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Purposeful scenario analysis: A framework to guide central banks and financial supervisors in the selection and design of climate scenarios

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Policy insight

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Contents

Summary

- Scenario analysis is a key tool for central banks and financial supervisors to better understand and prepare for the impacts of climate change on financial and monetary stability.
- Scenario analysis facilitates productive engagement with the uncertainties surrounding climate-related socioeconomic and technological developments, as well as the physical impacts of climate change, by calculating possible future outcomes in different sets of circumstances.
- Although scenario analysis is already widely used by financial institutions, it remains an underdeveloped practice. If optimised in its design and applications, it would have further potential to inform and prepare policymakers for the climate-related risks and opportunities that lie ahead.
- Current debates around climate scenario analysis largely focus on the shortcomings of scenarios used, such as a lack of sectoral granularity or insufficient modelling of the financial sector.
- However, an exploration of how scenarios may be fit for specific application, such as stress testing or financial disclosure, can better support central banks and financial supervisors to appropriately employ and develop scenario analysis. Clarity around the purpose of a scenario exercise is crucial to avoid misunderstandings, pitfalls and potential unintended consequences.
- This policy insight suggests a typology of potential purposes of and uses for scenario analysis from the perspective of central banks and financial supervisors. These are divided between strategy and planning (using scenario analysis to support organisational resilience, prioritisation of efforts, and communication and engagement), and policy implementation (the prudential and monetary applications of scenario analysis).
- The report proposes a framework of requirements scenarios can meet in order to serve these identified purposes. The framework is designed to initiate a discussion and outline potential starting points for further analysis and research on purpose-specific selection and design of scenarios.
- Having clearly articulated the intended purpose of scenario analysis, central bankers and financial supervisors can take further steps, including assessing existing scenarios to determine the applications they are best suited for and identify gaps; and assembling core scenario elements to assist the development of specialised scenarios.
- Scenario analysis has significant potential but is unlikely to be a silver bullet for central banks and financial supervisors in the context of continuously worsening climate change and biodiversity loss. There are likely to be trade-offs with alternative analytical or policy approaches. To avoid the danger of offering a solution before defining the problem, it is vital to first obtain clarity on purposes and goals before developing, selecting and deploying scenarios.

1. Introduction

This policy insight presents an initial conceptual framework on the application of climate scenario analysis and associated design requirements.

Since the Task Force on Climate-related Financial Disclosures (TCFD) first recommended the use of scenario analysis for climate risk management in 2017, this has become an integral tool for financial institutions, central banks and financial supervisors alike. In 2022, the Financial Stability Board (FSB) and the Network for Greening the Financial System (NGFS) counted 67 completed, ongoing or planned climate scenario exercises in 36 jurisdictions (FSB and NGFS, 2022). Currently, efforts are also underway to extend the use of scenario analysis to the theme of nature and biodiversity loss.

This broad uptake of scenario analysis reflects the suitability of this approach for addressing the challenging characteristics of climate- and also nature-related risks: namely, scenario analysis is forward-looking and explores a range of different possible pathways, enabling it to capture the non-linear and uncertain nature of risks and opportunities that are expected to materialise over long time horizons which often extend beyond the typical timeframes of financial planning or business cycles (TCFD 2017; NGFS 2021a; NGFS 2021b).

Despite the rapid rise of scenario analysis and a concerted effort by central banks and financial supervisors to develop, update and standardise underlying scenarios through the NGFS, climate scenario analysis remains a nascent practice in the financial sector, and among central banks and financial supervisors in particular. To date, scenario analysis exercises have mostly been conducted in an exploratory manner and have yet to result in direct and significant changes to supervisory requirements or investment practices.

The difficulty of directly translating the outcomes of scenario analysis exercises into policy changes indicates a number of shortcomings to currently available scenarios. These include: a lack of sectoral, temporal and sometimes spatial granularity; overly simplistic model structures; and a discrepancy between scenario outputs and the type of data needed for financial analysis and investment decision-making. While these factors certainly hamper efforts to use the results of climate scenario analysis to recalibrate specific policy instruments, **this report raises a more fundamental issue: a lack of clarity around the purpose and use of scenario analysis exercises**.

A growing number of reports describe the use and properties of climate scenarios in central banking and financial supervision, yet the specific purpose of these exercises is often obscured by imprecise language, such as scenario analysis serving "the identification and assessment of risk exposures" (FSB and NGFS, 2022: p.4), the use of climate scenarios "to identify, assess and understand climate risks" (NGFS, 2021b: p.4), and scenario analysis as "a vital tool that helps us to prepare for a range of future pathways" (NGFS, 2021a: p.2).

Failing to clearly define the specific purpose of a given scenario creates the possibility of a potential mismatch between scenario design and its intended use. This is illustrated by a recent report by the FSB and the NGFS that acknowledges that the existing NGFS scenarios – used in multiple jurisdictions as so-called 'climate stress tests' (see e.g. Hong Kong Monetary Authority, 2021) – likely underestimate climate risks, which would therefore disqualify them as stress scenarios. A more thorough examination and more explicit discussion of the purposes of scenario exercises is therefore needed.

