Climate-related risk: drivers, transmission channels and measurement methodologies

BCBS

List of abbreviations

Abbreviation	Meaning
BCBS	Basel Committee on Banking Supervision
GHG	Greenhouse Gas
TFCR	Task Force on Climate-related Risks
UNEP FI	United Nations Environment Programme Finance Initiative
CFTC	Commodity Futures Trading Commission
PD	Probability of default
LGD	Loss Given Default

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Introduction

The BCBS published two reports regarding the information on developments in the banking sector to help identify current or emerging risks for the global financial system, measurement and methodologies, as well as practical implementation by banks and supervisors

Introduction

- Climate-related financial risks **could impact the safety and soundness of individual financial institutions**, giving rise to broader financial stability implications within the banking system. Therefore, the Basel Committee has established the **TFCR** to undertake work on climate-related financial risks.
- The combined economic and financial impacts associated with climate change may give rise to considerable future losses for banking institutions. Against this background, an effective risk management framework for banks and supervisors should:
  - Identify material climate risk drivers and their transmission channels.
  - Map and measure climate-related exposures and any area of risk concentration
  - Translate climate-related risks into quantifiable financial risk metrics.

- In this context, the BCBS has published the **Report on Climate-related risk drivers** and their transmission channels which synthesises relevant literature to create a single framework that charts how climate risk drivers can give rise to financial risks in banks.
- Also, the BCBS has published the **Report on Climate –related financial risk – measurement methodologies** which provides an overview of measurement methodologies that banks and supervisors are currently employing or developing.

- This document summarises the main aspects of these BCBS reports.

Access the full Report on climate risk drivers

Access the full Report on climate financial risk measurement methodologies

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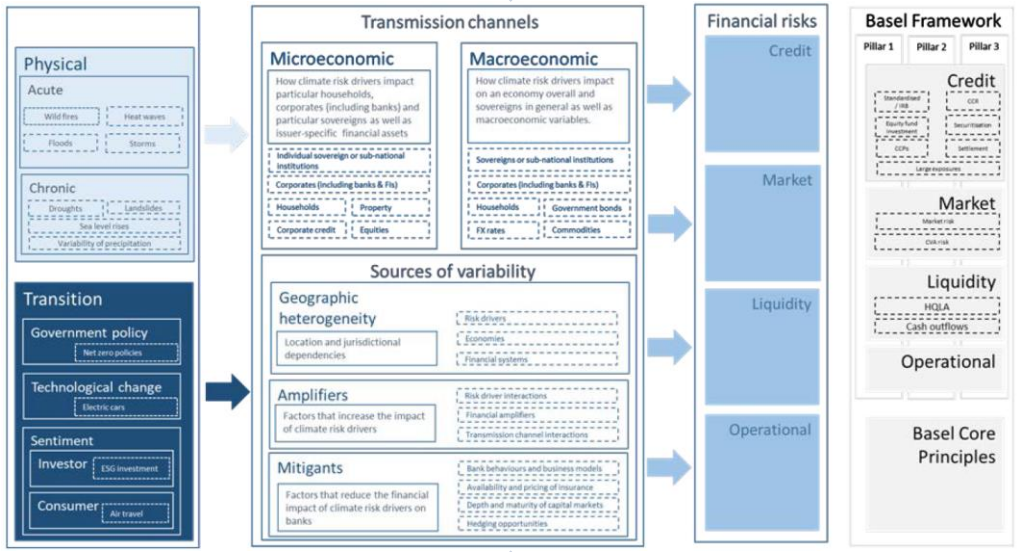
Executive overview

Financial risks from climate risk drivers

The Report on climate risk drivers and their transmission channels synthesises relevant literature to create a single framework that charts how climate risk drivers can give rise to financial risks in banks

Banks and the banking system are exposed to climate change through **micro and macroeconomic transmission channels** that arise from physical and transition risk drivers. Evidence suggests that the impacts of these risk drivers on banks can be observed through traditional risk categories.

To size climate-related financial risks, banks and regulators require plausible ranges of scenarios to assess the potential impacts of both **physical and transition risk drivers** on their exposures.



Existing literature largely focuses on the impacts of climate risk drivers on those aspects of the economy relevant to banks' **credit risk**, and to a lesser extent on **market risk**.

The likelihood and size of the impact of climate risk drivers can be affected by a number of additional variables. These are the **sources of variability**, which include: the geographic location of the bank, asset or exposure, interactions and interdependencies between transmission channels and climate risk drivers that can amplify impacts, and mitigants that reduce or offset impacts.

