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The validation challenge in climate risk and ESG models

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Executive summary

The assessment of climate change and environmental impacts on risk in the financial industry is becoming increasingly dependent on complex models that challenge existing validation functions attuned to traditional credit risk approaches.

Models that assess climate-related risks or which generate other environmental, social and governance (ESG) data are being developed and recast to support strategy, provisioning, stress testing, ESG ratings, and disclosures in an environment where approaches, data sources, scientific research and regulatory oversight are in a state of flux. Regulators in many jurisdictions are requiring banks to assess both, the physical risks of climate change and the transition risks arising from the global shift towards a low-carbon economy.

As these models are becoming 'mainstreamed' into banks' operations, model risk managers are faced with the challenge of validating methodologies and approaches that can be very unlike the credit risk models they are familiar with.

Traditional credit risk modelling methodologies assume a cyclical economy in which the past can be used to predict the future. Hence, validation approaches have relied heavily on back-testing against historical data to give confidence in future predictions. A suite of standard metrics (for e.g., Gini, Kolmogorov–Smirnov, R^2) have been developed for quantifying this confidence.

But climate risk does not have suitable historical precedent to evaluate the impacts of global warming on credit risk metrics that can be easily used for model validation. So they do quite the opposite, i.e., extrapolate from present trends, apply assumption-based adjustments to risk metrics, and incorporate expert judgement where data is lacking.

Validation functions must, therefore, place greater emphasis on assessing the conceptual soundness of methodologies and assumptions of these models, apply sensitivity testing and scenario analysis to understand model behaviour, and evaluate whether the models are complete or miss any key drivers of risk.

In this paper, we provide an overview of the types of models encountered in financial climate risk modelling, the key challenges faced by financial institutions in validating them, and how CRISIL can support financial institutions in overcoming these challenges.

Climate models are varied and harder to validate

Regulators across jurisdictions are increasingly requiring banks to measure, monitor, manage and report on their exposure to climate risk. These regulations call upon banks to understand how climate change may impact their business models under different scenarios of transition to a low carbon economy over the short-, medium- and long-term horizons.

The Bank of England and the European Central Bank (ECB) have led with the publication of Supervisory Statement 3/19[1] and the 'Guide on climate-related and environmental risks', respectively. Australia released 'CPG 229 Climate Change Financial Risks' in 2021 and the US Office of the Comptroller of the Currency (OCC) published the 'Principles for Climate-Related Financial Risk Management for Large Banks' the same year.

While not excluding qualitative approaches, these regulations imply that proper management of climate risks would require a quantitative approach just as credit and market risks are assessed quantitatively. For banks, this means adopting modelling methodologies that can be very different from existing approaches.

There is no single uniform method for incorporating climate risk into financial models. Instead, climate risk models include a range of statistical, extrapolation-based, or expert judgement-based approaches used to predict the impact of current environmental events and future climate change on risk metrics relevant to financial institutions. These effects encompass both, the physical impacts of global warming and the economic impacts of reducing greenhouse gas (GHG) emissions under different scenarios of how these two risk drivers will change over time (*see box on Page 6, Types of climate and environment-related risks*).

While a minority of approaches to estimating the impact of climate on risk metrics involve a single, stand-alone model that combines climate and credit risk drivers, most combine the outputs of multiple sub-models or 'feeder' models to calculate the impact of climate risk. A complete climate risk solution could involve any of the following models and calculators:

- A set of models describing how physical parameters (temperature, precipitation, sea level rise) change over time for a given region
- A model to downscale regional parameters into local effects and risk of physical damage (e.g., from precipitation in a 50 km square to flood risk on an individual property)
- A model or calculator that quantifies physical damage from descriptive terms into monetary values (e.g., estimating a one in 100 probability of a 2 metre flood producing £30,000 of property damage)
- A set of models for estimating missing physical or transition risk data (e.g., estimating carbon emissions or fuel use for a property based on age, construction, and location)
- Models that convert asset- or business-level physical and transition risks into adjustments to default risk (PD) or loss given default (LGD)
- Macroeconomic models that use climate scenario-specific drivers (e.g., carbon pricing, sector level gross value added) to adjust measures of default risk or loss
- Calculation engines to extrapolate effects across short, medium and long (30+ year) time horizons

[1] *SS3/19 'Enhancing banks' and insurers' approaches to managing the financial risks from climate change', Bank of England. April 2019*

- Scenario expansion models specific to climate risk (to create variable paths for econometric factors that have not been supplied with a scenario)
- Calculators of net-zero and temperature alignment based on own and financed emissions

Numerous banks have devised their own approaches based on available climate data and their technical skill set, while various third-party providers have devised partial or complete climate risk solutions for the financial industry. Some third-party models may be open source, but most providers wish to protect their intellectual property and provide only limited insights into the accuracy and assumptions of their methodology. Regulators, too, have been reluctant to impose any standardisation over assessment methodologies. Hence, despite several consultations on standardising ESG ratings[2][3], transparency of third-party models and data is unlikely to improve in the immediate future.

