TC NOTES

PRACTICAL **LEADERSHIP**
AND **GUIDANCE** FROM
TORONTO CENTRE

STRESS TESTING AND CLIMATE CHANGE

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STRESS TESTING AND CLIMATE CHANGE

Introduction[1]

Climate change poses significant risks. It is essential that both financial sector supervisors and the organizations they supervise understand the risks posed by climate change and take appropriate action in response to these risks. The FSB's Task Force on Climate-Related Financial Disclosures (TCFD) divided climate-related risks into two major categories: (1) risks related to the transition to a lower-carbon economy and (2) risks related to the physical impacts of climate change. Transition risks arise because 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. Physical risks resulting from climate change can be event-driven (acute) or longer-term shifts (chronic) in climate patterns.

The effects of climate-related risks are wide-ranging. They affect consumers (especially the poor), businesses, public sector organizations, financial markets, and the economy. Although climate change is global, its effects are uneven. For example, some areas are more prone than others to physical risks and developing and emerging countries often face greater risk than wealthier countries. These risks flow through to all types of financial institutions.

Climate-related risks can be difficult to quantify. Although some effects of climate change are already evident, the risks will evolve over a long timeframe. Many possible pathways for this evolution exist, which will be driven in part by the actions of policymakers and others. The pathways are subject to scientific uncertainty regarding how effective these actions will be in slowing climate change and mitigating its effects. Quantifying the potential effects of these risks on financial institutions – including banks, insurers and reinsurers, asset owners[2], and asset managers – over a timeframe that can be much longer than their typical planning horizon, can be especially challenging.

Understanding climate-related risks, including quantifying them where possible, informs appropriate actions. Alternative climate change pathways and their potential effects on various parties should be considered. Making this a part of enterprise risk management enables a financial institution to develop business strategies that respond to the needs of its customers while maintaining a prudent risk profile. Climate change can affect inherent risks in many supervisory risk assessment categories. So, timely and proportionate regulatory action or supervisory intervention might be needed to ensure the achievement of policy objectives. Stress testing and scenario analysis are tools that can help to build such understanding and drive action.

Supervisors should understand how stress testing and scenario analysis can help them and the financial institutions they supervise to assess and manage climate-related risks. This Toronto Centre Note should help supervisors to:

- understand the key aspects of stress testing and how they might need to be applied differently in dealing with climate-related risks;

[1] This Note was prepared by Michael Hafeman.
[2] Asset owners include public- and private-sector pension plans, insurance companies, endowments, and foundations.

- understand how climate change scenarios can be developed and their potential effects analyzed;
- understand how the potential effects of climate change scenarios can be translated into assumptions that can be used in stress testing;
- identify how financial institutions might use stress testing and scenario analysis in dealing with climate-related risks; and
- identify steps that supervisors can take to use stress testing and scenario analysis, and to promote their use by the financial institutions they supervise.

Together with the earlier Toronto Centre Notes (2017 and 2019) on climate risks, this Note should guide supervisors toward making appropriate choices when considering possible regulations or supervisory actions in the context of their particular circumstances.

Key aspects of stress testing

Stress testing and scenario analysis

Stress testing and scenario analysis are valuable risk assessment tools for both financial institutions and their supervisors.[3] This section provides a brief overview of some key aspects of stress testing and the related topic of scenario analysis. It also highlights issues to consider when applying them to climate-related risks.

A scenario describes a consistent future state of the world over time, resulting from a plausible and possibly adverse set of events or sequences of events. A stress test provides an assessment of an extreme scenario, usually with a severe impact on the firm, reflecting the inter-relations between its significant risks.[4]

Scenario analysis is an important method of exploring emerging risks, such as climate-related risks. Although scenarios describe hypothetical possible future paths, they are not predictions or forecasts. Using a variety of scenarios can enhance critical thinking about the future. It can build understanding of alternative pathways of climate change, how the potential effects of these changes might be transmitted to various parties, and the resulting effects on financial institutions and financial systems. Scenarios support both qualitative and quantitative analyses of risks, including stress testing.

