MILLIMAN PAPER

Climate change risk stress and scenario testing

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Introduction

Stress and scenario testing is a common challenge for insurers as they embed risks related to climate change within their risk management frameworks. As stress and scenario testing develops and evolves, we anticipate that understanding of climate change-related risks will rapidly improve. The Bank of England's Climate Biennial Exploratory Scenario (CBES) results indicate that firms still have a long way to go in developing their stress and scenario testing, and this was reiterated in the Bank of England's Dear CEO letter in October 2022 on the same topic.

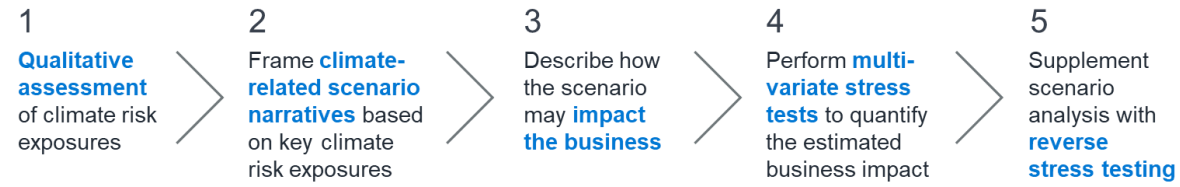
As an important area in the evolving nature of the management of climate-related risks, this paper covers:

- Current market practices with respect to climate change risk scenario testing
- References to some useful resources that we are aware of and may be useful to firms when developing climate change risk scenario testing frameworks
- Some of the common challenges firms are facing with respect to climate change risks
- Some of the areas where firms are currently demonstrating effective practice
- A case study to demonstrate a potential future development that firms could use to make stress and scenario testing more thorough and sophisticated.

Current market practice

An overall approach that can be taken to developing climate-related scenarios is summarised in Figure 1.

FIGURE 1: SCENARIO DEVELOPMENT APPROACH



In this section we discuss the common practice we have observed across the market in relation to these key stages and provide some thoughts on how approaches could be enhanced further.

QUALITATIVE ASSESSMENT

Firms typically start their climate change stress and scenario testing journey by identifying how their existing key risks are impacted by climate change. The diagram in Figure 2 shows some examples of how climate-related risks may map to existing, common risk types for insurers.

FIGURE 2: EXAMPLES OF MAPPING CLIMATE RISKS TO COMMON INSURANCE RISKS

	RISK DRIVER	EXAMPLE	RISK TYPE
TRANSITION RISK	Policy and regulation	Implementation of carbon taxes would adversely affect the value of carbon intensive assets.	Market risk
	Technology	Advances in clean energy technology results in losses on private loans to companies dependent on carbon-based power generation.	Counterparty risk
	Reputation	Investment in carbon-intensive industries and failure to adapt products could result in reputational damage, increasing lapses and reducing new business volumes.	Strategic and lapse risk
PHYSICAL RISK	Acute physical risk	Climate change increases the frequency/impact of extreme weather events, resulting in higher claims.	Underwriting risk
	Chronic physical risk	Chronic climate change-related impacts can impact companies' assets (including people), causing disruption and increasing costs.	Operational risk

Firms can consider each of the different risk types in more depth. For example, for underwriting risk it would be useful for firms to consider the key root causes and drivers of claims and premiums across multiple time horizons and across physical, transition and liability risks. This will vary depending on the type of insurance contracts offered. Extreme weather events and changing climate conditions impact the frequency and severity of claims, while government policy responses, customer operational policy responses (e.g., changes to business travel policies for employees) and shifts in customer demand may impact premiums and claims from a transition risk point of view. As part of the 2021 UN Climate Change Conference (COP26), ClimateWise produced a report which examined several tools that aimed to assist insurers in aligning their underwriting portfolios with Net Zero by 2050 targets. An underwriting risk assessment tool, which Milliman assisted to develop, was selected by ClimateWise as one of its case studies. The tool was designed to help non-life insurers consider the key root causes and drivers mentioned above, to help them understand the impact of climate change on their underwriting portfolio and to support decision making in areas such as risk appetite and product development.