At the same time, with climate risk and ESG models become integrated into the strategy, risk management, and operational aspects of banks, there is a growing requirement to provide effective independent validation of the conceptual soundness, model design, assumptions, and methodology of each model.

In line with good model risk management principles, validation functions will be required to provide an independent and effective challenge to both the model development approach and use of models within the business, proportional to the importance of the climate risk models in the bank's overall risk management framework.

However, many of the validation techniques developed for traditional credit risk approaches are not necessarily appropriate, or are unable to evaluate whether climate risk modelling methods are conceptually sound and adequately supported by published research or industry practice. In addition, where models depend heavily on assumptions and expert judgement, or involve the combined outputs of multiple feeder models, validation functions may not appropriately communicate the limitations of the model and its sensitivity to changes in inputs and parameters to senior stakeholders.

Therefore, the challenge for model risk managers is to provide the senior management with a measure of confidence in the outputs from various models and calculation engines, identify and explain the assumptions underlying the outputs, and fully integrate climate risk models into banks' model risk management framework in compliance with the relevant regulations.

The next section discusses these challenges and potential solutions.

[2] *'Future regulatory regime for Environmental, Social, and Governance (ESG) ratings providers', HM Treasury, March 2023*

[3] *'Proposal for a regulation of the European parliament and of the council on the transparency and integrity of Environmental, Social and Governance (ESG) rating activities,' European Commission, June 2023*

Types of environmental and climate-related risks

Climate change is expected to impact financial institutions through two broad classes of environmental and climate-related risks:

Physical risks, due to both changes in the average precipitation and temperature, and through increased probability of extreme weather events; and

Transition risks, due to increasing carbon prices, changes in environmental and emissions regulations, new technologies, and changing consumer sentiment

Physical risks can be further divided into acute or event-driven effects, and chronic long-term shifts in climate. The former comprises extreme weather events (floods, wildfires, etc) that may physically damage assets or create temporary disruptions in business operations. The latter includes sea level rises, droughts, or sustained higher temperatures that will have more fundamental and long-lasting effects.

Climate change is expected to increase both the frequency and the impact of these risks over time, with the rate of increase dependent on whether and how rapidly carbon emissions are brought under control.

The Intergovernmental Panel on Climate Change (IPCC) gives several plausible trajectories of GHG emission concentration based on various assumptions and scenarios. These are known as representative concentration pathways (RCPs), and used to model future climate impacts. RCPS are then mapped to latest projections of how socioeconomic factors such as population, economic growth and education could change over the next century to produce shared socioeconomic pathways (SSPs), to create narratives of future climate risk.

At one extreme (RCP 2.6, SSP1) is a world that shifts gradually but pervasively towards a more sustainable future, with consumption oriented towards low material growth and lower energy intensity, and carbon emissions reaching zero by 2100. At the other extremes are a world of regional conflicts pushing countries to focus inward, resulting in slow economic development, strong environmental degradation, and continued fossil fuel use (RCP 7.0, SSP3), and a world of strong global economic and social development, but powered by the increasing exploitation of fossil fuel resources and the adoption of energy intensive lifestyles around the world (RCP 8.5, SSP5). Scenario narratives such as these define the nature of and degree to which physical and transition risks would evolve under different scenarios.

A checklist for climate model validation

Within a robust model risk management framework, the validation function is expected to provide an evaluation of the model's conceptual soundness, analyse the model outcomes against current and historical actuals, and provide ongoing monitoring and process verification to ensure the model is appropriately implemented and performing as intended. It is also expected to identify whether changes in internal (products, exposures) or external (markets, clients) conditions require that models be adjusted, redeveloped, or replaced.

Validation functions will thus need to provide the expertise and skill to cover the following dimensions:

- Conceptual soundness of the model and appropriateness to the purpose it was designed for
- The model's underlying theory and supporting assumptions
- Accuracy and completeness of the model's implementation
- Model performance
- Inter-dependencies between linked models
- How the model is used and any limitations in use
- Quality and completeness of documentation
- Compliance with internal model standards and external regulatory requirements
- Evaluation of the model's monitoring and control framework
- End-to-end lifecycle documentation

The nature and variety of climate risk and ESG models, in themselves, pose issues in how validation functions may incorporate them into the model risk management framework. While a subset of climate risk models might be constructed along conventional lines, many would partially or substantially rely on assumptions and extrapolation or comprise complex calculation engines integrating the outputs of various feeder models (*see box on Page 9, Climate model designs*).