This report is designed to create a starting point for this debate. The hope is to facilitate deeper discussions about purpose-specific scenarios in central banking, supervision, and in the financial sector at large.

2. Potential applications for climate scenario analysis

This section presents a typology of different uses that central banks and financial supervisors could make of climate scenario analysis, differentiating between: (i) strategy; and (ii) planning and policy implementation as the two main categories. This is followed by some initial considerations for the design of purpose-appropriate scenarios. First, we briefly consider the main purpose ascribed to scenario analysis to date.

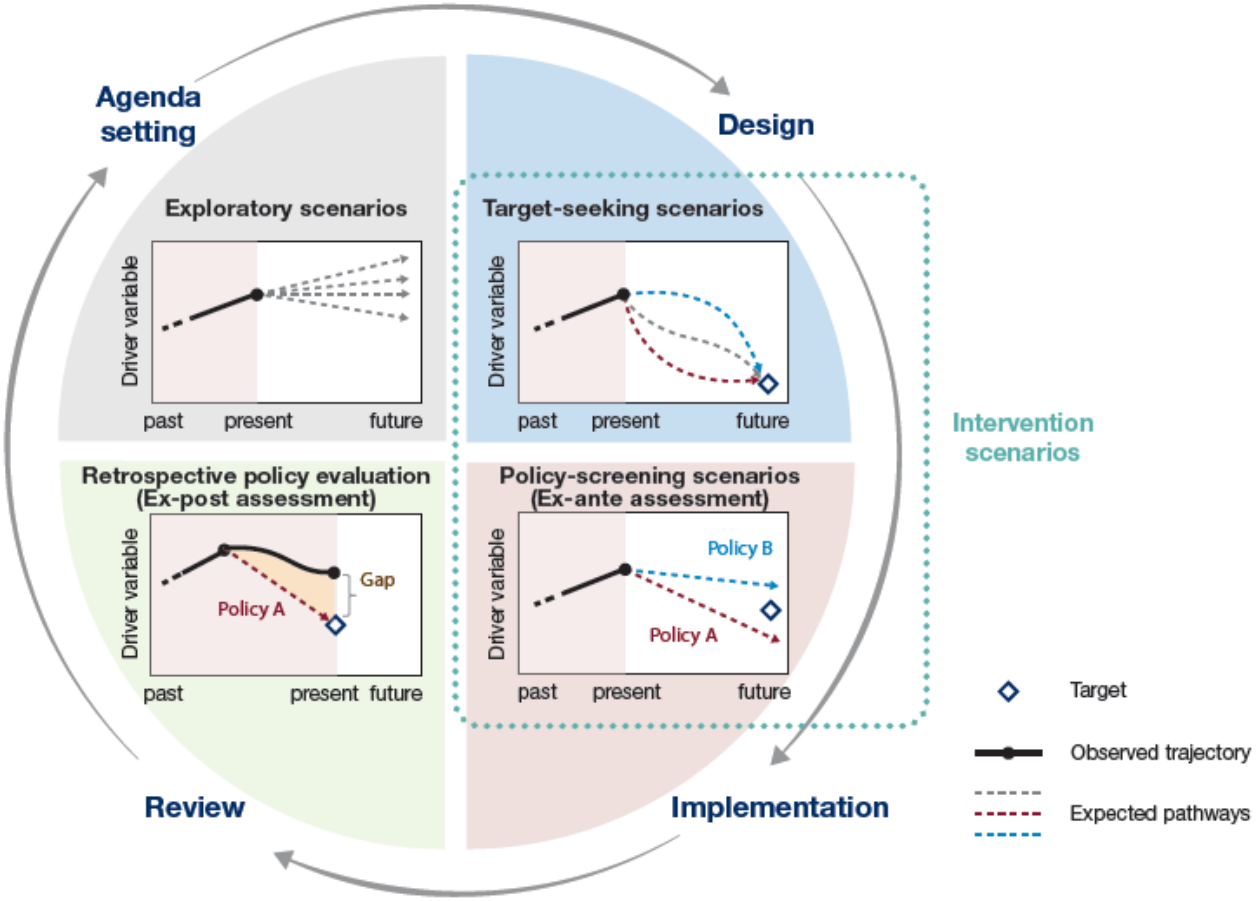
The fundamental purpose of scenario analysis is to aid the navigation of uncertain future developments by identifying a range of plausible pathways. As a tool that embraces and thus navigates deep uncertainties, scenario analysis has been employed in contexts as diverse as the military, environmental politics and business planning (Garb et al., 2008; Pulver and VanDeveer, 2009; VanDeveer and Pulver, 2021).

In the context of climate change, scenario analysis is used to assess, typically over long time horizons, how climate-related risks affect the macroeconomy, while acknowledging various dimensions of uncertainty associated with analysing climate change (Barnett et al., 2021). Unlike probabilistic approaches to envisioning the future, scenario analysis thus also embraces the radical uncertainty characterising climate change (see e.g. Chenet et al., 2021) and medium- and long-term socioeconomic developments. The statistical concepts of likelihood or 'most/least likely' are not necessarily applicable – and are potentially inappropriate – in the context of scenario analysis because they can obscure rather than productively engage with these inevitable uncertainties. The statistical concept of likelihood is therefore replaced with the concept of plausibility.