Initially firms have been focussing on their most material exposures—for example, carbon-intensive asset exposures for life insurers, and lines of business and geographical areas that are most impacted by extreme weather events for general insurers—but it is also important to consider less "obvious" risk exposures such as the potential impact of acute physical risk on health and life insurance liabilities in the future. Another key consideration for insurers is developing multivariate scenarios, because climate risk drivers can have wide-ranging implications across the business and give rise to interactions between assets and liabilities. Current commonly used market practice is to perform stress tests on specific risk exposures in isolation, which could limit an insurer's ability to understand the wide-ranging interdependencies of its climate risk exposures.

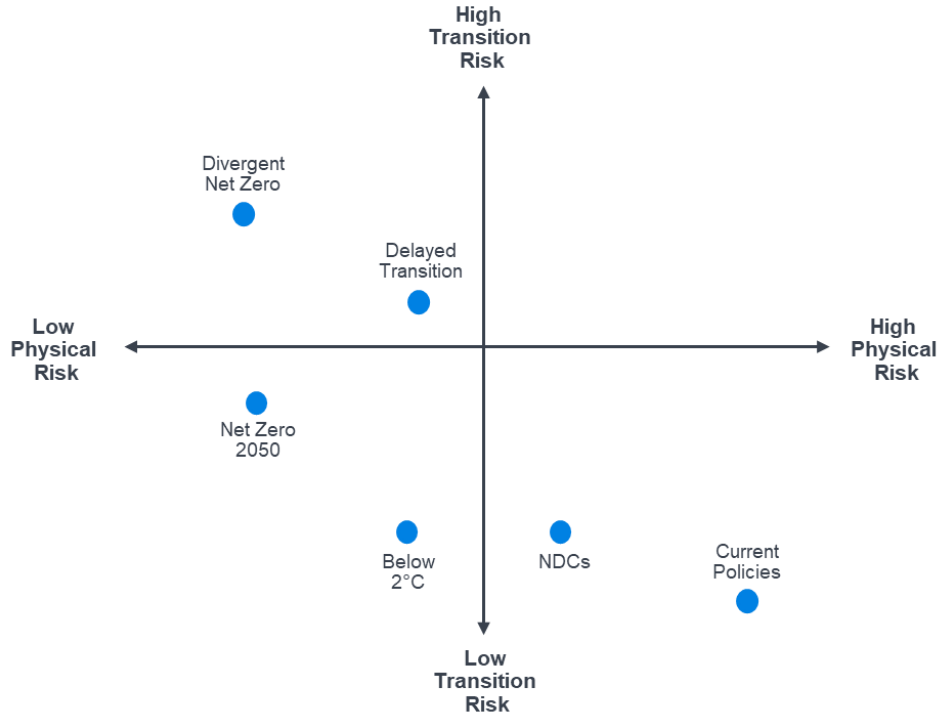
DEVELOPING SCENARIO NARRATIVES AND DESCRIBING THE BUSINESS IMPACT

Once all material climate-related risk exposures have been identified, firms should frame climate-related scenario narratives based on each material risk exposure. A commonly used framework for a number of regulators is the Network for Greening the Financial System (NGFS) scenarios. For example, the CBES exercise was based on a subset of the NGFS scenarios covering various timelines to transition to Net Zero by 2050.

The full set of NGFS scenarios covers six different scenarios:

- **Net zero 2050**: Orderly transition by around 2050, which limits warming to 1.5°C. Low physical risk, moderate transition risk.
- **Below 2°C**: Orderly transition, which has a 67% chance of limiting warming to 2°C, with net zero achieved after 2070. Moderate physical and low transition risk.
- **Divergent net zero**: Disorderly transition, which limits warming to 1.5°C by 2050. Low physical risk, high transition risk.
- **Delayed transition**: Disorderly transition starting in 2030, which has a 67% chance of limiting warming to 2°C. Moderate physical risk, high transition risk.
- **Nationally determined contributions**: Countries stick to currently pledged policies, resulting in around 2.5°C warming. Moderate-to-severe physical risk, low transition risk.
- **Current policies**: No further policies are implemented, with emissions growing until 2080, leading to around 3°C warming. Severe physical risk, low transition risk.

