks
Market	Medium	High	High
General Insurance	High	Medium	High
Longevity	Medium	Low	Low
Mortality / Morbidity	Medium	Low	Low
Lapse	Low	Medium	Low
Counterparty	Medium	High	Medium
Operational	Low	Medium	Low
Strategic	Medium	High	High
Reputational	Low	Medium	High

Source:

https://www.actuaries.org/IAA/Documents/Publications/Papers/CRTF_ImportanceClimateRelatedRisksActuaries_FINAL.pdf

[9] https://www.fca.org.uk/publication/corporate/climate-financial-risk-forum-guide-2020-scenario-analysis-chapter.pdf

Assessing impact

Scenario testing is a key tool for risk management given the level of uncertainty associated with how climate change will unfold, particularly since for climate change the past is not a good indication of the future. When using scenario testing, it is important to appreciate that the scenarios used may not be predictions of the future, but rather are used as a tool to explore the possible impacts under different potential future outcomes.

One of the outputs from using scenario testing should be to identify actions, noting that it is easier to identify actions over shorter terms (such as 3-5 years) than over longer terms (more than 20 years). Scenario testing can be used, for example, for assessing:

- Physical risk's impact on business continuity
- Physical and/or transition risks' impact on asset valuations or balance sheets
- The impact on risk exposure from using different strategic asset allocations

Scenario testing can be qualitative or quantitative, each providing different types of insights. It may be possible to attach ranges of likelihoods to scenarios, for example, the stress scenarios to determine capital requirements under Solvency II are calibrated at a 1-in-200 likelihood level.

The difference between climate scenario testing and other scenario testing generally employed by insurers are generally that the impacts from climate change are expected to emerge gradually over much longer period, e.g. decades rather than years or a time zero stress and there is less data available to support scenario calibration.

To support development of understanding of the risks and challenges associated with future potential climate pathways standardised scenarios are being developed. These may be designed by regulators, international bodies (such as the Network for Greening the Financial System, the IEA and PRI), software providers or by consultants.

Generally, climate change scenarios are based on different routes to achieving carbon reductions (e.g. orderly or disorderly transition, early or late policy action, or inevitable policy reaction) and/or failing to do so (e.g., failed transition scenario or no further policy action). This allows for an assessment of the impact of the potential physical and transitional risks that an enterprise may be exposed to.

When using these scenarios, it is important to gain suitable levels of understanding so as to be able to challenge them appropriately given the use to which they are being put. Challenges can include their reasonableness of assumption, whether they are disruptive enough, appropriate for the geographic region or how they identify discontinuities, such as a disruptive transition or impact from climate tipping points. Climate scenario models may be complex, with significant model and calibration risk.

Risk management deep dive - Model design and build

At its broadest, model risk is operational risk: the risk that a model fails to deliver results, or delivers unsuitable results, leading to adverse outcomes for the client or other stakeholder.

Model risk has multiple aspects, including the risks of:

- Unsuitable design
- Defective build (e.g. coding error)
- Inappropriate use
- Defective use (e.g. calibration error)
- Miscommunication

Some aspects of model risk are likely to present in different ways for climate models.

MODELLERS AND MODEL USERS

This deep dive is paired with the one that follows: together they consider model risk from different perspectives.

- This case study is from the perspective of modellers, i.e. actuaries who design, build, validate and maintain the model.
- The following case study is from the perspective of model users, i.e. actuaries who provide results and advice to clients, based on runs of the model.

Clearly these two perspectives are not totally independent. We identify some issues that need attention from both modellers and model users. Moreover, some actuaries may be both modellers and model users (and setting-up, executing and checking model runs may be done by modellers and/or by model users).