Broadly speaking, climate change scenario analysis has mainly been used in an exploratory capacity (examining different scenarios that map a broad range of plausible future outcomes) or a target-seeking capacity (comparing different scenarios that lead to the same desired outcome) (see Figure 1). In both these capacities it is used to describe plausible futures under climate change and other relevant variables such as GDP growth paths and their interactions. Identifying different possible courses of action provides decision-makers with a tangible set of options to work with.

One specific purpose of scenario analysis is climate stress testing, which examines the resilience of an organisation or system under different extreme but plausible stress conditions. Scenarios chosen for stress tests need to include such system- or organisation-specific stress situations, as appropriate. Whether a scenario is suitable therefore depends first and foremost on the purpose of the scenario analysis exercise and the questions it is employed to answer.

Figure 1. Types of scenario



Source: IPBES: https://www.ipbes.net/scenarios-models/what/scenario-methodologies

Use in strategy and planning

Central banks and financial supervisors

One of the most common applications of scenario analysis is to aid an organisation's strategy and planning. In the context of climate change and central banking, this refers to medium- and long-term strategy development for delivering on the primary and secondary objectives of mandates – e.g. price and financial stability and supporting government policies, respectively – in the context of climate-related uncertainties; thus it does not refer to immediate macro-prudential implications or implementation strategies.

This broad purpose can be broken down into three more specific aspects: organisational resilience, prioritisation, and communication and engagement.

(i) Organisational resilience

By exploring the implications of a broad range of possible future pathways of how the changing climate and economic systems interact, central banks and financial supervisors can enhance their organisational resilience. For instance, the development of reaction plans and policy responses for different adverse scenarios can shorten reaction times and provide a repository of reactive strategies. The identification of key indicators – such as 'red flag' indicators which function as an early warning system by identifying trends that lean towards specific pathways – can thereby create anticipatory capacity within central banks and financial supervisors to proactively mitigate adverse effects on financial stability, for example.

Building internal expertise and capacity through training and hiring new staff for conducting scenario exercises can enhance the sophistication of policy responses and further contribute to organisational resilience.

(ii) Prioritisation

Scenario analysis exercises can support central banks and supervisors in their prioritisation of efforts by revealing climate risk hot spots. The extent to which financial institutions or systems may be exposed to climate risks via specific transmission channels will vary. For instance, while some Indian banks might be exposed to significant transition risk through their holdings of assets related to coal-fired power plants, regional banks in the Southwest United States might be more exposed to physical risk in relation to their agriculture-related assets. Surveying different risk transmission channels and their relative importance under different scenarios can therefore help to direct research and other efforts where they are most urgently needed, especially where resources and capacity are limited.

Similarly, scenario analysis can be employed to chart different possible pathways towards policy goals (through target-setting scenarios), prioritising options based on feasibility considerations, concerns around unintended consequences, or potential conflicts with other primary or secondary objectives. More fundamentally, scenarios can help to identify a priority or policy goal in the first place. For instance, the current NGFS scenarios[1] clearly show that scenarios in which a low-carbon transition is successfully achieved are more desirable in terms of minimising overall economic costs and financial risks compared with scenarios that represent current climate action pledges or the continuation of 'business-as-usual'. These insights could also enable central banks and financial supervisors to assess their current policy frameworks and instrument calibrations based on whether they might hamper progress towards such goals (Matikainen et al., 2017) and could be recalibrated to avoid any such potential negative effects (Schoenmaker, 2021).

(iii) Communication and engagement

When central banks and financial supervisors engage with climate change in the context of their mandate, some may find that their mandate constrains them in taking a longer-term strategic view and setting priorities that are only indirectly related to their primary objectives. In this case, scenario analysis can function as a communication and engagement tool that central banks and financial supervisors can use to address governments, parliaments, intergovernmental bodies (e.g. the FSB) and international organisations. Presenting scenario results and different climate futures can raise awareness among these public bodies on how their climate-related actions and policies could impede or enable central banks to deliver on their core mandates. While it is not the role of a central bank to guide government climate policy or indicate preferences, it does have an important role in assessing how climate-related risks affect the macroeconomy under different plausible pathways. And doing so may lead to the identification of a pathway with the least significant price and financial stability implications – which is potentially valuable information for governments and legislative bodies.

Financial institutions

The key uses for scenario analysis by central banks and financial supervisors also apply to financial institutions – i.e. enhancing organisation resilience, aiding prioritisation by gauging the size and importance of hazards and transmission channels, and facilitating communication with stakeholders.

Financial institutions taking such action could have implications for micro- and macro-prudential supervision. By conducting scenario analysis exercises to analyse and gauge the size of climate risks under different pathways and enhance organisational resilience, financial institutions can build capacities relevant for the informed definition of institutional risk appetite, for their financial

[1] See https://www.ngfs.net/ngfs-scenarios-portal/ for details of the four NGFS scenarios, 'Orderly', 'Disorderly', 'Hot house world' and 'Too little, too late'.

disclosures, and for other central building blocks of the Basel III framework.[2] On the other hand, financial institutions' use of scenarios for strategy and planning could jeopardise resilience. For example, if a limited number of readily available scenarios are relied upon (such as the NGFS scenarios), this could weaken organisational resilience by reinforcing potentially inaccurate assumptions and perpetuating possible blind spots inherent to the scenarios in question. Therefore, while an open database of climate scenarios relevant to finance is a desirable and perhaps necessary analytical infrastructure, maximum transparency around the underlying methods and assumptions, as well as a sufficient range of scenario types, is pivotal to adequately managing these pitfalls.