Executive overview

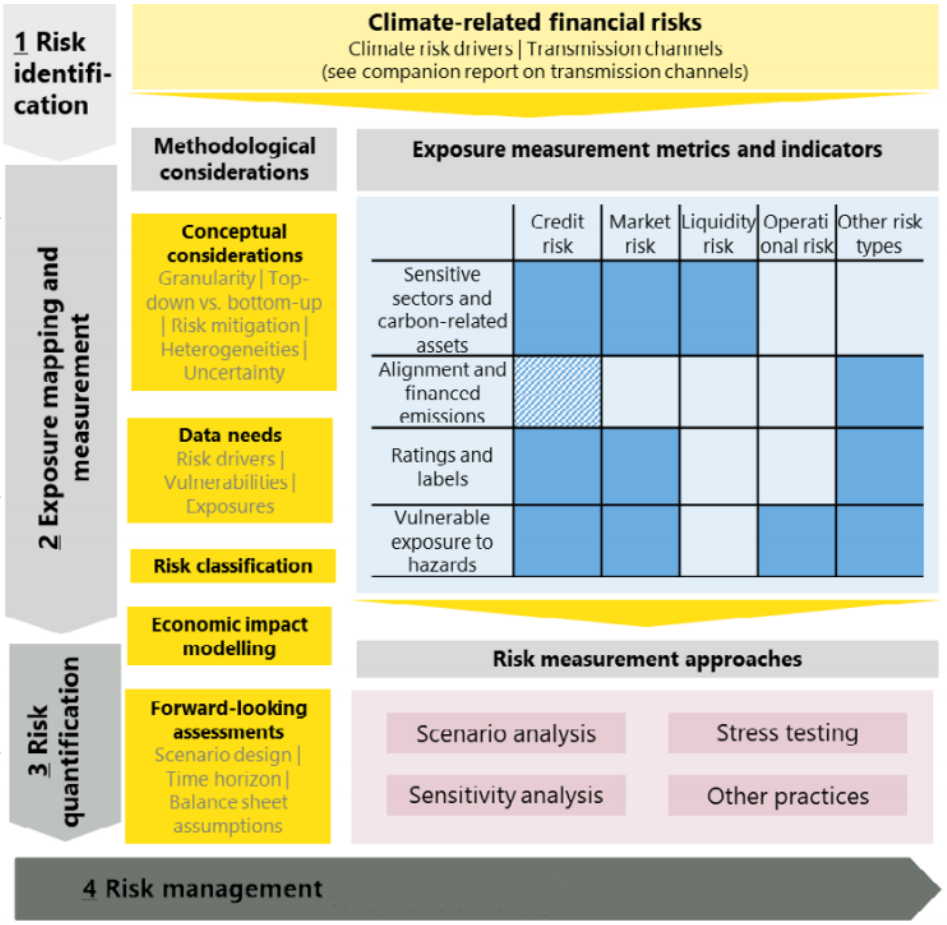
Financial risks – measurement methodologies

The Report on climate related financial risks – measurement methodologies provides an overview of conceptual issued related to the measurement and methodologies of climate related financial risks as well a practical implementation by banks and supervisors

A particularly high exposure granularity may be needed to assess both physical risks and transition risk. This need arises from **heterogeneities at different levels**.

Measurement of climate-related financial risks by banks and supervisors has centred on **mapping near-term** transition risk drivers into counterparty and **portfolio exposures.**

Climate-related financial risks have unique features, necessitating granular and forward-looking **measurement methodologies.**



Banks and supervisors have predominantly focused on **assessing credit risk**, as they advance in applying methods to translate climate-related exposures into categories of **financial risk**.

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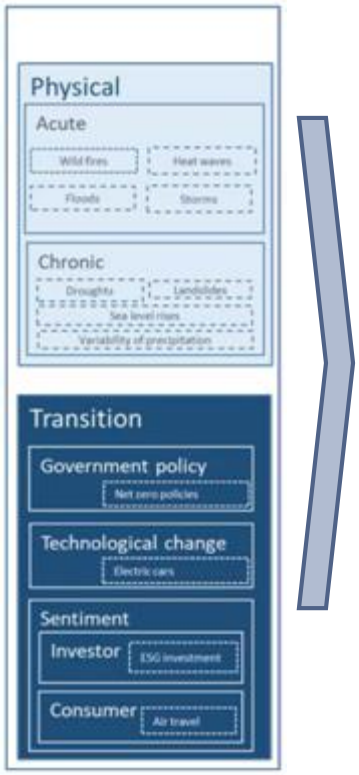
Physical Risk & Transitional Risks
Main Characteristics