A robust climate risk and ESG model validation approach will thus need to provide both, an outcome-based evaluation that analyses and documents the model's behaviour under different setups or given inputs, and a test of the conceptual soundness (i.e., of the underlying approach and assumptions contained within the model).

Bearing this in mind, we have identified the following considerations that every model validation team reviewing climate risk models should cover:

Purpose 	• Climate risk models should have a defined purpose and conditions of use which encompass any limitations on time horizon, region, or portfolio that may limit its use case. For example, a model's purpose and limitations could be that it is designed to predict transition impacts over a five-year window for assets in Belgium
Data 	• Sources for any data used in the model should be provided, and information on data quality checks for integrity and accuracy included • A complication with climate risk and ESG models is that many types of climate data are only realistically obtainable from third-party specialists (for e.g., granular physical risk data) and the method of producing the data may be difficult to review due to intellectual property restrictions • Similarly, economic assumptions and forecasts may be derived from climate integrated assessment models[4] that are not available to the validation function
Documentation 	• It should include clear and detailed descriptions of modelling assumptions, limitations and any supporting evidence from internal or external research, if appropriate • Documentation should ensure that any outputs or analysis include a description of the climate scenario(s) involved, including the overarching narrative and details relevant to the model • Feeder and imputation models supplying data for the model under review would normally require a separate validation, subject to the materiality of the models, rather than being included in the documentation of the model in question
Model outputs 	• One challenge with climate models is the lack of a suitable historical period to compare model outputs with. Where outputs cannot be directly compared with current or historical actuals, validation functions should test model outputs for consistency with the model methodology, published climate literature, and the business purpose • Model outputs should include a description of the climate scenario(s) involved, including the overarching narrative and details relevant to the model. Validation functions should ensure that a robust and appropriate set of scenarios have been used in development and testing and that the rationale for using a particular set of scenarios has been documented • For models that rely heavily on assumptions and expert judgement, sensitivity testing may be the only feasible way to evaluate their performance. Sensitivity testing should attempt to provide information on how much confidence (both statistical and conceptual) should be placed on the model outputs as parameters are varied across their potential range

A final consideration in validating climate risk and ESG models is establishing how the model would be monitored and what triggers exist for review and revision. Climate modelling is a changing landscape with data, published

[4] *Integrated assessment models, or IAMs, combine of models of energy system technologies with simplified economic and climate science models to evaluate different population, economic and technological pathways of climate change. Many of the climate stress tests that have been carried*

research and industry standards constantly evolving. Validation teams will need to be familiar with improvements in methodology and industry practice, as well as the benefits and risks of alternative approaches to models they are asked to evaluate. Periodic model reviews, in which models are tested for the continued accuracy and relevance of their coefficients and parameters, would therefore need to be supplemented with an examination of whether the model continues to fulfil its purpose or if changing requirements, regulation, or industry good practices have rendered them obsolete.

Climate model designs

Climate risk and ESG models can be broadly categorised into three groups, based on the challenges they present for validation and ongoing monitoring.

Conventional predictive models are built using industry standard methodologies, with minimal or no assumptions and expert judgement. They are intended to be used to make predictions within or just outside the bounds of the development data. The predictions they make may be time-independent or used only over short-term horizons. An example of such a climate risk model would be a regression model that estimates carbon emissions based on property size, date of construction, primary use and geographic location, for use in filling missing data gaps in a real estate emissions dataset.

Extrapolation models are built using industry standard methodologies but required to make predictions well outside the bounds of the development data by extrapolating from historical trends or known data ranges. In climate risk, these models are often used for evaluating risk over medium to long term horizons, e.g., a model that estimates flood risk to a property up to 2050 for stress testing purposes.

Expert judgement models are built mostly or entirely around assumptions that are not directly obtained from statistical analysis of relevant data. Instead, these models may make use of information obtained from subject matter experts, published scientific research, or statistical insights obtained from analogous datasets. Despite the lack of direct data used in their construction, such models may be technically sophisticated, e.g., a regression model that scores companies on their resilience to transition risk developed from the opinions of subject matter experts on the relative riskiness of a pool of example businesses with known ESG characteristics.

In addition, there is a fourth class of model — **central calculation hubs** — that combine the outputs of the previous three model types to produce a new composite output. Calculation hubs may introduce additional assumptions and extrapolations onto the outputs of their contributing models, and therefore, increase the risk and uncertainty around their predictions. They can also introduce uncertainties and errors as they combine different model outputs and types. A 30-year climate risk stress test engine for a commercial mortgage portfolio, combining conventional predictions of default risk with long-term forecasts of evolving flood risk and assumptions on resilience to changing emissions regulations is a familiar example of this model type.

out by regulators in the UK, Europe, and USA base their scenario narratives and variable paths on IAMs provided by the Network for Greening the Financial System.