A further risk is that scenarios branded or perceived as 'most central', 'most likely' or 'middle-of-the-road' could be picked up by a significant number of financial institutions as quasi-forecasts, leading to performative effects such as self-fulfilling prophecies (Callon, 2010; MacKenzie, 2007).

There is a strong rationale for central bankers and financial supervisors to clarify the purpose of scenario analysis for themselves and also to be aware of their potential use by financial institutions for different purposes. This intention and awareness contributes to supporting, rather than unintentionally undermining, the pursuit of financial stability objectives.

Uses in policy implementation

Scenario analysis can serve several purposes in the context of prudential and monetary policy implementation. While central banks and financial supervisors have a well-established and tested policy assessment toolbox at their disposal, the non-linearity and irreversibility of climate change calls for additional, forward-looking analytical instruments.

Prudential applications

As discussed above, supervisory scenario exercises might be conducted to aid capacity-building in both supervising and supervised entities. This has clear relevance in the micro- and the macro-prudential context. However, the primary goals of a scenario analysis exercise determine whether a bottom-up or top-down approach is most appropriate. In the former, the financial institutions conduct the scenario-based risk assessment themselves, while in the latter, the central bank leads the exercise.

There are important trade-offs to consider. For example, when conducting a top-down scenario exercise, as done by the European Central Bank (ECB et al., 2021), capacity will be primarily built within the supervisory entities (while nonetheless also including smaller entities which might lack the capacity to participate in bottom-up exercises). On the other hand, a bottom-up approach that requires supervised entities to assess their assets against scenarios provided by the supervisor is likely to be more effective in building capacity within the supervised entities. The latter also enables more granular analysis, accounting for intra-sectoral differences in risk, for example. However, given the size of the scenario analysis consulting industry, and the tendency of banks and other supervised entities to outsource parts of their scenario exercises, a bottom-up approach may not necessarily result in expertise or capacity being developed and held within supervised entities.

Macro-prudential

At the macro-prudential level, scenario analysis exercises can contribute to assessing financial stability implications by testing the resilience of a domestic or regional financial system under different climate-related stress conditions. Systemic risks might materialise in different ways in these stress scenarios. For instance, contagion effects (the spread of impacts from one region to another) and indirect exposure to affected assets could lead to cascading risks that eventually endanger financial stability (FSB and NGFS, 2022) – as demonstrated by the 2008 global financial crisis. In this context, detailed representations of the financial sector in scenario models are

[2] The Basel III framework is a set of financial regulatory measures developed by the Basel Committee on Banking Supervision in reaction to the 2008/09 banking crisis.

pivotal, but this feature is largely absent from many climate scenario models currently in use (see Battiston et al., 2021 and Monasterolo et al., 2023).

Further research is needed to strengthen the incorporation of physical- or transition-related exogenous shocks as sources of systemic risk. The materialisation of chronic climate risks can pose a different type of systemic risk by eroding the basis for entire markets. This could occur in the insurance sector, for example, if whole regions became uninsurable, with potential systemic implications for holders of affected assets and potentially for diversification issues arising from market shrinkage.

Micro-prudential

Climate scenarios can inform the implementation of micro-prudential policies in several ways. As noted by the Bank of England (2023), the results of scenario analysis could instruct the updating of capital requirements under Pillar I of the Basel Framework. Similarly, climate scenario exercises could be employed to update the requirements of regulatory supervision of the financial sector under Pillar II.

Scenario analysis is already recommended in making financial disclosures, but this is rarely specified in detail by many financial regulators. In many jurisdictions setting disclosure requirements lies outside the mandate and remit of the central bank, but disclosure is a key tool in making material [i.e. relevant] information available to the market, thus facilitating risk-pricing and market discipline. Financial disclosures deserve closer attention in this context as the primary strategy to address climate risks, and given its potential is frequently criticised (Ameli et al., 2020; 2021; Christophers, 2017).

For central bankers and financial supervisors integrating climate scenario analysis into financial climate-related disclosures, as recommended by the TCFD (2017), there are trade-offs to be made and pitfalls to be navigated. The underlying scenarios have to be sufficiently specific to the entity in question to ensure that material information specific and applicable to the reporting entity is being disclosed. However, the more that disclosure is based on bespoke, heterogeneous scenarios, the more challenging it becomes for investors and other users of financial disclosures to digest the results at scale. At the same time, the process of undertaking bespoke disclosures is more resource-intensive for the reporting entities.