FIGURE 3: NGFS SCENARIOS



Not dissimilar to the NGFS scenario used within the CBES exercise, the European Insurance and Occupational Pensions Authority (EIOPA) suggests that firms build a scenario narrative by choosing the scenario ambition—i.e., the target reduction on warming (or lack of)—and then choose the speed at which this arises.

A tool has also been developed by the cross-industry Scenario Analysis Working Group of the Prudential Regulation Authority and Financial Conduct Authority's Climate Financial Risk Forum (CFRF). The Scenario Narrative tool summarises the relevant climate-related risks and opportunities for banks, insurers and asset managers based on the business activities, products or risks of the firm and the materiality of different lending exposure types, underwriting classes, asset classes and economic sectors for the firm. The tool is useful in helping firms to better appreciate their financial climate change exposures.

The descriptions provided draw on data from the scenarios developed by the NGFS in June 2021. Two types of report can be obtained: an Institutional Report, which gives a firm-tailored report, and a Sector Report that provides information relevant to the sector the firm operates in. The Institutional Report requires input of information on a given firm including:

- Exposure by line of business
- Bond and equity exposure by sector
- Sovereign bond exposure by country
- Real estate exposure

A scenario can then be selected, and a detailed report is given on how each aspect of the business could be impacted, as well as high/medium/low risk ratings for each exposure. For example, under NGFS orderly scenarios (i.e., below 2°C and net zero 2050), possible impacts on life protection underwriting exposures are:

- Transition effects related to reductions in pollution levels could in turn lead to a reduction in rates of cancer, respiratory diseases, heart attack and stroke
- Orderly transition risk scenarios could lead to a limited fall in gross domestic product (GDP), which could impact the rate of growth in healthcare spending, which could in turn impact mortality and morbidity

These reports could prove useful for firms in starting to think about their climate risk exposures and linking them to scenarios.

An appropriate scenario time horizon will need to be chosen when developing scenarios; climate-related risks should ideally be tested across a long time horizon in order to enable strategic decisions to be made taking into account the long-term climate risk profile. We understand that currently firms are generally only shocking their current balance sheets rather than taking a long-term view (i.e., a 30-year view as outlined in the scenario descriptions described above).

Initially the work should qualitatively describe how the material climate-related risk exposures could manifest within the scenario narrative in question. This could be carried out via workshops with input from across the business. Looking at the first example in Figure 2 above, we might expect significant adverse impacts on asset values under a rapid, disorderly transition type scenario, but limited or no impact on asset values under a hothouse world/no transition type scenario.

Understanding materiality is a key EIOPA requirement; scenario analysis should be carried out only once a particular risk is deemed material. Risks are considered material under Solvency II where ignoring the risk could influence the decision-making or the judgement of the users of the information. Firms may look to see whether a risk is outside their current risk appetites and/or out of line with their overarching climate policies to aid this decision. For example if a firm is exposed to an impactful transition risk, but the overarching climate strategy is to disinvest or disengage with large carbon emitters, it would be a clear indicator that the risk is material and relevant for scenario analysis.

QUANTIFYING THE BUSINESS IMPACT

The most challenging step is to come up with quantitative stresses for each of the material risk exposures, in order to carry out a multivariate stress test. Some firms did initially use the 2019 life insurance stress test (LIST) shocks provided by the Prudential Regulation Authority (PRA), applied to various asset classes and industries, and the parameters provided under CBES are another common source of information when determining quantitative stresses. However, for material climate-related risk exposures, firms should now look towards creating stresses more tailored to their own business and risk exposures.

With respect to general insurance firms, outputs from catastrophe (CAT) models could be used when defining scenarios. Firms underwriting natural catastrophe exposure have been making use of catastrophe modelling as part of their realistic disaster scenario exercise and would be expected to extend this explicitly for climate change (e.g., firms underwriting Energy, Marine, or Property business in geographical regions exposed to natural catastrophes).

Typically, catastrophe models will consider perils such as inland floods, earthquakes, hurricanes, wildfires and winter storms. These perils will be considered across different products and different regions. The Occurrence Exceedance Probability (OEP) and Aggregate Exceedance Probability (AEP)[1] will generally be modelled at different return periods.