How CRISIL can help financial institutions

CRISIL can assist financial institutions in addressing regulatory and business challenges pertaining to climate risk and ESG-related models, with its extensive experience in front office, risk management and change management functions of top-tier financial institutions. Our key offerings are:

1 Regulatory self-assessment, gap analysis and remediation

CRISIL can help financial institutions in the completion of self-assessments against current regulatory requirements (SR11-7, PRA SS1/23, EGIM, etc.), gap identification/assessment and the formulation of a roadmap for gap remediation. This includes addressing gaps highlighted by regulators or internal audit.

2 Independent validation of climate risk models and associated controls

CRISIL can assist financial institutions with the independent validation of climate risk models and associated controls, including:

1. Critical evaluation of strategy documentation, including role and implementation of climate risk and ESG models and metrics
2. Evaluation of test results to validate identified assumptions and limitations
3. Independent assessment and challenge of the conceptual soundness of the modelling choice
4. Testing the conceptual soundness, design, and effectiveness of controls
5. Completion of validation documentation, as per regulatory guidelines

3 Governance, risk management and approval process for climate risk models

CRISIL can assist financial institutions in defining and embedding robust governance and oversight arrangements for climate risk models, including:

1. Defining, monitoring, and overseeing execution of model risk policies and procedures across the first and second lines of defence
2. Risk management process workflow re-engineering, design, implementation, and documentation
3. Defining a process for the approval and decommissioning of climate risk models
4. Assisting in obtaining Board approvals for climate risk and ESG governance framework
5. Defining a risk appetite framework for climate risk and ESG, covering existing and emergent risks; ensuring consistency with the firm's risk appetite and governance framework
6. Identifying, assessing and reporting of risks from the climate risk and ESG monitoring architecture
7. Assisting the risk management function in formulation and execution of risk-mitigation plans
8. Helping bridge the climate risk and ESG skills gap in the governance teams

4 Model development and implementation testing

CRISIL can help financial institutions in addressing various challenges in climate risk model development and implementation testing, including:

1. Implementation and enhancement of source code
2. Execution of key functions, controls, quality assurance, and capacity testing
3. Back testing and ongoing performance monitoring
4. Implementation of parameter-sensitivity analysis
5. Identification, assessment and reporting of risks based on the risk architecture
6. Programme/Project management, business analysis
7. User acceptance testing support covering regulatory/business change

5 Model inventory and documentation

CRISIL can help financial institutions in enhancing the completeness of their climate risk model inventory and documentation to ensure that it stands the test of regulatory scrutiny, through:

1. Documentation uplift support (methodology, process, and policy/procedure documentation) as per regulatory and internal standards
2. Establishing a single comprehensive inventory of climate risk and ESG algorithms, associated controls and documentation
3. Establishing minimum documentation standards in line with regulatory guidelines
4. Capturing data sources, inputs, output, design, and specifications
5. Defining and enhancing documentation covering climate risk and ESG methodologies and model uses (including credit risk, stress testing, financed emissions and net-zero, and scenario analysis), associated controls and climate risk architecture

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It is India's foremost provider of ratings, data, research, analytics and solutions with a strong track record of growth, culture of innovation, and global footprint.

It has delivered independent opinions, actionable insights, and efficient solutions to over 100,000 customers through businesses that operate from India, the US, the UK, Argentina, Poland, China, Hong Kong and Singapore.

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Global Research & Risk Solutions is the world's largest and top-ranked provider of high-end research and analytics services. We are the world's largest provider of equity and fixed income research support to banks, and the foremost provider of end-to-end risk and analytics services to trading and risk management functions at world's leading financial institutions. We provide corporate research and analytics solutions to operations, strategy, and sales and marketing teams of corporations globally. Coalition provides analytics and business intelligence to 14 leading global investment banks. We operate from 8 research centers in Argentina, China, India and Poland, working with clients across time zones and languages. Being part of CRISIL enables us to attract and retain top quality talent. We have over 2,300 employees, 75% of whom hold advanced degrees in finance, accounting and management. We employ the largest number of CFAs and CFA aspirants in India. We have won top honours at the World HR Congress on Talent Management and HR Project for the year 2015. We have also won the NASSCOM Exemplary Talent Practices Award (NExT Practices) for skill development for two years in succession in 2011 and 2012. The award recognizes us as a firm that has the vision to proactively invest in its people and get them future-ready.

We are committed to delivering cutting-edge analysis, opinions, and solutions. This underscores our proposition of being the best people to work with.

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