On the other hand, disclosure based on standardised scenarios, while facilitating comparability between disclosing entities might lack relevance for disclosing entities. Given the nature of this trade-off, there is no inherently better or worse scenario design solution but rather purpose-appropriate and purpose-inappropriate approaches. When deploying climate scenarios for disclosure, central bankers and financial supervisors therefore need to carefully assess which purpose they are supposed to fulfil (e.g. capacity-building or the targeted facilitation of market discipline around specific hazards or risk transmission channels), in order to balance the trade-offs between relevance and usability of information.

Furthermore, central bankers and financial supervisors need to navigate the pitfalls of the two extremes of scenario-based disclosure. On the one hand, fully bespoke scenarios might carry the danger of being designed in way overly favourable to the reporting entity, or may lack sufficient transparency on pivotal design choices and assumptions. On the other hand, employing fully standardised scenarios throughout entire markets could lead to herd behaviour and the systematic creation of blind spots in market assessments of climate risks – which could become a systemic risk in itself.

Monetary applications

Climate scenarios can also be used to inform the implementation of monetary policy. Central banks rely on macroeconomic workhorse models to produce forecasts and scenario analysis. They are increasingly recognising that the integrated assessment models (IAMs) underpinning climate scenarios can be used to assess the impact of climate change on key macro-variables in the longer term, highlighting how scenario exercises can be used to inform monetary policy (Boneva

and Ferrucci, 2022). Scenario exercises can help to account for different compounding effects of climate and –nature impacts on the macroeconomy and price stability, requiring climate risks to be integrated into the determination of target variables for central banks, such as interest rates and inflation targets. For example, the European Central Bank has conducted a scenario exercise to assess the ability of macroeconomic stabilisation policies to respond to standard business cycle fluctuations in the context of a lower natural rate of interest, more frequent demand and supply shocks, and the more limited ability of monetary and fiscal policies to provide macroeconomic stabilisation in the face of standard business cycle fluctuations (ECB, 2021).

Given the lack of historical examples, it could also be desirable to assess the impact of greening monetary policy ex-ante, to explore the efficacy of doing so, alone or in combination with fiscal measures, such as through green targeted refinancing operations. Scenarios that include assumptions about the plausible impacts of green monetary policies could aid an exploratory assessment of the relative efficacy of these policies alone or combined with fiscal measures. Moreover, scenarios can help to assess the consequences of potential climate- or nature-harming biases of conventional monetary policy measures.

3. Why clarity on purpose is critical

The multitude of potential purposes and uses that scenario analysis can serve for central banks and financial supervisors makes it essential for scenarios to be designed and selected appropriately. Informed decisions based on a clear purpose can help to avoid biases created by path dependencies, the effects of organisational silos and misleading market consensus.

Developing, maintaining and running scenarios requires significant expertise, time and resources, such as access to models and data. This is a factor in some scenario analysis practitioners possibly dismissing calls for purpose-specific scenarios as being naïve or impractical. However, the resource-intensity of developing scenarios is one of the core reasons why establishing a clear purpose to guide scenario design and selection is critical. Scenarios are usually assembled by a multitude of teams, organisations and experts from across different professions (e.g. economists, hydrologists, catastrophe modellers etc.) because the multitude of models (from climate to land use, energy and macro-economic models) and databases needed require a diversity of expertise to understand the underlying phenomena and dynamics. These complexities make it particularly important to develop clear overarching guidance on the purpose a scenario should serve, to avoid the risk that the multitude of judgement calls, assumptions and calibrations going into every scenario design are unduly shaped by organisation-specific dynamics and routines, professional convictions and path dependencies (e.g. model assumptions and calibrations might be chosen based on previous model runs and configurations for efficiency reasons).

The NGFS scenarios demonstrate this need. Partly relying on data inputs and model structures developed for target-seeking scenarios (to instruct policymakers during climate negotiations), some features of the scenarios such as the significant smoothing of development pathways (e.g. assuming zero market friction or perfect foresight), are of only limited value for certain risk assessment purposes. Similarly, scenario elements developed within academia might be strongly influenced by academic priorities such as avoiding speculative statements, which could conflict with needs related to a scenario's purpose (e.g. the need to explore extreme scenarios).

As different elements of scenarios are developed within different teams, organisations and professional groups, the risk of insufficient communication, coordination or mutual understanding grows. The 2008 global financial crisis serves as an example of the potentially disastrous effects of silo formation. This manifested as a disconnect between departments evaluating credit default obligations and asset-backed securities within credit rating agencies leading to a systematic underestimation of correlation risk (MacKenzie, 2011). The misunderstanding and misuse of climate model outputs within the financial sector, as highlighted by Fiedler et al. (2021) and Pitman et al. (2022), could be seen as an early indication of silo formation. Clearly defining the use-case and purpose of a scenario and communicating its intended applications across organisational and professional boundaries is therefore necessary (although not solely sufficient) to avoid the effects of organisational silos for climate scenario analysis.