SPECIFIC MODEL RISK CHALLENGES FOR MODELLERS

Climate risk modelling presents some particular challenges for modellers, but also opportunities:

- Because model risk appetite may be difficult for model users to express (see 0), risk appetite statements for climate models may be provisional and relatively open to being changed, which may generate a high demand for model change.
- Because climate modelling is new to most organisations, there is an opportunity to embed model risk management from the outset. This will hopefully be easier, cheaper and more value-adding than retrofitting model risk management to models already in use.
- In other words, model risk can be identified, filtered and assessed alongside model design, build and test. Ideally the model will be risk appetite compliant by design - subject to the proviso above that risk appetite could change.
- Model risk mitigation may be constrained, because more accurate or more robust solutions might not exist yet, or might involve prohibitive cost or delay. Thus, if model risk is assessed to be outside appetite, this situation might persist for longer.
- The framework for model risk governance may need to be adapted to be effective on climate models, including to manage specific aspects of risk such as those mentioned below. So the modeller may need to meet new model risk management requirements.

MODEL DESIGN RISKS

Whilst modelling the physical processes of climate is a relatively well-established field, climate risk modelling for most commercial and financial organisations is new, and standard (generally accepted) approaches have not yet (mid 2022) emerged. This situation presents additional design risks compared with typical financial modelling.

Choosing the modelling strategy and scope

A key consideration is, of course, the range of purposes to which the model will be applied, or may potentially be applied.

For example, an integrated assessment model (IAM) includes the physical processes of climate, and links those to economic and financial impacts. This may be an appropriate choice, even though it is much more complex, if the purpose of modelling includes decision-making that would influence those processes.

A model of financial impacts, taking climate scenarios as an input, may be more appropriate if the purpose is restricted to managing financial risks. Within this class of model, there is a wide range of complexity and granularity to choose from.

Choosing what to model

The choice of metrics is discussed in Section 0. The desired metrics may be easier or harder modelling challenges. If they are hard to model, then modelling another quantity that approximates the desired metric may be a good place to start. Such choices of course need to be explained to model users and potentially to clients and agreed, perhaps with a plan to develop more accurate modelling later.

Choosing other models to rely on

Climate risk models may rely on other models for parts of the design or for input parameters (in regulatory terms "external models"), thus the reliances and limitations of the external models are imported to the climate risk model.

For example, the modeller taking an IAM approach may choose between various established models for the physical processes of climate. The modeller needs to understand the strengths and weaknesses of each, in relation to the purpose of the IAM.

At design stage and throughout the model life cycle, evidence needs to be gathered that supports reliance on external models.

Choosing data sources

Climate models may require physical and financial data that are newly created, inconsistent between different sources, variable in quality, partial, or even not yet in existence (as modelling sometimes drives data, converse to the usual situation).

For example, when modelling how climate scenarios will impact investments, there are several alternative data sources for corporate carbon footprints, while data on companies' exposure to climate risks is currently very incomplete.

Most of the data will be from sources other than the client (in regulatory terms "external data"), thus the reliances and limitations of the external data are imported to the climate risk model.

At design stage and throughout the model life cycle, data quality needs to be assessed and managed, including for external data.

After data quality has been managed, residual data quality issues and risks may need to be accepted that are more significant than usual. Ideally a plan will be established to reduce the exposure to such issues and risks over time.

Interaction with clients regarding design

Currently climate models are commonly built to the specific requirements of a client or of a question, as noted above. This contrasts with the availability of pre-built models and generally accepted approaches, typical in other areas of practice.

In such a situation, design choices such as the above, the rationale for them, and the resulting model risk, need to be explained to clients and ideally agreed with them. The client may be asked to understand more about the model, and to have more direct interaction with the modellers, than would be typical in other areas.

OTHER MODEL RISK CONSIDERATIONS

Challenger models

These may be used as part of the design and/or ongoing validation.

As climate risk modelling for commercial and financial clients is a relatively immature field, an all-in commitment to one type of model may be unwise or limiting. Such commitment could be:

- intellectual, if the modeller, model user, or client believes that one modelling strategy is "right";
- technological, if a model is chosen because it is compatible with available data and technology platforms, or vice-versa;
- cultural, if a model is chosen because it does not challenge the client's status quo, or because it does.

Continued engagement with a variety of models can mitigate the tendency to centre on the primary model and the views that it encodes.