Stress testing quantifies the potential effects of adverse scenarios. Financial institutions can use stress testing to help them to understand and quantify the risks they face, establish a risk appetite, and develop strategies to manage the risks. The scope of stress testing can vary to meet the needs of the financial institution. For example, stress testing of climate-related risks might be done at a group-wide level, as part of a financial conglomerate's enterprise risk management (ERM), or it might be focused on a business activity, such as the potential effects of transition risk on investment and lending. The time horizons for stress testing can also vary, both in terms of the period over which a scenario might occur and the period over which its

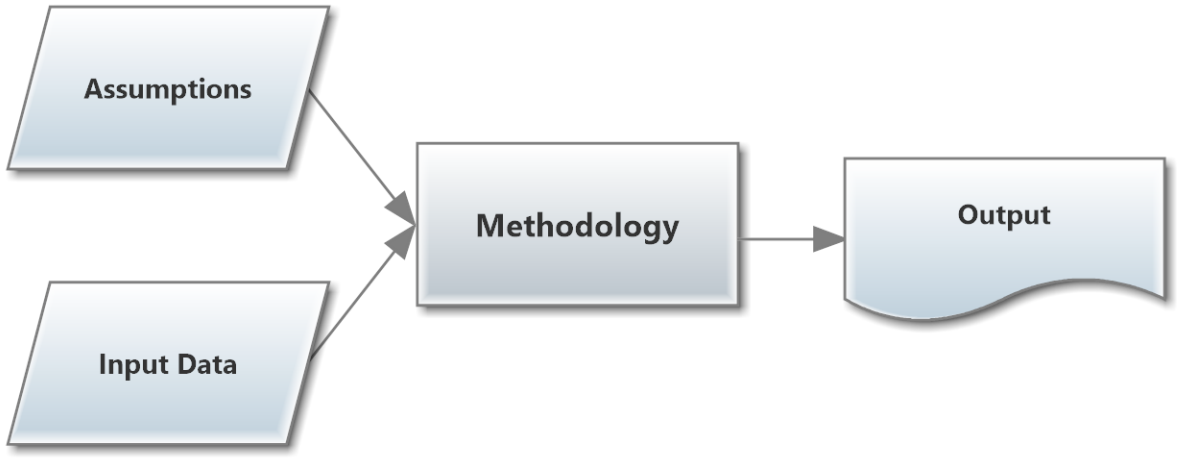
[3] See, for example, BCBS (2018), IAA (2013), IAIS (2019), and IOPS (2019).
[4] The definitions in this paragraph are from IAA (2013), which covers many aspects of stress testing and scenario analysis.

effects are measured. Climate-related risks, other than acute physical risk, have a considerably longer time horizon than that typically used by financial institutions in their stress testing.[5] Stress testing can also be used by supervisors to assess risks quantitatively. It can indicate the potential effects of climate-related risks on key indicators, such as capital adequacy ratios, liquidity levels, and rates of investment return. This can inform risk assessments under a range of risk assessment categories, at both micro and macro levels of supervision.

Models

Models are used when performing stress testing. A model should sufficiently represent aspects of the real world that are relevant to the decisions that are to be informed by the stress testing. To achieve this objective, a stress testing model must deal effectively with each of the elements common to all models: data, assumptions, methodology, and output.

Figure 1. Elements of models



A wide range of data might be used in stress testing, including climate data, economic and market data, the accounts of the financial institution, and its exposures to potential losses. In the case of climate-related risks, exposure data might include investments by industry sector, loans by type of borrower and geographic location, and insurance risk by coverage and type of property. Many supervisors have noted data problems, including unreliability, insufficient granularity, inconsistency across jurisdictions and sectors, and incomplete data on risk exposures, as a significant concern in the measurement of climate-related risks.[6]

Assumptions might be required about many things, such as the climate change pathway scenarios that will be tested, the frequency and severity of risks arising from the scenarios, the channels through which the effects of risks that are realized will be transmitted, the impacts of the scenarios on economic and market parameters, and the extent to which management actions that might be taken should be considered. It is essential that the assumptions made for stress testing be both plausible and adverse.

[5] Among other things, this makes the treatment of management actions in stress testing more important. Many stress tests do not allow any management actions to be taken, but financial institutions might claim that they will adjust before climate risks hit them. This is an important point for supervisors to address.
[6] See BCBS (2020) and FSI (2019).

Methodology is the mathematical approach used to translate the data and assumptions into a representation of what might happen in reality. More complex methodology might enable a more accurate representation than a simple approach, but all models have limitations – and complex methodology will not overcome serious data problems or faulty assumptions. The methodology should recognize potential non-linear relationships and cliff effects; for example, the impact of a 4°C-increase scenario may be more than twice that of a 2°C-increase scenario. Methodology is also a significant concern of supervisors.

One key aspect of methodology is the manner in which a model uses probabilities. The deterministic approach makes assumptions about various parameters, for example, using best estimates of the rates at which loan defaults or insurance claims are likely to increase under a particular stress scenario. The stochastic approach uses the probability distributions of one or more of the parameters to generate multiple stress scenarios. Although the deterministic approach is much simpler, the stochastic approach has the advantage of providing insight into the range of possible outcomes and their likelihood.