Even when certain scenarios are used widely for a seemingly similar purpose (e.g. the use of NGFS scenarios in supervisory scenario exercises), it remains essential to assess whether scenarios indeed fit the stated purpose because models and other tools can be adopted and used extensively across the financial sector for reasons other than their intended purpose. Tools may be put to use because adopting organisations find them to be useful in other ways. For instance, the Black-Scholes option pricing model owes its initial success to its easy application rather than to its predictive accuracy, and it has been shown to have systematically underestimated option prices when it was first introduced on trading floors (MacKenzie, 2007). Similarly, the Gaussian copula model family achieved widespread use due to its usefulness in booking traders' profits and losses, among other reasons, rather than its accuracy (MacKenzie and Spears, 2014). Having clarity on the purpose of scenarios is therefore critical for central bankers and financial regulators so that they can avoid following best practice' or 'market practice' that is shaped by organisational usefulness rather than supervisory or prudential purposefulness.

4. Purpose-specific requirements for scenarios: a framework

The diversity of potential purposes and uses for scenario analysis, and the potential pitfalls of not clearly specifying or communicating a purpose during the design or selection of scenarios, raise the important question of what features climate scenarios need to have in order to serve different purposes. Further work is needed to answer this question comprehensively, recognising the limitations a purely theoretical approach. In the meantime, this section provides an initial framework with suggested starting points for a discussion around the design of purpose-specific scenario requirements, based around four key dimensions: narrative, level of granularity, model specificities, and uncertainty.

Narrative

The scenario narrative provides the qualitative foundation of each scenario. Key questions to ask to ensure that a scenario's narrative matches its intended purpose include:

- *Is it more appropriate for the narrative to outline a more plausible or a more extreme case?*
- *What is the appropriate timeframe for the narrative and how far into the future should it look?*
- *How relevant are balance sheet assumptions to the narrative?*
  This question is particularly relevant in a scenario capturing a sudden, uncoordinated and ill-prepared transition – often called a 'disorderly transition scenario' – where a dynamic balance sheet approach, which allows financial institutions to change their portfolio composition, can be interpreted as misaligned with the sudden nature of the rest of the narrative. In this particular case, and to avoid an underestimation of risk exposure, the scenario narrative might require a more nuanced, dynamic balance sheet approach that prohibits just-in-time adjustments and reactions based on efficiency. Equally, a static balance sheet approach might be misaligned with the long time horizons of strategic planning.
- *How stable or flexible should the narrative be?*
  While the purpose of enhancing organisational resilience may, for instance, call for a regular fundamental change of scenario narratives (e.g. see the early example of Shell, in Wilkinson and Kupers, 2013), narratives underlying scenarios used for strategic planning and the pursuit of long-term policy goals need to maintain same basic continuity in their narrative over years to serve their purpose.
- *Which are the relevant drivers of a scenario narrative?*
  While it is currently accepted practice to develop scenario narratives based on the two key drivers of transition and physical risk, alternative drivers might be more appropriate for specific use cases. For instance, scenarios for monetary policy applications could be driven by different combinations of climate- or nature-related supply or demand shocks.

Granularity

Providers of scenarios – including the NGFS – often face calls to increase the level of granular detail to their scenarios. The question of optimal granularity has to be discussed in the context of the purpose of the scenario exercise.

In general, there are three dimensions to scenario granularity:

- *Sectoral granularity* – how many sectors and sub-sectors are modelled separately

- *Temporal granularity* – how long or short the modelling time intervals are, e.g. 1, 5 or 10 years
- *Spatial granularity* – how many countries or regions are separately modelled.

While there are further important differences – for example, relating to whether granularity is achieved through separate modelling or through post-modelling disaggregation – these three types of granularity provide an initial starting point for a discussion of the implications of different purposes for scenario granularity. Additionally, areas within the scenario model should be differentiated. For instance, to conduct macro-prudential supervision, a central bank might choose to employ a spatially and sectorally high-level macro scenario, featuring a 'coarse', i.e. low, level of granularity. This scenario could be generated with a general equilibrium model that represents the financial sector in greater detail, potentially including cascading and contagion effects. A financial institution, on the other hand, might choose to rely on a partial equilibrium model that features the particular sectors of relevance in a more disaggregated and granular, bottom-up manner. While the optimal level of scenario granularity will ultimately be determined by the purpose of the exercise, the application in practice can also be limited by data gaps related to granular climate-related information on counterparties, location data and climate-related projections (FSB and NGFS, 2022).

Model specificities

Several model specificities also need to match the purpose of scenario exercises, including the type of representation of the overall economy (Monasterolo et al., 2023), which can deeply affect scenario outputs. Relevant considerations include whether stress scenarios should employ a stock-flow-consistent or an agent-based model to account for endogenous and exogeneous shocks. Similarly, the level of integration of different scenario modules or components might vary in relevance across different scenario exercise purposes.

The role that transition and physical risk factors play in scenarios is another important aspect. The deep integration of physical and transition risk components might be highly relevant for strategy and planning purposes where the transition to a low-carbon economy is a priority, as physical hazards could severely impact transition pathways. But this would be a lower priority in the context of macro-prudential supervision of financial systems that are primarily exposed to physical risk.

Uncertainty

As they aim to meaningfully represent possible futures, analysing uncertainty is at the very core of scenario analysis exercises. However, the extent to which scenario outputs can be subject to uncertainties varies. For instance, lower-bound estimates exclude some of the most uncertain hazards or dynamics and carry a lower degree of uncertainty than so-called 'middle-of-the-road estimates' as they explicitly only define a lower-bound value rather than a single value that might be more or less precise.