To understand the impact of the climate risk into financial risk is important to have a clear vision of the physical and transition risk drivers, these represent climate-related changes that could give rise to financial risks

There is broad consensus within literature that climate risk drivers can be grouped into the following categories:

- Physical risks, which arise from the changes in weather and climate that impact the economy; and
- Transition risks, which arise from the transition to a low-carbon economy



Physical risks

Acute physical risk drivers

- Consist of lethal heatwaves, floods, wildfires and storms, including hurricanes, cyclones and typhoons as well as extreme precipitation

Chronic physical risk drivers

- Include: rising sea levels, rising average temperatures and ocean acidification

Geographical heterogeneity

- Climate change is a global phenomenon, but the way in which physical risks impact economies will vary depending on geographical location as different regions exhibit distinct climate patterns and levels of development

Transitional risks

Climate policies

- Many jurisdictions have established a number of policy initiatives, that encourage the transition of the economy, towards activities that produce fewer GHG emissions, and lower carbon emissions.

Technology

- Energy-saving, low-carbon transportation, and increasing use of non-fossil fuels or other technologies that help reduce GHG emissions are needed to meet policy goals. These developments, are expected to change the way in which households, corporates and sovereigns are impacted by climate change.

Investor sentiment

- The investors are incorporating climate risk considerations into their investment decisions, reflecting the pressure from non-governmental associations

Consumer sentiment

- A change in human behaviour is required to an economy with lower carbon emissions. A shift in behaviour to climate-friendly consumption would, for example, create a move to more climate-friendly transportation, manufacturing and energy use

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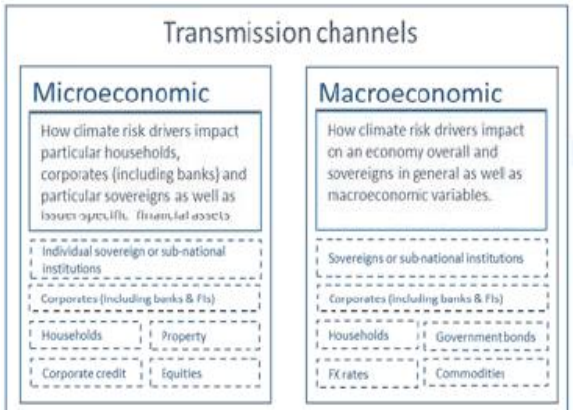
Transmission Channels
General Overview

Transmission channels are the causal chains that explain how climate risk drivers impact banks directly and indirectly through their counterparties, assets, and the economy in which they operate.

The BCBS report classifies transmission channels as microeconomic or macroeconomic. This split better is considered to better allows for an analysis of banks' financial risks in key areas.



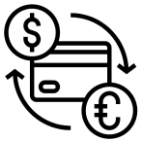
Microeconomic	Macroeconomic
• Include the causal chains by which climate risk drivers affect banks' individual counterparties, potentially resulting in climate-related financial risk to banks and to the financial system • This includes the direct effects on banks themselves, arising from impacts on their operations and their ability to fund themselves. • Also capture the indirect effects on name-specific financial assets held by banks (e.g. bonds, single-name CDS and equities).	• Consist of the mechanisms by which climate risk drivers affect macroeconomic factors (for example, labour productivity and economic growth) and how these, in turn, may have an impact on banks through an effect on the economy in which banks operate • Also capture the effects on macroeconomic market variables such as risk-free interest rates, inflation, commodities and foreign exchange rates

Climate risk drivers can translate into traditional financial risk categories, rather than representing a new type of risk:

Credit Risk

Market Risk

Liquidity Risk



Operational and reputational risk

Transmission Channels
Microeconomic

The BCBS Report summarises how climate risk drivers can affect a bank's credit risk through its counterparties, its market risk through the value of financial assets, its liquidity risk through its deposits, funding costs and drawdowns of credit or liquidity lines and risk to banks' operations

	Highlights	Examples
Credit Risk	• Climate risk drivers can impact household, corporate, or sovereign income and/or wealth. • Physical and transition risk drivers increase a bank's credit risk as soon as they have a negative effect on a borrower's ability to repay and to service debt (the income effect) or on a bank's ability to fully recover the value of a loan in the event of default because the value of any pledged collateral or recoverable value has been reduced (the wealth effect).	• Physical risk, households. there is empirical evidence of property value declines resulting from damage caused by severe weather events, or chronic flooding • Transition risk, government policy. Firms may face higher operating expenses because of a higher tax on GHG emissions. The impact of this tax could reduce earnings and therefore also reduce the corporation's creditworthiness.
Market Risk	• Physical and transition risks can alter or reveal new information about future economic conditions or the value of real or financial assets, resulting in downward price shocks and an increase in market volatility in traded assets. • Climate risk could also lead to a breakdown in correlations between assets, reducing the effectiveness of hedges and challenging banks' abilities to actively manage their risks.	• Physical risk. Wachter (2013) the risk of a consumption shock similar to one following a natural disaster explains high levels of stock price volatility1 • Transition risk. UNEP-FI considered a portfolio of 30,000 listed companies under a 1.5°C scenario by 2100, and estimated that the portfolio could lose 13.16% of its value as a result of the transition to a low- carbon economy