The output of models can vary greatly, depending on the nature and purpose of the model. For example, the output of stress testing financial models used by financial institutions and supervisors often includes key risk indicators related to assets, liabilities, capital adequacy, and liquidity. A deterministic model will provide a single value for each of these indicators under each assumed scenario, while the output of a stochastic model will be probability distributions for the indicators.

Stress testing often involves the use of multiple models, which might be linked to one another directly or indirectly. For example, climate change models might be used to generate scenarios focused on physical risk or transition risk.[7] The output of such models might serve as an input to econometric, catastrophe, and loss models, whose output might in turn be used by claims and financial models.[8] Of course, it is not necessary for financial institutions or supervisors to maintain all of these models internally. However, users should avoid treating models as "black boxes" and the risk of doing so is particularly high when using external modelling services.

Responsibilities

There are two basic approaches to carrying out stress testing of financial institutions for supervisory purposes: top-down and bottom-up. In the top-down approach, supervisory authorities perform the stress testing themselves, using data provided by the financial institutions. In the bottom-up approach, supervisory authorities make use of the results of stress testing performed by the financial institutions. The bottom-up approach might be a formal, collaborative exercise. For example, the supervisory authority might work with industry to develop a set of climate change scenarios and assumptions, which are then applied by each financial institution.

Alternatively, financial institutions should in any case be required to perform stress testing as part of their ERM processes. So, the determination of scenarios and assumptions could be left to each institution and the results reported to the supervisor. This might be done through their incorporation in reports already being provided to the supervisor, such as an internal capital

[7] See, for example, TCFD (2017), Appendix 1 and FSI (2019), Annexes 2 and 3.
[8] See, for example, The Geneva Association (2018).

adequacy assessment program (ICAAP) or own risk and solvency assessment (ORSA) report, or perhaps through a thematic review of what major financial institutions have been doing with respect to climate risk stress testing. Many jurisdictions make use of both top-down and bottom-up approaches.

To be successful, any stress testing program needs to be well governed. It should be driven from the top of the organization – whether a financial institution or a supervisor – and be subject to senior-level oversight. The identification of risks and development of scenarios should be informed by broad input from those within the organization and, where appropriate, outside experts. For example, few financial institutions are likely to have all the expertise they need on climate change available internally. The modelling should be performed by experts using suitable tools and be subject to appropriate controls. The results of stress testing should be clearly communicated to those – including the board and senior management of a financial institution – who would benefit from having this information as they make their decisions.

Climate change scenarios

Designing scenarios

The future course of climate change is far from certain, so it is important to use a range of scenarios in stress testing. Climate change scenarios can be designed very differently, depending on the purpose and situation for which they will be used. This might include the use of different climate change pathways. Alternative time horizons might also be used, particularly when considering different types of risk. For example, a one-year time horizon might be relevant when assessing acute physical risks, but a considerably longer time horizon might be appropriate when assessing transition risks or chronic physical risks.

Various scientific and other organizations have developed climate change scenarios that can serve as starting points.[9] One such organization is the Intergovernmental Panel on Climate Change (IPCC), which has developed four Representative Concentration Pathway (RCP) scenarios (see box 1). These scenarios are relevant in assessing both transition and physical risks. A pilot project of the United Nations Environmental Program Finance Initiative (UNEP FI) and banks on implementation of the TCFD recommendations used two of these scenarios, RCP2.6 and RCP8.5. Another example is the International Energy Agency, whose World Energy Outlook (WEO) scenarios focus on transition risks.[10]

[9] See TCFD (2017) for some references.
[10] See https://www.iea.org/topics/world-energy-outlook .

Box 1. IPCC Representative Concentration Pathway (RCP) scenarios[11]

RCP8.5 is the high-emissions scenario, consistent with a future with no policy changes to reduce emissions and characterized by increasing GHG emissions that lead to high atmospheric GHG concentrations. It is aligned broadly with a Current Policies or Business-As-Usual Scenario.

RCP6.0 is a high-to-intermediate emissions scenario where GHG emissions peak at around 2060 and then decline through the rest of the century.

RCP4.5 is an intermediate-emissions scenario, consistent with a future with relatively ambitious emissions reductions and GHG emissions increasing slightly before starting to decline circa 2040. Despite such relatively ambitious emissions reduction actions, RCP4.5 falls short of the 2°C limit/1.5°C aim agreed on in the Paris Agreement. It is aligned broadly with the GHG emissions profile that would result from implementation of the 2015 NDCs (out to 2030), followed rapidly by peaking and then reduction of global emissions by 50% by 2080.