General insurers could make assumptions about how climate change will impact the OEP of natural catastrophe events. When considering flood events, firms could consider how the OEP for a 1-in-50-year flood event, modelled in 2022, may increase over the next 30 years if different climate pathways are followed. For example, firms may decide that if limited transition is made, by 2050 then the estimated OEP for a 1-in-50-year flood event may be equivalent to the current day OEP for a 1-in-250-year flood event.

The difference in the OEP would give an indication of the increase in the estimated gross loss as a result of climate change. The most challenging step will be to decide on the return periods used, so discussions with the catastrophe modellers will be required. Collaboration with exposure management teams and ensuring that existing catastrophe models are fully utilised should be an important part of defining climate change scenarios.

Some non-life insurers may not have developed CAT models (e.g., due to size or cost constraints), so scenarios for climate change could be developed by making assumptions about how the frequency and severity of claims may change if different climate pathways are followed.

Firms could consider different scenarios based on different temperature increases as specified by EIOPA in its 2021 Opinion. EIOPA states that insurers should subject material climate change risk to at least two long-term climate scenarios, where appropriate.

Irrelevant of the risk type involved, scenario calibrations will need to be reviewed frequently as the situation may be rapidly changing. For example, what is a 1-in-200-year physical risk event at the current time could well be a 1-in-50-year event in several years' time if no progress towards transition is made.

Where possible, output of the scenario analysis should then be used to consider the impact on liquidity as well as solvency. To date we have seen a greater focus on the impact of scenarios on the solvency position of the firm over the liquidity position. There is a risk that scenarios may understate the impact of climate change if second-order effects are not properly considered.

The output of the scenario analysis can then be used to inform discussions around management actions available to the firm, and the implications on company strategy.

REVERSE STRESS TESTING

We would also expect insurers to supplement their scenario analysis with some level of reverse stress testing, although this is an area we have seen receive very limited attention to date. The significant data limitations that currently exist (as discussed further in the next section) mean that insurers are unable to draw conclusions on how plausible each individual projected climate risk scenario is, and the scenario analysis performed will be limited by the range of scenarios and associated outcomes that are used. Reversing the exercise and asking questions such as "If we were to experience a reduction in solvency or liquidity of *X*, what climate risks would we expect to see manifested to have this impact?" means less risk of failing to consider "extreme" scenarios that may currently be considered too unlikely to warrant scenario analysis.

Challenges

Firms are encountering several challenges when attempting to further develop and mature their climate-related scenario analysis; as a result stress and scenario testing is not currently hugely advanced or complex. The challenge most frequently cited by firms is around data availability and relevance.

[1] The Occurrence Exceedance Probability (OEP) gives the probability of a loss of a given size or larger in a year. The Aggregate Exceedance Probability (AEP) gives the probability of total losses of a given size or larger in the year. See https://www.actuaries.org.uk/system/files/documents/pdf/a05evans.pdf.

For life insurers, this usually centres around a lack of asset data being made available by asset managers. Insurers typically require information on the specific type of business being carried out for assets held and associated measures such as the carbon intensity of this business or the expected impact of transition to a net zero economy on the business. We understand that asset managers typically do not have the data or resources to provide this, and a lack of consistent terminology or classification when it comes to identifying the sectoral or specific carbon intensity of assets means there is a lack of comparability or consistency in the approach of firms.

For general insurers, difficulties typically arise due to a lack of granularity or coverage of data regarding particular perils, geographies or climate impacts that is not available. For example, major catastrophe vendors will tend to focus on windstorm and earthquakes in the US, and floods in the UK and EU. Other perils and regions tend to be less standard, and occur less frequently, which means that they don't have the same level of catastrophe modelling sophistication, for example floods in Asia or Australia, or wildfires in the UK.

More generally, there is not a huge amount of data that is publicly available, and sourcing data can be expensive and does not always guarantee a full data set. An added complication many firms encounter is that they are not able to independently verify the external data they acquire, and therefore place heavy reliance on information without a huge amount of confidence in it. A valuable tool that insurers could use for this purpose is the NGFS Directory, which assesses current climate data, identifies gaps and indicates ways to close these gaps. The NGFS Directory can also be used to browse the data sources available for different purposes and to support the production of a range of metrics.