In the process of designing scenarios, a purpose-driven discussion around whether certain types of risks are underrepresented is needed, including whether there is too great a focus on middle-of-the-road scenarios or whether 'black swan' scenarios should be considered. The answer will depend on the use and purpose. For example, a prudential application of scenario analysis that aims to also inform capital requirements may warrant a lower tolerance for uncertainty than an exploratory use of scenario analysis that aims to build organisational resilience.

Table 4.1 provides a starting point for a discussion around purpose-specific requirements for climate scenario analysis. Organised around the set of dimensions discussed above, and applied to the two overarching applications of scenario analysis as described in Section 2 – strategy and planning, and policy implementation, it describes the relevant characteristics of scenario exercises for the main purposes of scenario analysis identified.

Table 4.1. Purpose-specific requirements for scenario analysis: a framework for discussion

Purpose	Narrative	Granularity	Model specificities	Uncertainty
Strategy and planning				
Organisational resilience	Exploratory scenarios capturing a wide range of plausible futures reflected in narratives. Regularly changing narratives to account for new trends and developments.	Overall coarse (low) granularity, unless otherwise specified in narratives (e.g. by a sector- or region-specific component of the narrative).	Varying model structures to increase variation between exercises.	High tolerance for uncertainty as the primary objective is to explore the possible.
Prioritisation of risks	Exploratory scenarios capturing a wide range of plausible futures reflected in narratives.	Coarse granularity, but increasing sectoral and spatial granularity might be needed for more advanced prioritisation efforts.	Models to enable the isolated assessment of different transmission channels and risk drivers.	High to medium tolerance as the goal is to assess the order of magnitude.
Prioritisation of policy goals and strategies	Target-seeking scenarios to be reflected in narratives. Less focus on extreme narratives (e.g. sudden technological breakthroughs). Regular updates of narratives (e.g. at 5-year intervals).	Coarse granularity.	Transition and physical risks plus their interactions to be represented. Trade-offs between mitigation and adaptation measures to be captured. Integration of economic and nature systems is needed.	High tolerance for uncertainty as directional indications rather than precise quantities are sought.
Engagement	Depending on the nature and target of the engagement effort, requirements may be similar to one of the two prioritisation purposes.			
Policy implementation				
Prudential				
Micro-prudential	Exploratory, focusing on extreme/stress scenarios. Regular updating of narratives to account for new	High level of granularity to sufficiently reflect institution-specific differences.	No general equilibrium or other models smoothing pathways. Bottom-up approach using partial equilibrium models.	Low tolerance for uncertainty to facilitate integration of results into the prudential framework (e.g. Pillar I and Pillar II).

	trends and developments.			
Macro-prudential	Exploratory scenario narratives focusing on different types of extreme or stress scenarios.	Spatial granularity roughly matching jurisdictions. Medium to high temporal granularity.	Interdependencies between financial institutions and cascading effects to be accounted for.	Low tolerance for uncertainty.
Disclosure	Exploratory. Institution-specific or standardised. Plausible stress scenarios delineated by the two most relevant risk-drivers for a given institution. Regular updates of narratives (e.g. every year).	Narrative- and institution-specific granularity (geographic and sectoral). High temporal granularity with a short time horizon.	If narratives are bespoke, models to enable different channels' effects to be easily shut down to focus on institution-specific risk.	Medium tolerance for uncertainty.
Monetary				
Targeted financing operations	Policy-screening scenario narratives.	High granularity needed to account for company- and bank-level information.	Integration of economic and non-economic systems. Risk channels can be kept separate. Representation of a bank lending sector required.	Medium tolerance for uncertainty.
Interest rate setting	Exploratory scenario narratives.	Coarse granularity.	Macro models that integrate economic and non-economic systems as well as physical and transition risk.	Medium tolerance for uncertainty.

Source: Compiled by authors.

5. Conclusions and recommendations

Given the growing reliance on climate scenario analysis by central banks, supervisors and market participants, there is a need for a focused discussion about the purposes of scenario analysis exercises and the need for scenario design to match their respective applications. For central banks and supervisors, this may be to inform high-level strategy and planning or the calibration of prudential and monetary instruments. A range of purpose-specific design questions then have to be answered.

Having clearly articulated the intended purpose of scenario analysis – whether in the context of climate change or the broader decline of biodiversity and nature (see e.g. NGFS and INSPIRE, 2022) – central bankers and financial supervisors can take the following subsequent steps:

1. Existing scenarios can be screened and assessed in the context of the purpose-specific design criteria outlined in this report to determine the applications they are best suited for.
2. Gaps in the landscape of existing scenarios can be identified, prompting either more targeted scenario design efforts or a search for alternative tools.
3. A set of core scenario elements could be assembled around features shared by scenarios used for different purposes in order to assist the development of specialised scenarios, building on these core elements.

This policy insight has attempted to steer current discussions away from a focus on the shortcomings of scenarios and towards the purpose-specific fitness of the scenarios for central banks and supervisors. A focused debate on purpose, use and purpose-specific design criteria will not only contribute to enhancing existing and instructing new scenarios, but could also result in agreement over the purposes that scenario analysis simply cannot (yet) serve.