Transmission Channels
Microeconomic

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	Highlights	Examples
Liquidity Risk	• Climate risk drivers may impact banks' liquidity risk directly, through their ability to raise funds or liquidate assets, or indirectly through customers' demands for liquidity • Natural disasters could impact the ability of a bank to fund increases in its assets and meet obligations as they come due without incurring unacceptable losses.	• Physical risk. If households and corporates affected by physical risks need liquidity to finance recovery and other cash flow needs, they may withdraw deposits or draw on credit lines. These withdrawals could put the bank's own liquidity under pressure and lead to crystallised liquidity risks within banks.
Operational Risk	• There is little public research on the operational risks faced by banks and arising from physical risk drivers, but there are parallels to be found in other natural disasters.	• Physical risk. If physical hazards disrupt transportation facilities and telecommunications infrastructure, banks' operational ability may be reduced. • Transition risk. Corporates, as well as banks, may also be exposed to an increasing legal and regulatory compliance risk as well as litigation and liability costs associated with climate-sensitive investments and businesses. Furthermore, climate-related lawsuits could target corporations, as well as banks, for past environmental conduct whilst seeking to direct future conduct.

Transmission Channels
Macroeconomic

Considering the macroeconomic factors, the credit and market risk are the ones that are expected to have the greatest impacts

Highlights

Credit Risk

- Climate-related increases in human mortality and declines in labour productivity are projected to be key drivers of reductions in output.
- The cost of recovery following a natural disaster can be significant, particularly for poorer municipalities. The effect of climate change on economic growth appears to be more pronounced in developing countries. Empirical evidence suggests that exposure to climate risk has raised the average cost of debt by 117 basis points in a sampling of developing countries
- Increased borrowing costs could lead to higher taxes, lower government spending and reduced economic activity, which may indirectly impact banks' credit risk.
- Transition risk drivers can affect the income of banks' counterparties, which, in aggregate, could have macroeconomic effects

Market Risk

- There is little research that seeks to make a connection between macroeconomic effects and banks' climate-related market risk.
- Changes in asset values may be driven by a policy change that affects an individual borrower, or by the effect that policy change may have on the economy more broadly.

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Sources of Variability

Geographic heterogeneity main characteristics

While climate risk drivers may impact banks through transmission channels, several different factors may determine the likelihood or the size of the impact from both physical and transition risk drivers. These factors include geographical heterogeneity, amplifiers and mitigants

Geographical heterogeneity is driven by several factors:

- Differences in the likelihood and severity of **climate risk drivers** themselves
- **Structural differences in economies and markets** that affect the relative importance of various transmission channels
- Differences in **financial systems** that may impact banks' exposures to climate-related risks.

Implication in Risk Drivers

- As average global temperatures rise, the incidence and severity of physical hazards, both acute and chronic, are very likely to increase.
- The **heterogeneity** in **physical risk drivers** translates into elevated levels of climate-related financial risks for banks operating in higher-risk areas
- Similarly, countries, regions and sectors are exposed to **different levels of transition risk** depending on the likelihood of policy action, technological innovation or broad shifts in sentiment within a particular jurisdiction.

Economic & Market Structure

- Even when exposed to similar climate risk drivers, countries may experience disparate **microeconomic** and **macroeconomic** consequences driven largely by differences in economic policies, economic and financial systems and insurance availability.
- Higher global temperatures are also expected to **have an outsize impact on agriculture and tourism**, resulting in larger adverse effects in countries with activity concentrated in these sectors, while transition risk drivers may have an outsize impact on economies that are heavily reliant on the production of fossil fuels.

Financial Systems

- **Differences in the structure** of a country's banking system as well as the maturity of capital markets may impact a bank's exposure to climate-related risks and its ability to transfer or offset that risk
- Empirical evidence suggests that the structure of the banking sector within individual jurisdictions has **implications for the impact of climate risk drivers on banks' credit risk**. Where small, local banks account for a greater share of the banking sector than large banks, banks are more likely to increase credit exposures to retail and corporate borrowers in affected areas following a severe weather event.