Ethics of modelling

Modelling choices have moral and ethical content, as noted by Thompson (2021). For example, IAMs that focus on atmospheric metrics (temperature, rainfall, wind) may by their design prioritise climate-related trends that directly impact human life, over other trends such as loss of habitat and biodiversity. The modeller should consider what issues a model design cannot address, as well as what it can address, and whether the design enshrines sound ethics.

Communicating limitations

The modeller should take all reasonable care that model users understand, and explain to clients, the relevant modelling limitations. The modeller may need to take part in forming the explanation to clients.

Extent and impact of model changes

In the present state of climate risk modelling, one could argue that every model of financial impacts is preliminary: the best models and data sources available now could seem rough and ready within a few years. Whilst physical climate models are relatively more advanced, they too are likely to change continually. But it is generally agreed that managing climate risk is urgent, so the results from today's models and data sources will be relied on.

Future improvements may significantly affect the results, and those changes will need to be explained clearly and promptly to model users and clients, both when the changes are designed and when the revised results are provided.

Thus model change control and analysis of change are important, not only in the usual good practice sense, but as key elements that will maintain the credibility of models and of actuaries.

Risk management deep dive - Model use and communication

This case study complements the earlier case study on Model design and build by considering model risk from the perspective of model users.

SPECIFIC MODEL RISK CHALLENGES FOR MODEL USERS

Climate risk modelling presents some particular challenges for model users:

- Model users may find it difficult to express their model risk appetite in a durable form, so that modellers can work within it. Existing statements of model risk appetite will be oriented to financial models for reserving, pricing, etc., so are unlikely to be a ready fit for the new field of climate modelling.
- Because modellers may be constrained in mitigating model risk (see 0), if model risk is assessed to be outside appetite, this situation might persist for longer.

RISKS OF MISUSE

Inappropriate use: Scenarios and data

Various sets of representative climate scenarios (or pathways) are publicly available, and others are proprietary. Most organisations will adopt existing pathways, rather than carrying out for themselves the climate science and IAM modelling needed to build coherent pathways.

The choice of pathways imports a reliance on the work done to build the pathways, including the data, assumptions and judgements that the builders used. The climate model is then suited to answer questions that are consistent with the pathways - but it may not be suited for questions that are not consistent.

Similarly where the climate risk model relies on external data, the limitations of data quality may restrict the range of questions that can be answered reliably.

It is not always possible to identify upfront that a question is outside the model's safe range of use, so validation and explanation of the results before they are released is an important safeguard.

Defective use: Many assumptions

Some climate models are not only very rich in data, but also very rich in assumptions. Instances are known to the authors where the assumptions file contains millions of fields.

Managing a very large assumptions file resembles a modelling task in itself, since the traditional “pairs of eyes” approach to setting assumptions is not feasible. Suitable controls over assumption setting processes are needed, and data science tools may help.

Ultimately, confidence in the assumptions file may be statistical, e.g. tests show a high percentage confidence that the assumptions file is not materially flawed.

RISKS OF MISCOMMUNICATION

Some of these risks affect any area of practice but may be particularly relevant in climate modelling, and some are specific to climate modelling.

Communicating limitations and impact of changes

The model user should take all reasonable care that clients (i.e. those who will rely on the results and advice given) understand the relevant modelling limitations and the impact of model changes. This effort may involve the modeller too.

That includes clients “downstream” of those who directly receive results, and those clients may not be in contact with the model user.

Statements of limitations tend to become detached from headline results as the latter are transmitted. This is hard to prevent but as a minimum, the model user can seek to ensure that the results can be traced back to their source.

Preliminary results

Model results that are preliminary, draft, or rough are particularly prone to having unintended impacts, if they are transmitted without making that fact clear. The risks of releasing such results need to be understood and managed.

Professional balance

The actuarial profession has a duty and a desire to influence outcomes in the public interest. Many actuaries care deeply about climate risk, and are determined that their work should have an impact for good.

In this situation, model users will sometimes need to exercise professional restraint, so that model-based assertions and decisions do not over-reach relative to the quality of the model.