New types of data are also required; for example, data on counterparties' transition plans and customer behaviour is required in order to holistically understand the climate-related risks across the business as a whole. This could be extremely time-consuming if done for each counterparty, as well as challenging if it requires individual engagement with each counterparty. There is certainly the demand therefore for external data sources to provide information or ratings on the transition potential for (initially) large or listed companies. The paper "Credit Ratings and Climate Change – Challenges for Central Bank Operations" states that although credit rating agencies indicate that identifiable and material climate-related risks are considered when a credit rating is issued, there is not enough transparency around the methodologies used by credit ratings in incorporating climate-related risks into their rating decisions.

The observation of data-related challenges has been corroborated within the Bank of England's CBES results, which showed that firms lacked data even on essential aspects of climate risk management such as the geographical location of corporate assets and standardised information on value-chain emissions.

In the short term, firms could look to specialist data providers to overcome the data challenges highlighted by the Bank of England. One such data provider that Milliman has worked with is Ambiental, a company which carries out flood risk assessment at the individual property level and produces flood score risk metrics that indicate the current level of flood risk. Ambiental provided Milliman with its flood risk metric data at three different time horizons (2027, 2055 and 2093) and for three different Representative Concentration Pathways (RCP) scenarios as set out by the Intergovernmental Panel on Climate Change. The scenarios, below, are considered in the following three time epochs (2015-2040, 2040-2070 and 2070-2100):

- RCP 2.6 – a low emissions scenario.
- RCP 6.0 – a medium emissions scenario.
- RCP 8.5 – a high emissions scenario.

Milliman was able to use Ambiental's data to create an asset price model (a simple discounted cash flow model that showed the impact of physical and transition risks on rental income). Although the data was useable, time was needed to understand and manipulate the data for this purpose. These are issues that firms will encounter when using external data providers.

Firms will also need to ensure that they understand whether climate change has been factored into the data. If it has been, firms may find it difficult to untangle the climate change aspects from other aspects, such as economic factors. Other issues for firms will include:

- Cost, e.g., the cost of sourcing the data
- Relevance, e.g., whether the data is suitable for the portfolio of business that the firm writes
- Reliability, e.g., how reliable the data is and whether data from a different external data provider produce materially different results
- Frequency of update, e.g., if climate data is only updated annually, then how will the risk framework respond to rapid developments?

Firms could begin to collect such data, but time and cost will be factors again, and firms are unlikely to be able to collect data at the same granularity that external data providers do. That being said, if resource limitations prevent the use of more granular external data, best-effort endeavours using publicly available data can provide some insights whilst the industry overcomes current data limitations.

Whilst many firms are only stressing their current balance sheets at the moment, developing scenario testing into longer time horizons requires a much longer-term view of the business. Given that climate risk should be considered decades into the future, this poses a challenge in terms of developing a longer-term understanding of how the business will develop. Therefore, the initial output from long-term scenario analysis should provide a view as to whether or not the business model will still exist in future decades, and if and how the business strategy would need to change. How does the underwriting of electric vehicles differ from the underwriting of petrol and diesel vehicles for motor insurers, for example? Is a life insurer likely to be left with a large portfolio of stranded assets? Once this is understood, scenario analysis can be re-performed with a high level understanding of how the business could evolve based on strategy adjustments made to reflect climate risks.

A further challenge is the adaptation of existing models to perform climate change scenario testing over longer timeframes. If appropriate, firms could consider using existing own risk and solvency assessment (ORSA) models, which have capability to roll forward the balance sheet and assess whether these models can be adapted for longer timeframes. Firms should keep in mind, however, that it is impossible for any model to perform highly reliable projections spanning multiple decades, and that there is a real risk of spurious accuracy arising in such models. As such, it is important to interpret and communicate the results of longer-term modelling carefully, and ensure that they are considered as part of a scenario approach.

An interesting observation from the Bank of England's CBES results is the indication that the impact of climate change on insurers (and in particular transitioning to net zero) should not be substantial in terms of their capital positions, although the CBES exercise did not intend to evaluate capital. This poses an interesting question as to whether or not the current modelling carried out lacks sophistication or is too optimistic. In respect of the latter, there is a possibility that insurers have initially focussed on the "base" case scenarios, and not the tail of the risk, an area that capital modellers concentrate on more (rather than lower return period losses).