RCP2.6 is the only IPCC scenario in line with the Paris Agreement's stated 2°C limit/1.5°C aim. This RCP is consistent with ambitious reduction of GHG emissions, which would peak around 2020, then decline on a linear path and become net negative before 2100.

It is appropriate to adapt or build on the internationally available climate change scenarios to reflect conditions in a specific jurisdiction or region. For example, a jurisdiction might be prone to weather-related catastrophes, such as severe storms, drought, or wildfires. The economy might be dependent on carbon-intensive sectors, which could pose significant transition risk. The political climate in a jurisdiction and others in its region could significantly influence the nature and timing of policies to deal with climate change.

Scenarios used for the stress testing of climate-related risks need not focus solely on those risks. Scenarios could be developed that involve climate-related risks being realized at the same time as other risks, such as those arising from the COVID-19 pandemic. The pandemic has had significant social and economic effects, some of which might be long-term in nature. Some of these effects might actually be helpful in mitigating climate change, such a shift toward working at home, which could reduce carbon emissions from automobiles. But the pandemic might heighten transition risk and does nothing in the short term to mitigate acute physical risk. For example, a severe storm is no less likely during the pandemic than it would be in the absence of a pandemic. The ability of an already stressed society to respond to climate-related risk might be reduced, which could compound the risks to financial institutions and those they serve. Historical experience can be useful in designing climate change scenarios, for example, regarding acute physical risks. However, many climate change scenarios will necessarily be hypothetical in nature. But all climate change scenarios should be plausible, distinctive, consistent, relevant, and challenging (see box 2).

[11] Source of summary: TCFD (2019). See IPCC (2014) for more information on the RCP scenarios.

Box 2. Desirable characteristics of scenarios[12]

1. **Plausible**. The events in the scenario should be possible and the narrative credible (i.e., the descriptions of what happened, and why and how it happened, should be believable).

2. **Distinctive**. Each scenario should focus on a different combination of the key factors. Scenarios should be clearly differentiated in structure and in message, not variations on a single theme.[13] Multiple scenarios should be used to explore how different permutations and/or temporal developments of the same key factors can yield very different outcomes.

3. **Consistent**. Each scenario should have strong internal logic. The goal of scenario analysis is to explore the way that factors interact, and each action should have a reaction. Neither actors nor external factors should completely overturn the evidence of current trends and positions unless logical explanations for those changes are a central part of the scenario.[14]

4. **Relevant**. Each scenario, and the set of scenarios taken as a whole, should contribute specific insights into the future that relate to strategic and/or financial implications of climate-related risks and opportunities.

5. **Challenging**. Scenarios should challenge conventional wisdom and simplistic assumptions about the future. When thinking about the major sources of uncertainty, scenarios should try to explore alternatives that will significantly alter the basis for business-as-usual assumptions.[15]

Analyzing scenarios

Before stress testing the potential effects of a climate change scenario on a financial institution, it is essential to consider how the scenario might affect those to whom the institution is exposed and, more broadly, the environment in which it operates. A key step is to identify the channels through which the effects of risks that would be realized under a scenario might be transmitted. There can be many second-and third-order effects, as illustrated in figure 2, so this can be a challenging exercise.[16]

[12] Source: TCFD (2017), page 3, which was adapted from *Scenario Analysis: A Tool for Task Managers*, by Jonathan N. Maack, published in Environmental Science, 2001 https://www.semanticscholar.org/paper/Scenario-Analysis-%3A-A-Tool-for-Task-Managers-Maack/ca52b281959d45018e427fb61084714894a16c77 .