Approaches to measuring climate risks

Metrics and the risk management framework

Existing risk management frameworks contain a number of metrics already to support the monitoring and measuring of exposures to risk. As an initial step, before necessarily identifying additional metrics for climate change, it is worth reviewing the existing metrics for how they could be impacted by climate change. This may limit or negate the need for additional climate change metrics. Some examples of current metrics that could be impacted by climate change are:

- Exposure to sectors, locations or counterparties for which the tolerances could be revised in the light of climate change,
- Metrics used to identify and monitor conflicts of interests which could be used where trade-offs have to be made between the insurer's climate targets versus the impact of those targets on stakeholders such as customers, sales teams, staff and/or shareholders.

It is also important to take into consideration the time period over which the risk is being assessed:

- The impact of physical risk on operations, asset holdings and insurance liabilities are projected by scientists to increase incrementally over a number of years, with the impact dependent on the mitigation and adaptation put in place over the same time periods.
- Transition risk can however have much more near term impacts as the market reacts potentially in a volatile manner to the policies being introduced to support the transition to low carbon economies.

The remainder of this section discusses metrics currently in use for identifying and managing climate change risk and disclosures under the following categories:

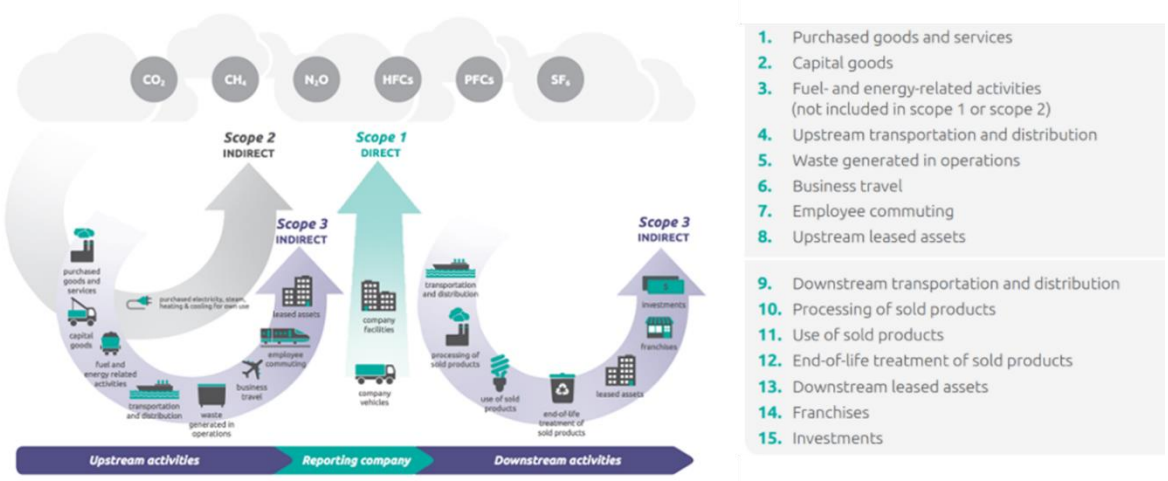
- Point in time climate related metrics
- Scenario testing and forward looking metrics

Point in time climate related metrics

This section considers point in time carbon metrics. These metrics rely on public disclosure as well as estimations of data points where disclosures are not available. As such, the quality of the underlying data should be borne in mind when considering materiality for these metrics.

The starting point for this discussion is the carbon footprint for corporations. The Greenhouse Gas Protocol and Partnership for Carbon Accounting Financials (PCAF) provide standards for measuring this, dividing it into Scope 1, 2 and 3 as follows. These categorises of emissions aim to support understanding of the emissions from an entity's business model, including its value chain.