There is currently no consensus on whether climate change should be allowed for in capital requirements yet, although this is an area that the PRA is actively considering currently. We note that EIOPA is also considering including climate risk within the natural catastrophe standard formula calculation. If it is recommended that climate risk be included in capital requirements, thought will need to be given as to whether current stresses really constitute a 1-in-200-year severity of risk. For example, questions will need to be asked around whether capital requirements already capture the climate drivers that are expected to impact traditional risk components of the SCR over the next one-year period at the 1-in-200-year level, or whether the risk margin may be a more suitable means of taking account of climate risk drivers. The latter may be more appropriate in the context of the timeframes used in calculating capital requirements; SCRs assess risks over the next 12 months whereas the risk margin projects non-hedgeable capital requirements over a longer timeframe, which therefore may facilitate reflection of the impact of climate risk drivers on traditional risk components in the longer term.

The CBES results highlight that there is currently no consensus on modelling best practice. Given the relative infancy of climate change stress and scenario testing, that is perhaps to be expected. The Bank of England says it will engage with firms individually and collectively to help them target their efforts.

Finally, a more practical consideration for firms is when to carry out climate change stress and scenario testing. Typically firms have carried this out within the ORSA but, as pointed out by EIOPA, timelines applicable to climate change risks are well beyond the ORSA time horizon and typical business planning period. Therefore, it may be more sensible for firms to address scenario testing in a separate exercise, with results feeding into the ORSA and decision making.

Effective practice

Whilst the consensus is that firms generally still have significant progress to make with their approaches to climate stress and scenario testing, there are areas where there is some consensus around effective practice. We set out below the key areas of effective practice that have been observed by the Bank of England under the CBES exercise and best practices outlined within the United Nations Environment Programme Finance Initiative's "Comprehensive Good Practice Guide to Climate Stress Testing." Although many insurers will not yet be achieving all the practices outlined below, this should not be seen as an impediment to progress. It is important instead to seek incremental improvements year on year.

SCENARIO DESIGN

- Adapting reference scenarios geographically and sector-wise and deriving the impact on key drivers, in order to develop a relevant scenario narrative.
- Implementing a process to integrate the latest scenario developments and emerging methodology standards into the scenario design for climate stress testing.

ASSET MODELLING

- Using granular modelling approaches for sectors with specific climate risk exposures such as power, oil and gas and transport, capturing the interaction between public policy, demand elasticity and capital expenditure on transition or adaptation.
- Making an explicit link between bond and equity valuations for the same counterparty.
- For less material holdings, either extrapolating the detailed results from larger counterparties or using the sector-specific "gross value added" paths provided under the CBES exercise.
- Adjusting pricing models to allow for the near-term impacts of expected future changes in climate risks.

LIABILITY MODELLING

- Modelling a wide range of perils beyond those of the most readily available catastrophe models, making use of a variety of tools.
- Making adjustments to address limitations identified in third-party models.
- Incorporating the results of academic research into physical risk modelling.
- Demonstrating validation and review of results by comparing against alternative internal models or the outcomes of scientific research.
- Developing a clear plan of how to address any gaps identified in modelling approaches and keeping informed of external modelling approaches.

DATA CHALLENGES

- Understanding where data gaps and limitations exist, highlighting them in any results produced and aiming to address them over time. As a minimum, firms should make simple adjustments by adding margins where data gaps exist.
- Engaging in active stewardship in order to encourage improvements in available data, e.g., via asset managers or large counterparties.

UTILISING SCENARIO ANALYSIS OUTPUT

- Ensuring the output of climate scenario analysis is used to raise the firm's awareness of climate risk, encouraging the board to understand and take a strategic approach to climate risk and improving the approach to climate risk management.
- Considering the uncertainty in scenario analysis output and taking it into account when using the results.