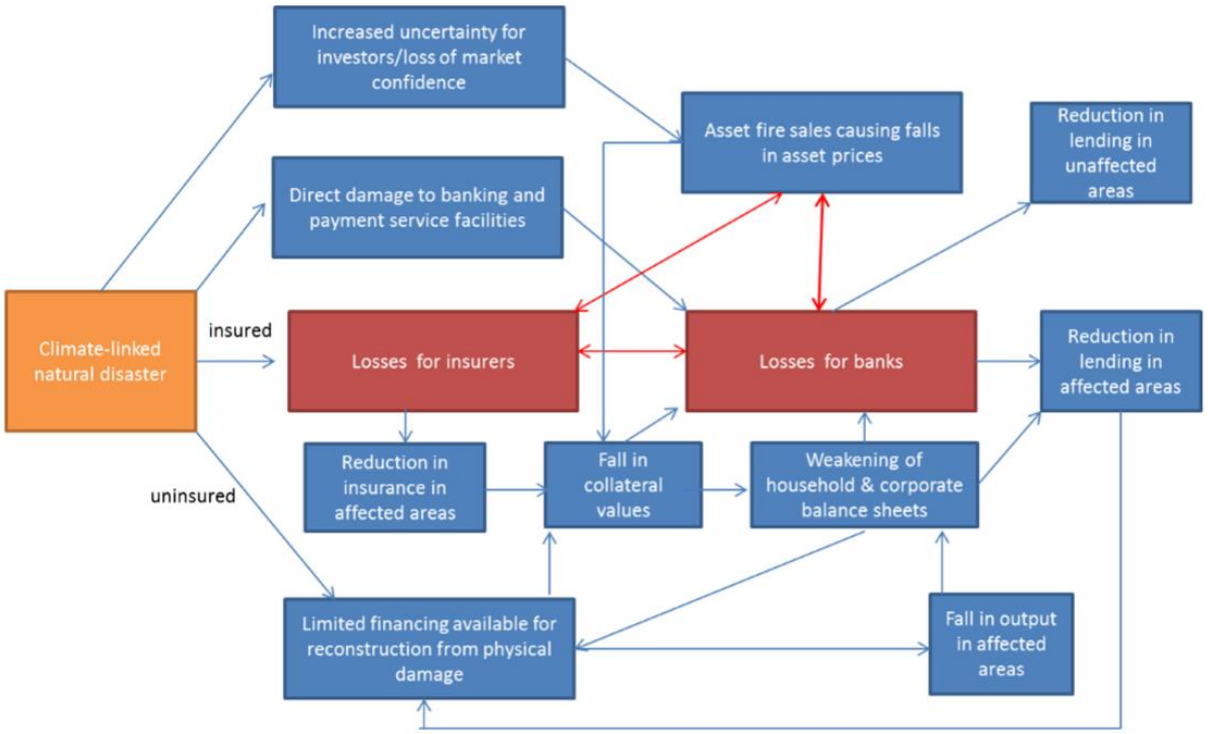
[13] However, this should not be interpreted as discouraging stress testing of, for example, alternative temperature-increase scenarios, the effects of which might differ considerably.

[14] For example, as noted by J.N. Maack, it is highly unlikely that there will be low inflation and high growth, or that a regulatory agency that was formerly very strict will significantly loosen its requirements without some extenuating circumstances.

[15] In the terminology used by many supervisors, they should be “severe but plausible” or “plausible adverse” scenarios.

[16] See BCBS (2020), which notes that additional work is planned in this area.

Figure 2. A transmission map from a natural disaster to financial sector losses and the macroeconomy[17]



This analysis might be organized by considering the effects of the scenario on various groups. At a high-level, the groups could be consumers, businesses, the public sector, and financial institutions. Depending on the scenario, further subdivisions could be useful. For example, the effects on consumers might vary by income level, gender, age, occupation, and location. The effects on businesses might vary by industry sector or size of the business, and on financial institutions by the business segments in which they operate.

In some cases, it might be practical to make quantitative estimates of the effects. For example, historical data could be used to estimate the effects of a severe drought on health, agricultural output, tourism, and other sectors of the economy. In other cases, qualitative assessment might be needed, for example, in considering how the behaviour of consumers and investors could change in response to climate change.

It can be useful to obtain broad and expert input, both in designing climate change scenarios and in analyzing their potential effects. This might include not only persons within the organization but also outside experts, such as climate scientists, risk modellers, academics, actuaries, economists, government officials, and representatives of consumer organizations.

[17] Source: Bank of England (2016).

Stress test assumptions

In order to perform stress testing, the potential effects of climate change scenarios need to be translated into assumptions that can be used in the stress testing financial models. In some cases, the quantification of effects done as part of the scenario analysis discussed in the previous section can produce such assumptions directly.

In some other cases, the scenario analysis might provide information that can be used in specialized models, the output of which can be used in the stress testing financial models. Such other models might include natural catastrophe models, loan loss models, insurance claims models, and econometric models.

Expert judgment is needed not only in selecting and using these models, but sometimes to supplement them. For example, in one project to assess transition risk, credit and sustainability experts identified links between scenarios and the creditworthiness of borrowers, facilitating the calibration of assumptions that could be used in credit risk modelling.[18]

Informed judgment can also be used in other ways to develop assumptions. For example, historical experience in stress scenarios that share some characteristics of the climate change scenario, in terms of how parties were affected, could be considered.