Sources of Variability
Amplifiers main characteristics

While climate risk drivers may impact banks through transmission channels, several different factors may determine the likelihood or the size of the impact from both physical and transition risk drivers. These factors include geographical heterogeneity, amplifiers and mitigants

The impacts of the climate-related financial risks can be amplified by…

- **… interactions and interdependencies** between climate risk drivers.
- … through the **combined impact of risk drivers** transmitted through more than one channel.
- … through **feedback of financial risks**.

Risk drivers interactions

- As average global temperatures rise, the incidence and severity of physical hazards, both **acute and chronic**, **are very likely to increase**.
- The heterogeneity in physical risk drivers **translates into elevated levels of climate-related financial risks** for banks operating in higher-risk areas
- Similarly, countries, regions and sectors are exposed to **different levels of transition risk depending on the likelihood of policy action**, technological innovation or broad shifts in sentiment within a particular jurisdiction.

Financial Amplifiers

- Financial amplifiers have the potential to increase the impact of climate-related financial risks to banks.
- The materialisation of climate-related risks on bank balance sheets might be amplified by **behavioural actions** taken within the financial system and interaction with the real economy. These amplifying effects may increase losses in the financial system .

Multiple Channels

- A given **risk driver may impact a bank through more than one transmission channel**, therefore amplifying the effect of climate-related financial risks.
- **Physical risk drivers can damage houses**, and thereby negatively impact individuals' household wealth and in turn and in aggregate impact banks' credit risk.
- **A vicious cycle** may arise where physical risk drivers **magnify macro-financial risks** for a country.

Sources of Variability
Mitigants main characteristics

While climate risk drivers may impact banks through transmission channels, several different factors may determine the likelihood or the size of the impact from both physical and transition risk drivers. These factors include geographical heterogeneity, amplifiers and mitigants

Financial mitigants can moderate or offset banks' exposure to climate-related financial risks through both proactive and reactive actions:

Proactive actions	Reactive actions
Include those that banks take to pre-emptively reduce their vulnerability to climate-related financial risks.	Include those taken to respond to climate risks that are already embedded in balance sheet exposures.

Bank behaviour and business model

- **Physical risks**, in particular, are generally thought to affect companies idiosyncratically, and investors can thus **diversify** their portfolios to mitigate the impact of these risks.
- **Asset allocation** strategies can provide possible mitigation, for example through **increasing investment in sustainable companies**, but only if investors have sufficient information on which to act.

Availability and pricing of insurance

- Insurance can reduce the financial impact of **natural catastrophes**.
- Insurance can entail **a bank insuring itself** against losses from physical hazards (eg losses from a borrower's default or operational outages) **or a bank's counterparty insuring itself** against losses from physical hazards (eg flooding damage to a house).

Maturity of capital markets

- Evidence suggests that, in some jurisdictions, lenders may transfer risk by originating loans in climate-vulnerable areas and **securitising** them or **via loan sales**.

Hedging opportunities

- **Weather derivatives** are used by banks and their counterparties most commonly by the agricultural, entertainment, tourism, energy and insurance sectors to hedge localised risk associated with unexpected weather conditions and seasonal fluctuations.

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Methodological considerations
Conceptual considerations in measuring climate-related risk

Mapping and measuring risk exposures constitute fundamental components of an effective risk governance framework

- The assessment of climate-related financial risks introduces new concepts to risk managers. These concepts feature prominently in both the mapping of exposure to climate risk and the measurement of climate-related financial risks. The **main pertinent concepts** for banks and supervisors are described below.

Physical and transition risk measurement

- Physical and transition risks are often viewed and assessed separately; however, several features relating to climate change are increasing the likelihood that **these risks may be dependent on each other**, which may necessitate their being considered jointly.

Exposure granularity

- Banks are exposed to climate-related financial risks through their **transactions with clients and counterparties**. In estimating the implications of climate risk drivers for these transactions, banks and supervisors will need to **determine the level of exposure granularity most relevant** for their respective risk assessments.

Top-down and bottom-up approaches

- **Top-down approaches** start by dimensioning risk at the general, or aggregated, level and then “push down” or attribute the aggregated measure of risk to component parts.
- **Bottom-up approaches** dimension risk at the component level, aggregating these individual measures of risk up to provide a consolidated view of risk.

Risk mitigation and risk reduction

- As banks consider how to measure climate-related financial risks, they may need to **estimate the effect of potential risk mitigation** and to what extent mitigants could moderate or offset risk-taking.
- Distinguishing between **net and gross exposures** can allow banks to disaggregate the impact of risks and of mitigating actions.