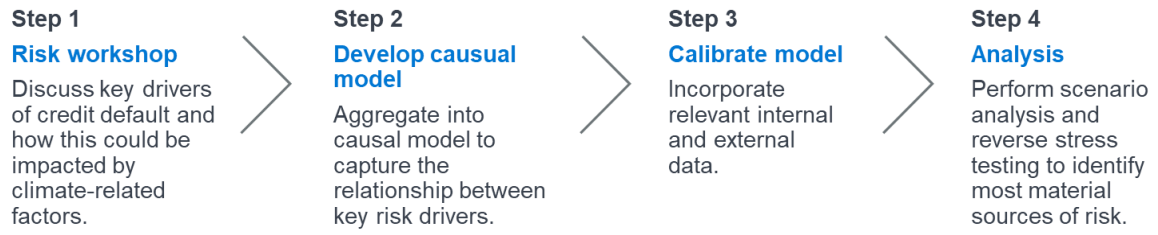
Future developments

Whilst the above sections have outlined how firms can get started with the climate change scenario analysis and stress testing and begin to approach the topic in a pragmatic way, it is clear that the PRA expects approaches to become more thorough and advanced over time. In light of this, the case study below outlines a more sophisticated approach that Milliman has used which draws out the complex system of underlying transition risk drivers and the impact it could have on a corporate bond portfolio.

CASE STUDY: SCENARIO ANALYSIS FOR EXPOSURE OF ASSET PORTFOLIOS TO CLIMATE CHANGE RISKS

Milliman has developed an approach that can be used to help clients understand how climate-related risk drivers could impact the credit rating of their asset portfolios across all industries. This approach included the steps shown in Figure 4 to model the impact of transition risks on a portfolio of corporate bond holdings.

FIGURE 4: SCENARIO ANALYSIS APPROACH OVERVIEW



Firstly, Milliman ran workshops with credit risk experts to walk through the key drivers of credit default, and to drill down into each to describe how climate-related factors could influence them. An example of a credit default driver that could be worsened by climate change is a reduction in consumer and investor confidence. Due to a shift in sentiment away from carbon-intensive activities, a company could lose the confidence of its customers and investors if it is unable to transition to a greener business model. This in turn leads to a reduction in the company's revenue and, thus, its ability to service its debt obligations.

This work was then aggregated into a causal model that builds a narrative around how climate-related drivers might cause a company to default on its debt obligations as a result of transition risk. The causal model captures the relationships between these drivers and the relative influence that each driver is expected to have on the corporate bond portfolio. For example, the company's ability to transition to a greener business model, as outlined above, may be influenced by various factors, including the industry in which the company operates, the carbon intensity of its business model, any regulatory or political actions which may impact the company and the company's current financial strength.

The causal model also factored in relevant company-specific and external data to feed into the climate-related drivers. For example, the company-specific data included a measure of the company's past performance, its current ability to transition away from carbon-intensive activities and its level of investment in carbon-intensive assets. This was supplemented with external data on current and projected climate conditions.

Once calibrated, the model provided a useful tool to allow scenario analysis and reverse stress testing to be performed, allowing for a deeper understanding of how transition risk could impact the corporate bond portfolio. For example, the model could be used to assess questions such as:

- What is the expected impact on probability of default from worsening climate projections and increased regulatory and political action?
- What drivers are most likely to lead to a two-notch downgrade in the credit rating of a corporate bond?

A key benefit of this approach is the ability to model the more subjective and qualitative aspects of transition risk, which is a commonly cited challenge for insurers performing climate change scenario analysis. In addition, by providing a deeper understanding of the climate-related drivers that are most likely to lead to a deterioration in the asset portfolio, more tailored and effective indicators can be incorporated into firms' risk monitoring practices. Further, the model allows for a wide range of scenarios to be assessed based on the various underlying climate drivers and therefore provides a valuable tool for incorporating climate change scenario analysis into the regular ORSA process.

Conclusion

Whilst the effects of climate change on insurers is uncertain, they cannot be avoided. Insurers can make efforts to ensure they are as fully informed as possible on the potential impacts of climate change on their business. Therefore, whilst regulation may currently be the primary driver for climate change scenario analysis activity, it should also be viewed as a powerful tool that enables insurers to understand the potential impacts of climate change on their business and respond accordingly. Such activity may also present insurers with opportunities through identifying potential new product or service areas, or enable them to ascertain which companies would be expected to fare well in the transition to a net zero economy. Effective scenario analysis could also contribute to lowering the cost of transition if early action is taken to ensure an orderly transition. It is therefore in a firm's best interests to continue seeking ways to improve its climate scenario analysis approaches over time and engage with emerging solutions and best practices.

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