The assumptions used for stress testing non-climate risk scenarios should also be considered. For example, if an acute climate risk scenario is considered likely to trigger severe economic problems, the assumptions used for stress testing the effects of an economic recession are relevant. Judgment could be applied about whether the various economic effects of the climate risk scenario would likely be more or less severe than those of the recession scenario. Reference can also be made to the assumptions used by others in stress testing climate-related risks. For example, supervisors in some jurisdictions include climate risk scenarios in their bottom-up stress testing programs.[19]

As in the development and assessment of scenarios, input from a range of experts can be useful in developing and calibrating the stress testing assumptions. The wide-ranging effects of some climate change scenarios makes this particularly important. For example, a severe weather event in a smaller jurisdiction might adversely affect interest rates, equity and real estate values, credit losses, expense levels, insurance claims, foreign-currency exchange rates, and sovereign risk.

What should supervisors expect financial institutions to be doing?

Financial institutions should take account of climate-related risks and opportunities if they are to remain viable and meet their fiduciary responsibilities.[20] This should include undertaking stress testing and scenario analysis as they develop strategies for dealing with climate-related risks, just as they do with respect to other risks.

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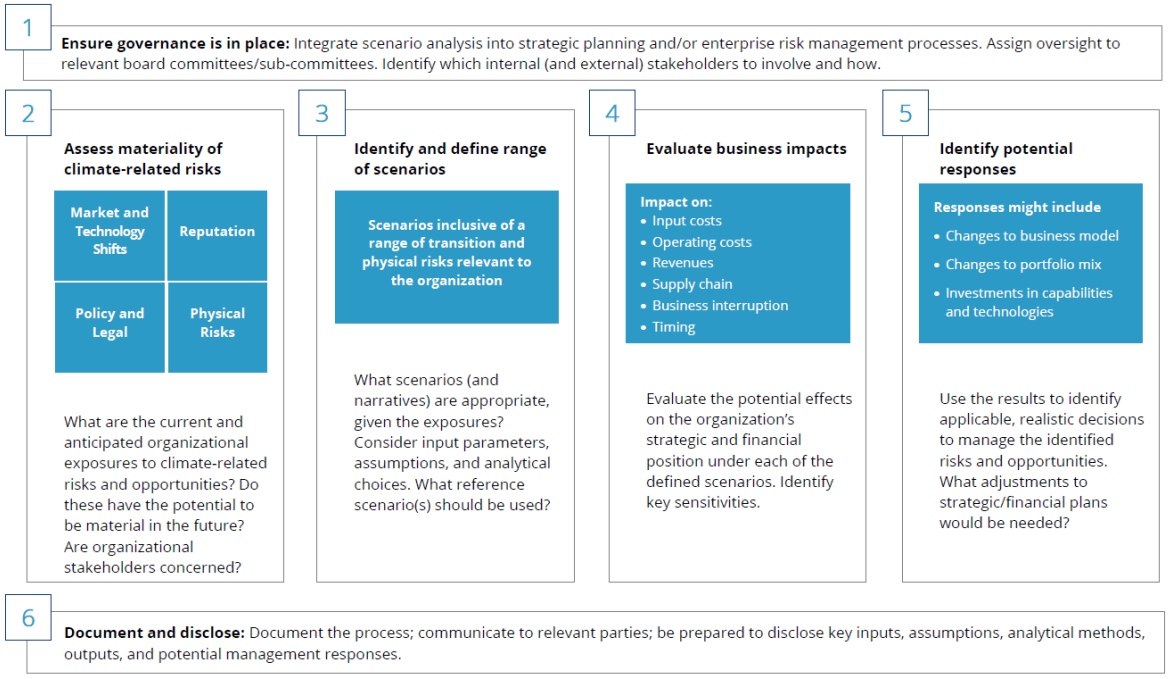
[18] See UNEP FI (2018a). See also UNEP FI (2018b), which deals with physical risk.
[19] See, for example, FSI (2019).
[20] See TC (2017 and 2019).

A financial institution might choose to focus on climate-related risks as a separate initiative, particularly in the early stages. However, the basic process for stress testing and scenario analysis should be much the same as used for other risks (see figure 3). Accordingly, the work could be integrated into the broader ERM of the organization, for example, being dealt with in the ICAAP and ORSA processes.

Figure 3. A process for applying scenario analysis to climate-related risks and opportunities[21]



Most of these steps have been discussed earlier in this Note. In the context of stress testing:

1. Ensure governance is in place – governance should extend to all aspects of the process, including the data, assumptions, methodology, and output of stress testing. For example, supervisors have expressed concerns about financial institutions lacking the data and expertise needed to assess climate-related risks.[22] Each financial institution should develop the capability to carry out this process through a mix of internal and external resources that is appropriate to the nature, scale, and complexity of its business and the climate-related risks it faces.
2. Assess the materiality of climate-related risks – stress testing can assist in assessing the materiality of various climate-related risks, both in relation to one another and in relation to other types of risks.
3. Identify and define a range of scenarios – a variety of climate change scenarios should be used in stress testing.
4. Evaluate business impacts – stress testing is an essential tool in quantifying potential impacts of climate-related risks.