Figure 4 – Scope 1, 2 and 3 emissions



Source:

https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

The carbon footprint from an entity can be allocated to its equities or corporate bonds, referred to as 'financed carbon'. These metrics need to be normalised using, for example, revenue or enterprise value, to create comparable scores. Holdings with a higher financed carbon score are generally more exposed to transition risk than those with a lower score. Further information are also becoming more disclosed by companies, such as water consumption and energy usage. Again, higher scores generally indicate higher scores are generally more exposed to transition risk. These scores can be presented gross or net of offsets through carbon credits; where they are presented net of offsets, the risks associated with the use of carbon credits (such as increase in costs) should be considered.

The weighted average carbon intensity (WACI) is a normalised carbon score which is weighted by the asset holdings in a portfolio. This summary metric can be used to compare the carbon score of two portfolios and is referenced in the TCFD recommendations. As it is a summary metric, its value can change for changes in underlying companies' carbon footprints (whether over time or through restatements) and the market values of holdings in counterparties. In line with good risk management practice, it is recommended to understand how a metric such as this can move, distinguishing between what can and cannot be controlled by the insurer.

Forward looking climate related metrics

Point in time metrics do not consider the impact of how climate change will develop. For this purpose, forward looking metrics are used. These forward looking metrics rely on additional assumptions, such as macro assumptions on whether carbon prices will increase in an orderly or disorderly fashion - as discussed in the scenario testing section following. They also rely on micro assumptions, such as companies achieving carbon footprint reduction targets that they have announced.

A forward looking metric that the TCFD consulted on during 2021 is 'temperature alignment', also referred to as 'warming potential'. This metric compares the projected carbon footprint of a company against the pathways that result in temperature increases by the year 2100. For example, if a company has a temperature alignment of 4 °C, it means that, were everyone on the planet to pollute in line with the company's projected carbon output profile, then the planet's temperature is expected to increase by 4 °C.

This forward-looking metric can be adjusted for companies commitments. It can be used to determine whether the company's target profile is in line with the Paris accord, which aims to limit temperature increase to well below 2 °C by 2100. The Paris target is based on the average performance of companies - different geographies and industry sectors will naturally have higher or lower profiles than this average, and within industries there will be companies above and below the sector average. To use the metric for engagements, it is therefore important to compare a company's temperature alignment after considering its geography and sector profile.

The metric can also be calculated for a portfolio, supporting asset owners in comparing the transition risk between two different portfolios: a higher temperature alignment is associated with higher transition risk, noting again that allowance needs to be made for geography and sector.

Climate impacts on business planning

The impacts from climate change are systemic. The long term physical risks require development of large scale adaptation and result in an unrepresented change in underlying risks that have not been factored into historic experience. The pace and scale of a successful transition to a low carbon economy and delivery of climate commitments present firms with new risks and opportunities. Firms need to take a strategic approach to how these risks and opportunities will impact on their business model, and this strategy should be reflected within regular business planning cycles.

Understanding how much risk a firm is prepared to accept for the returns it makes is a foundation of risk management. Climate risks need to be incorporated within a firm's risk appetites as it is already manifesting and will increase over time. A firm's risk appetite must be aligned with the business strategy and reflect the level of risks that they are prepared to take to achieve their strategic objectives.

A firm's business planning process should reflect both the climate risks within the firm's overall business strategy and its risk appetite. All work undertaken to identify climate change risks and determine appropriate mitigating actions can be used to inform strategy setting within the business. It is essential that this risk management works feeds into strategy discussions, supporting the business to identify areas of risk that they will need to mitigate and the opportunities that they may wish to exploit.

It is important consider the implications on:

- Investments: Examples may include how the investment risk/return profile may change over the plan period, impact of climate commitments and approach to engagement with investees to support climate commitments
- Insurance Liabilities: Examples may include how climate risk may impact on product risk factors, market landscape, implications for future pricing assumptions and potentially affordability, alongside specific risk mitigation approaches, such as reinsurance and underwriting changes
- New products and offerings: For example if these new opportunities introduce additional new risks or need new risk management processes
- Operations: how will the business operate, will there be additional business overheads that need to be incorporated into the business plan to deliver on Climate commitments, how will changes to the firm's operational resilience be considered within the plan.
- Counterparties, suppliers and distribution partners: the business will need to develop an understanding of these firms' own preparedness for climate risk.