Despite its significant potential, scenario analysis is unlikely to be a silver bullet for central bankers and financial supervisors in the context of continuously worsening climate change and biodiversity loss. Depending on priorities and goals, and given the significant resources and attention required to develop and maintain useful and purpose-specific scenarios, there are likely to be trade-offs with alternative analytical or policy approaches. To avoid the danger of offering a solution before defining the problem, it is vital to first obtain clarity on purposes and goals before developing, selecting and deploying scenarios.

References

Ameli N, Drummond P, Bisaro A, et al. (2020) Climate finance and disclosure for institutional investors: why transparency is not enough. *Climatic Change* 160(4): 565–589.

Ameli N, Kothari S and Grubb M (2021) Misplaced expectations from climate disclosure initiatives. *Nature Climate Change* 11(11): 917–924.

Bank of England (2023) *Bank of England report on climate-related risks and the regulatory capital frameworks*.

Barnett M, Brock W and Hansen L (2021) *Climate change uncertainty spillover in the macroeconomy*. Cambridge, MA: National Bureau of Economic Research.

Battiston S, Monasterolo I, Riahi K, et al. (2021) Accounting for finance is key for climate mitigation pathways. *Science (New York, N.Y.)* 372(6545): 918.

Boneva L and Ferrucci G (2022) *Inflation and climate change: the role of climate variables in inflation forecasting and macro modelling*.

Callon M (2010) Performativity, misfires and politics. *Journal of Cultural Economy* 3(2): 163–169.

Chenet H, Ryan-Collins J and van Lerven F (2021) Finance, climate-change and radical uncertainty: Towards a precautionary approach to financial policy. *Ecological Economics* 183(106957).

Christophers B (2017) Climate Change and Financial Instability: Risk Disclosure and the Problematics of Neoliberal Governance. *Annals of the American Association of Geographers* 107(5): 1108–1127.

ECB [European Central Bank] (2021) *Climate change and monetary policy in the euro area*.

ECB, Muñoz M, Kouratzoglou C, et al. (2021) *ECB economy-wide climate stress test: methodology and results*. European Central Bank.

Fiedler T, Pitman A, Mackenzie K, et al. (2021) Business risk and the emergence of climate analytics. *Nature Climate Change* 11(2): 87–94.

FSB [Financial Stability Board] and NGFS [Network for Greening the Financial System] (2022) *Climate Scenario Analysis by Jurisdictions: Initial findings and lessons*.

Garb Y, Pulver S and VanDeveer S (2008) Scenarios in society, society in scenarios: toward a social scientific analysis of storyline-driven environmental modeling. *Environmental Research Letters* 3(4): 45015.

Hong Kong Monetary Authority (2021) *Pilot Banking Sector Climate Risk Stress Test*.

MacKenzie D (2007) Is Economics Performative? Option Theory and the Construction of Derivatives Markets.In: MacKenzie D, Muniesa F and Siu L (eds) *Do economists make markets? On the performativity of economics*. Princeton, NJ: Princeton University Press, pp. 54–86.

MacKenzie D (2011) The Credit Crisis as a Problem in the Sociology of Knowledge. *American Journal of Sociology* 116(6): 1778–1841.

MacKenzie D and Spears T (2014) 'A device for being able to book P&L': the organizational embedding of the Gaussian copula. *Social Studies of Science* 44(3): 418–440.

Matikainen S, Campiglio E and Zenghelis D (2017) *The climate impact of quantitative easing*.

Monasterolo I, Nieto M and Schets E (2023) The good, the bad and the hot house world: conceptual underpinnings of the NGFS scenarios and suggestions for improvement. *Banco de España Documentos Ocasionales* 2302.

NGFS [Network for Greening the Financial System] (2021a) *NGFS Climate Scenarios for central banks and supervisors*.

NGFS (2021b) *Scenarios in Action: A progress report on global supervisory and central bank climate scenario exercises*.

NGFS and INSPIRE (2022) *Central banking and supervision in the biosphere: An agenda for action on biodiversity loss, financial risk and system stability*. Final Report of the NGFS-INSPIRE Study Group on Biodiversity and Financial Stability.

Pitman A, Fiedler T, Ranger N, et al. (2022) Acute climate risks in the financial system: examining the utility of climate model projections. *Environmental Research: Climate* 1(2): 25002.

Pulver S and VanDeveer S (2009) "Thinking About Tomorrows": Scenarios, Global Environmental Politics, and Social Science Scholarship. *Global Environmental Politics* 9(2): 1–13.

Schoenmaker D (2021) Greening monetary policy. *Climate Policy* 21(4): 581–592.

TCFD [Task Force on Climate-related Financial Disclosures] (2017) *Final Report: Recommendations by the Task Force on Climate-related Financial Disclosures*.

VanDeveer S and Pulver S (2021) Scenarios. In: Morin J-F and Orsini A (eds) *Essential concepts of global environmental governance:* Abingdon Oxon: New York; Routledge.

Wilkinson A and Kupers R (2013) Living in the Futures: How scenario planning changed corporate strategy. *Harvard Business Review* (May): 119–127.