[21] Source: TCFD (2017), page 7.
[22] See BCBS (2020) and FSI (2019).

5. Identify potential responses – stress testing should inform many aspects of business planning, including strategic, capital, liquidity, product, investment, and business continuity plans.
6. Document and disclose – the results of stress testing should be communicated in a manner that is useful to decision makers, both inside and outside the organization.

Supervisors have expressed concerns about the management of financial institutions lacking expertise to communicate risks to their boards, and for their boards to understand the risks.[23] Accordingly, the results of stress testing, which can be a very technical exercise, need to be presented clearly and with the opportunity for discussion by senior management and the board. Financial institutions should be implementing the TCFD recommendations, which include the disclosure of information related to the use of stress testing and scenario analysis to stakeholders outside the organization. Beyond the public disclosures, financial institutions should share information about their stress testing of climate-related risks, including the results, with their supervisors.

What should supervisors do?

Climate change is becoming increasingly relevant to the financial sector and the consumers that it serves, and regulators and supervisors need to be proactive in dealing with the emerging risks. Supervisors need to take steps to understand climate-related risks and their potential impacts, to support the development of a regulatory framework that enables them to be dealt with, and to assess how well the financial institutions they supervise are dealing with them.[24] Stress testing is an important risk-assessment tool. Accordingly, supervisors should ensure that their stress-testing frameworks capture climate-related risks.

Ensure climate-related risks are stress tested

Climate-related risks should be included in the stress tests performed as part of macroprudential supervision, as well as those designed to help assess risks at individual entity or group levels. The stress testing might be carried out on a top-down basis by the supervisor or as part of a structured bottom-up approach.[25] The decision about which of these approaches, or perhaps both, might be most appropriate for a particular jurisdiction will need to consider the respective capacity of the supervisor and the organizations it supervises to perform stress testing.

Regulators could establish requirements or guidelines to promote the development of stress testing capabilities in the financial sector and its application to climate-related risks. For example, guidelines on ERM and requirements for ICAAP and ORSA programs and reporting should extend to all types of risks. Nevertheless, it can be useful to clarify the expectation that these programs should deal with climate-related risks.

[23] See BCBS (2020) and FSI (2019).
[24] See TC (2017, 2018 and 2019).
[25] See FSI (2019).

Promote disclosure by financial institutions

Encouraging or requiring financial institutions to disclose information in accordance with the TCFD recommendations will also be useful in several respects. It could provide an impetus to the development of stress testing and scenario analysis capabilities, enhance risk management more generally, and generate information useful to a wide range of stakeholders.

Collaborate with others

Regulatory requirements should always be proportionate, and this is no less applicable in the case of requirements for the stress testing of climate-related risks. Supervisors might lessen the burden of regulatory requirements, while achieving valuable synergies, by collaborating with financial institutions on various aspects of stress testing and scenario analysis. This could include the development of climate change scenarios, the identification of transmission channels, qualitative and quantitative analysis of the effects on various parties, and the development of assumptions for key stress test parameters.

Collaboration with others can also help supervisors to develop their understanding of climate-related risks and capabilities to perform stress testing and scenario analysis. International supervisory organizations are performing studies and producing guidance on many aspects of climate-related risks, such as qualitative studies on transmission channels.[26] Supervisors might work with their counterparts in the jurisdiction and the region to develop climate change scenarios and share stress testing results. They should also seek input from outside experts, such as climate scientists, risk modellers, academics, actuaries, economists, government officials, and representatives of consumer organizations.

Consider in risk assessments

Supervisors should consider climate-related risks, including the results of stress testing and scenario analysis, when making risk assessments. The results can be relevant to many types of risk assessments, whether at the micro level (individual financial institutions and groups), sectoral level, or macro level. Thematic (horizontal) reviews, surveys, and questionnaires can be useful in gaining an understanding of how financial institutions view various climate-related risks and the steps they are taking to deal with them. For example, such tools might identify risks to the availability of products and services that would assist consumers in mitigating the financial effects of climate change.