Methodological considerations
Data needs

Revision of the methodological concepts that financial institutions and supervisors face when conducting exposure mapping and measurement of climate-related financial risks

- Assessment of climate-related financial risks will require new and unique types of data, different to the data banks have traditionally used in financial risk analyses. The data needed to map risk exposures and translate climate-related risks into financial risk estimates may be only partially available and may not adequately meet traditional data quality standards, such as the length of history, completeness, and granularity needed to support the risk decision-maker. Focusing on the **types of data** needed to assess climate-related financial risk, **three broad data categories** can be observed:

Data describing physical and transition risk drivers

Needed to translate climate risk drivers into economic risk factors (ie climate-adjusted economic risk factors)

- These data include climate information or information about current and projected hazard events.
- Many types of climate risk driver data are supplied by **government agencies and academic organisations**. Some are increasingly provided by **commercial third parties** that compile readily available and formatted data sets for use in financial risk assessment.

Data describing the vulnerability of exposures

Linking climate-adjusted economic risk factors to exposures

- These data tend to include features specific to those exposures, such as geospatial data for corporates (including their value chains), location data for mortgage collateral, or data on counterparties' sensitivity to energy prices or carbon emissions in the production and distribution processes.

Financial exposure data

Needed to translate climate-adjusted economic risk into financial risk.

- Additional data is needed to translate the vulnerability of exposures into financial loss estimates. Here, banks and supervisors can generally turn to the financial variables typically used in conventional risk measurement techniques – data used to project cash flows, valuations, or prices.

Methodological considerations

Models for assessing economic impacts of climate change

In order to quantify climate-related financial risks, banks and supervisors must first specify the paths of the main economic variables that underpin the performance of assets. In this sense, several approaches have been developed. All approaches exhibit various strengths and weaknesses relating to complexity, assumption validity, mechanism transparency, data requirements, and computational burden

	Strenghts	Weaknesses
Integrated assessment models (IAMs)	• **Combine approaches** from energy and climate modelling with economic growth modelling. • IAMs are highly applicable to policy problems and the mechanisms underlying their output are well understood. They have been **among the most commonly deployed methods for linking projections of transition risk drivers and GHG emissions to economic growth impacts**.	• They **do not capture the economic impacts of climate change extreme weather events** (acute physical risk). • **Do not capture simultaneous changes in multiple structural features of the economy in response to environmental changes**, such as changes in input-output relationships, industrial dynamics, technological transitions, sectoral shocks, and social interactions
Sensitivity analysis	• Has demonstrated **how drastically projections of climate change damages and the resulting welfare losses** resulting from increased temperatures vary **based on the probabilities assigned to tail events**.	• It is difficult to quantify by how much tail risk is underestimated (unknown uncertainty).
Input-output models	• **Quantify static economic linkages among sectors and geographic areas** to trace out upstream and downstream impacts of shocks to a given industry or region. • Allow to trace out the impacts of a policy shift like an emissions tax or to estimate supply chain impacts from extreme climate change events.	
Computable general equilibrium (CGE)	• Allow for **policy experiments with complex behavioural interactions** among sectors and agents in the economy, which are too complex to be solved analytically.	• Though some mechanisms driving CGE outcomes can be elucidated, the level of complexity is such that **the overall importance of the decision rules and parameter values governing economic agents cannot be assessed**.

Methodological considerations

Models for assessing economic impacts of climate change

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	Strenghts	Weaknesses
Dynamic stochastic general equilibrium (DSGE) models	• **Introduce yet further complexity into macroeconomic modelling**, especially in the vein of uncertainty in agent decision-making and endogenous technological change.	• Do entail a **significant computational burden** though, and can be **difficult to solve**. Ongoing investment in improving DSGE macroeconomic modelling, within both academia and central banks, may eventually make these models more useful in the context of assessing climate-related impacts.
Overlapping generation (OLG) models	• Constitute a **more transparent and stylised approach** to analysing **long-term macroeconomic evolutions**. • Their focus on the intergenerational distribution of consumption c**an highlight the large role played by discount rates** in estimating the social cost of carbon	
Agent-based models (ABMs)	• ABMs are simulations where **individual actors in the economy interact with each other and with institutions** based on a set of decision-making rules imposed by the modeller. ABMs can incorporate technological change and more realistic damage functions. • Used in measuring climate-related impacts for their ability to **better reflect uncertainty and complexity**.	• **High computational and data demands** and some **opacity** in the underlying mechanisms driving differing outputs across simulation runs.