Where climate change is a key part of the overall business strategy, the business plan should ensure that there is appropriate resource, budget and time spent to understand how the risks will be managed and opportunities achieved. Climate, like other emerging risks, affects business strategy in two ways: business-as-usual, and with respect to discrete projects or new initiatives. Major projects (e.g. a product launch, geographical expansion, M&A activity or a joint venture) may have their financial and risk profiles altered by increasing climate risk and so it is important that these risks are fully incorporated into projections.

Whilst climate change risks are slow to emerge, the actions that need to be taken to manage these risks can be taken in the near term, to support future resilience. The risk function has an important role in ensuring that these long term strategic risks are incorporated within the planning process.

Further, as the information available to identify and quantify these risks is rapidly changing, it is important that these changes regularly feed into the business' strategy discussions and that the strategy is reviewed and updated in light of these changes on a regular basis, for example annually.

This includes updating the communication of climate risks by, for example, updating dashboards to include climate risk metrics, coverage of other strategy factors such as climate change impacts on suppliers, distributors and counterparties, and consideration of changing regulatory requirements.

Next steps and closing remarks

The climate is changing globally at an unprecedented rate as a result of human activity. This change presents ecological, social, economic and financial risks. The potential impacts of climate change are global and systemic. As a result of highly disruptive physical changes there are significant implications for the entire financial system.

This guide has been produced to support actuaries working in risk management to understand the potential risks and opportunities presented by climate change, their impacts and how these can be considered in advice.

Climate change and sustainability represents a variety of risks, including material financial risks for financial institutions which are advised by actuaries and could impact the public interest. The understanding around the implications of climate change and sustainability considerations on financial systems has developed significantly and is an evolving area of expertise.

Some of these climate and sustainability risks are system-wide in nature and new, or emerging, areas around this include the risks, opportunities and impacts that can occur from changes to the environment and society.

These risks may not present additional risk factors on their own, but will change the future risk profiles of financial services. For example, the lack of historical data available leads to a need to consider allowances for a range of possible outcomes that may happen in the future and to plan for a variety of forward time estimates by stress and scenario testing. This might impact capital requirement for a company.

Actuaries can play a key role in shaping future financial systems and leading positive changes for the management of these risks. Risk management is a core constituent of a financial institution's response to climate change. Through providing risk based insights alongside business focus, the risk function can support financial institutions to provide services that are supportive of societal needs, remain relevant and benefit society.

Additionally, actions taken now in response to these risks could amplify them, or alternatively help to mitigate against them. This emphasises the importance of the professionalism required to consider, and support, individual and collective action in the mitigation of systemic risks.

We are a profession specialising in risk management, and climate change is one of the greatest risks facing our world today. Mitigating this risk is urgent. Future outcomes are uncertain, but the best value insurance premium that society can pay is to reduce our emissions today in order to avoid the irreversible consequences of unmitigated climate change tomorrow.

Our primary call to action is simple and unwavering: All actuaries must consider the impact of climate risks and opportunities in their advice. Failing to do so could have a detrimental impact on long-term outcomes.

Institute and Faculty of Actuaries

Beijing

14F China World Office 1 · 1 Jianwai Avenue · Beijing · China 100004
Tel: +86 (10) 6535 0248

Edinburgh

Level 2 · Exchange Crescent · 7 Conference Square · Edinburgh · EH3 8RA
Tel: +44 (0) 131 240 1300

Hong Kong

1803 Tower One · Lippo Centre · 89 Queensway · Hong Kong
Tel: +852 2147 9418

London (registered office)

7th Floor · Holborn Gate · 326-330 High Holborn · London · WC1V 7PP
Tel: +44 (0) 20 7632 2100

Oxford

1st Floor · Park Central · 40/41 Park End Street · Oxford · OX1 1JD
Tel: +44 (0) 1865 268 200

Singapore

5 Shenton Way · UIC Building · #10-01 · Singapore 068808
Tel: +65 8778 1784

www.actuaries.org.uk