Although some supervisors have established climate risk as a separate category in their risk assessment framework, many assess the effects of climate-related risks under relevant categories in their existing framework. For example, stress testing of a transition risk scenario might be relevant to the assessment of market risk, credit risk, and strategic risk, while an acute physical risk scenario might be relevant to credit risk, insurance risk, and operational risk. Supervisors should consider the potential effects of various climate risk scenarios in order to determine which risk assessment categories might be affected. In some cases, stress testing

[26] See, for example, BCBS (2020), IAIS and SIF (2018 and 2020), and the website of the Network for Greening the Financial System (NGFS), https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system .

will facilitate a quantitative assessment of the potential effects on a risk assessment category. For example, it might facilitate quantitative estimates of the potential effects on capital related to the exposure of financial institutions to industry sectors or geographic areas that are vulnerable to the risks of climate change. In other cases, only a qualitative assessment might be possible. Supervisory assessment needs to extend beyond the effects of climate change on inherent risks to the quality of risk management being applied by financial institutions in dealing with these risks. Factors to consider would include the characteristics of the stress testing and scenario analysis program with respect to climate change, the reasonableness of the results it is generating, how the results are being used as part of ERM and planning,[27] and how relevant information is being disclosed to stakeholders.

Act to deal with concerns

Timely and appropriate action should be taken to deal with any concerns identified through the supervisory assessments. This might include supervisory intervention to require an organization to strengthen its stress testing program or better mitigate climate-related risks highlighted by stress tests. For example, the failure of a financial institution to undertake stress tests or to use the results properly, and poor governance and risk management surrounding stress testing, could all feed into the risk assessment and lead to "Pillar 2" add-ons to capital and solvency requirements. In case of more wide-ranging concerns, it might involve the strengthening of regulation, the issuance of guidance, or taking steps to further collaborate on initiatives such as data gathering, the development of climate change scenarios, and the analysis of transmission channels. For example, financial institutions might be required to perform stress testing, if this is not already the case, or stress testing guidelines might be expanded to explicitly address climate-related risks. Supervisors might even publish the results of climate risk stress tests, for example as part of their financial stability report.

Conclusion

Climate change poses significant risks. It is essential that both financial sector supervisors and the financial institutions they supervise understand the risks posed by climate change and take appropriate action in response to these risks. Understanding climate-related risks, including quantifying them where possible, informs appropriate actions.

Stress testing and scenario analysis are tools that can help to build such understanding and drive action. Scenario analysis is an important method of exploring emerging risks, such as climate-related risks. Stress testing quantifies the potential effects of adverse scenarios. Supervisors should ensure, as far as possible, that the models used by themselves and by financial institutions when performing stress testing sufficiently represent aspects of the real world. They must deal effectively with each of the key elements: data, assumptions, methodology, and output. Stress testing of climate change often involves the use of multiple models, such as climate change models to generate scenarios, and econometric, catastrophe, and loss models, whose output might be used by claims and financial models.

[27] Including strategic, capital, liquidity, product, investment, and business continuity planning.

There are two basic approaches to carrying out stress testing of financial institutions for supervisory purposes: top-down and bottom-up. To be successful, any stress testing program needs to be well governed.

The future course of climate change is far from certain, so it is important for supervisors and financial institutions to consider a range of scenarios in the stress testing. It is appropriate to adapt or build on the internationally available climate change scenarios to reflect conditions in the jurisdiction or region. Scenarios could also be developed that involve climate-related risks being realized at the same time as other risks, such as those arising from the COVID-19 pandemic.

Before stress testing the potential effects of a climate change scenario on a financial institution, it is essential to consider how the scenario might affect those to whom the institution is exposed and, more broadly, the environment in which it operates. A key step is to identify the channels through which the effects of risks that would be realized under a scenario might be transmitted. In order to perform stress testing, the potential effects of climate change scenarios need to be translated into assumptions that can be used in the stress testing financial models. In this, as in other aspects of climate change stress testing and scenario analysis, it can be useful for both supervisors and financial institutions to obtain broad and expert input from persons both within their organizations and outside experts.

Financial institutions should perform stress testing and scenario analysis as they develop strategies for dealing with climate-related risks, just as they do with respect to other risks. This work could be integrated into the broader ERM of the organization, for example, being dealt with in the ICAAP and ORSA processes.

Supervisors should ensure that their stress-testing frameworks capture climate-related risks. Some specific steps that they should take would be to:

- carry out supervisory stress testing using a top-down approach, a bottom-up approach, or both
- establish requirements or guidelines to promote the development of stress testing capabilities in the financial sector and its application to climate-related risks
- encourage or require financial institutions to carry out stress tests using a range of scenarios, and to act upon the results
- encourage or require financial institutions to disclose information in accordance with the TCFD recommendations
- collaborate with financial institutions and others on various aspects of stress testing and scenario analysis
- consider climate-related risks, including the results of stress testing and scenario analysis, when making risk assessments
- take timely and appropriate action to deal with any concerns identified through the supervisory assessments.

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