Outputs of the models described in this section can be used as inputs **into other methodologies**.
Recent **stress testing** approaches have started linking the potential future climate paths and resultant economic damages identified in many of the modelling approaches above to the risk in bank portfolios

Methodological considerations
Broad risk measurement approaches

Among the risk measurement processes currently being applied by banks and supervisors, some more prominent and conventional practices include risk scores, scenario analysis, stress testing, sensitivity analysis, natural capital analysis and climate value-at-risk

Climate risk scores or ratings	• Climate risk scores (including heatmaps) **rate the climate risk** exposure of **assets, companies, portfolios**, or even **countries**. They combine a risk classification scheme with a set of grading criteria to assign a quality score to exposures according to their classification. The grading criteria used within these approaches can be **based on qualitative or quantitative factors**.
Scenario analysis	• Climate scenario analysis is a **forward-looking projection of risk outcomes** that is typically conducted in four steps: i) Identify physical and transition risk scenarios; ii) Link the impacts of scenarios to financial risks; iii) Assess counterparty and/or sector sensitivities to those risks; and iv) Extrapolate the impacts of those sensitivities to calculate an aggregate measure of exposure and potential losses.
Stress testing	• Stress testing is a specific **subset of scenario analysis**, typically used to evaluate a financial institution's near-term resiliency to economic shocks, often through a capital adequacy target. Recently, stress testing has been extended by some banks and supervisors to include climate-related risks and scenarios.
Sensitivity analysis	• Sensitivity analysis is also a specific **subset of scenario analysis** that is used to evaluate the effect of a specific variable on economic outcomes. Sensitivity analysis has often been used **in transition risk evaluation** to assess potential effects of a specific climate-related policy on economic outcomes, particularly in research settings to evaluate the range of economic impacts from the implementation of a carbon tax.
Natural capital analysis	• Natural capital analysis **posits nature as a capital stock** and accordingly assesses how natural degradation negatively impacts a financial institution. It is usually carried out, identifying: i) relevant geographies, sectors, borrowers and/or assets; ii) relevant natural capital assets; iii) potential natural disruptions; and iv) geographies, sectors, borrowers and/or assets most at risk. While natural capital analysis is usually conducted at a portfolio level, it can be adapted for client- or transaction-level analysis.
Climate value-at-risk	• Climate value-at-risk (VaR) assessments **apply the traditional VaR framework to gauge the impacts of climate change** on financial institutions' balance sheets. Specifically, these forward-looking, portfolio-level metrics quantify the impacts of climate change on the value of financial assets over a given time horizon at a given probability under particular climate scenarios.

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Measurement methodologies
Exposure mapping and measurement

Banks and Supervisors have developed different measurement methodologies to map and measure exposure to climate-related financial risks. These respective approaches share many similarities and overlaps. However, they may differ in terms of objectives

		Transition risks	Physical risks
Bank-level methodologies	• Approaches generally in early stages of development. • Indicators or metrics to map, measure and monitor exposures are usually distinguished by transition and physical risks:	How and to what extent certain sectors could be affected by a transition to a low-carbon economy, through **assessing the possible sources of shocks and transmission mechanisms**. Sectors often considered for these analyses include oil and gas, utilities, transportation and car manufacturing, metals and mining, and construction. Calculating the **carbon footprint** of banks' assets as a proxy for transition risk.	Indicators or metrics to map, measure and monitor physical risk at **portfolio level** aim to identify **geographical risk concentrations** and the **type of hazard** as well as its **probability** and **potential severity**. Risk scores or metrics estimate, for example, sensitivity to various acute or chronic physical risks. Some parties have developed location-based physical risk scores, covering a wide range of physical risk drivers such as heat stress, wildfires, floods and sea level rises.
Supervisors	• Indicators and metrics used are often similar to those employed by banks. • Exposures are considered according to the portfolio studied, or their sectoral, or geographical characteristics.	To assess the impact of transition risks on banks' exposures, supervisors' assessments are based on either **regulatory information or ad hoc surveys** that allow indicators associated with transition risk to be matched with banks' exposures.	To assess the banking system's exposure to physical risk drivers, supervisors identify hazards that are most relevant in their jurisdictions and, within these, the specific regions that are more vulnerable to these hazards.

Measurement methodologies
Risk quantification

Banks, Supervisors and third parties have developed methodologies to quantify climate-related financial risks, based on scenario analysis, stress testing and sensitivity analysis

Bank-level methodologies

- Bank-level scenario analysis and stress testing methods may be **used to quantify climate-related financial risks or to inform strategic planning**.
- In general, these tools seem to be still at an **early stage**, and are mostly focused on credit risk or market risk analysis.
- Climate-related financial risk scenario analysis is applied with the goal of understanding the potential impact on selected portfolios, to refine methodologies and assess limitations and benefits.
- Banks' **transition risk scenario analysis** tends to focus on impacts to credit parameters for counterparties belonging to **specific sectors** (e.g. use of a shadow price and its inclusion in a transition risk sensitivity exercise or as part of a scenario analysis: adjustments to basic prices such as electricity, carbon, fuel price, are used to evaluate how counterparties could be affected).
- **Bank's physical risk analysis** tends to focus on **corporate and household** (particularly mortgage) exposures.

Supervisory methodology

- Supervisors may use **scenario analysis and climate stress tests** for microprudential supervision, and to inform macroprudential policies. At **microprudential level,** scenario analysis and stress testing may be used to: i) quantify banks' financial exposures vulnerable to specific climate risk drivers; and (ii) understand the vulnerability of banks' business models when confronted with specific climate scenarios, and the implications for their business strategy. At **macroprudential level,** they may be used to assess the size and distribution of climate risks in the financial system, and whether these risks may be systemic in nature.
- A variety of approaches are used to **model the impact** of climate-related risks, at the macro, sector and firm level. At the macro level, and compared to most existing bank-level scenario analysis, climate scenarios are translated into macroeconomic and financial market variables. Multi-country macro-econometric models such as NiGEM are used to generate such macroeconomic variables. The impact of these variables on point-in-time credit risk parameters, including PD and LGD, are then estimated.

Third parties approaches

- In addition to specific data or metrics, supervisors and banks sometimes rely on **comprehensive methodologies or tools provided by third parties**. Features of third-party methodologies are similar to those discussed for banks and supervisors, including: exposure mapping, scenario selection, introduction of a transition or physical risk shock, and the assessment of impacts on firms' financial performance.
- Specifically for **physical risks**, a risk indicator is often proposed in the form of a climate risk score. Some methodologies assign a risk rating to an exposure based on the type of hazard to which it is exposed and vulnerable.

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Areas for future analytical exploration
Exposure mapping

Notwithstanding advances made over the last few years, practical considerations reveal significant room for enhancing the robustness of methodologies to measure climate-related financial risks

Risk classification approaches

- **Limitations of observed risk classification approaches.** While aggregate risk classification approaches exhibit several conceptual and operational advantages, they face a number of limitations in practice. Reflecting the current availability of data, identification criteria may not be granular or specific enough to sufficiently differentiate among counterparties.
- **Risk differentiation and comparability across banks and jurisdictions.** Comparability is generally a desired property of any risk classification system. However, comparability across banks' exposures, whether within or across jurisdictions, implies introducing elements of standardisation and/or simplification that may reduce risk differentiation.

Availability of appropriate data

- **Data describing physical and transition risk drivers.** A key issue is that information can lie outside the range of traditional financial data collections. The collection and usability of climate data may present methodological challenges.
- **Data describing the vulnerability of exposures**. External data providers often provide indicators to complete bank counterparty and exposure gaps – notably in relation to transition risk and/or physical risk, and assign ratings or scores with respect to these risks on an individual borrower basis.
- **Counterparty-level information**. In establishing a banking relationship and allowing the lender to perform a creditworthiness evaluation, counterparties provide proprietary non-public information, fulfil statutory disclosures, and meet other data requirements established by the bank that inform the latter about the potential client's main features.
- **Supervisory reporting data**. Supervisors can leverage their supervisory process to augment data needed to perform climate-related analyses on the banking.

Modelling framework

- **Scenario design and complexity of climate-related financial risks.** Difficulties in modelling comprehensive scenarios that can be integrated into existing risk assessment processes and structures, in particular related to the following aspects: i) uncertainty around the climate risk drivers; ii) capturing the specific impacts of climate scenarios; and iii) comprehensiveness of modelled impacts.
- **Translating scenario outputs to financial risks.** Challenges regarding the ability of financial risk models to factor in variables linked to climate scenarios. Financial models used to infer impact on risk parameters such as PDs or LGDs for credit risk have generally relied on the historical statistical relationship between a given risk driver and these parameters.
- **Time horizon related challenges.** The long-term nature of climate change is leading banks and supervisors to consider horizons that can extend significantly beyond the one commonly considered by institutions – up to 2050 in observed practices.
- **Operational complexity in the measurement of risk.** Climate risk measurement demands significant resources, including adequate systems infrastructure, relevant human resources, and a sophisticated organization.