Network for Greening the Financial System

Technical document

Climate Change and Monetary Policy

Initial takeaways

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Central Banks and Supervisors
Network for Greening the Financial System

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This document was prepared by the "Scaling up Green Finance" workstream of the NGFS, chaired by Sabine Mauderer from the Deutsche Bundesbank.

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Introduction

Climate change is one of the most significant structural force shaping the global economy. Its impact will be substantial and diverse, affecting all economic agents and sectors across the globe. This report compiled by the NGFS group of experts on monetary policy and climate change investigates the possible effects of climate change on the conduct of monetary policy. Based on a comprehensive review of existing literature, studies and expert analyses, it provides some early answers to the following questions:

(I) How does climate change affect key macroeconomic variables?
(II) What are the effects on the monetary transmission channels and central banks' assessment of their policy space?
(III) Do central banks' prevalent analytical toolkits adequately reflect climate change?
(IV) How might climate-related risks affect different monetary policy regimes?

The following key points reflect the views shared by NGFS members.

1. Climate change and its mitigation will increasingly affect key macroeconomic variables for the conduct of monetary policy across many different time horizons

Figure 1 below gives an overview of some of the key variables that are typically affected by climate change, and lists some of the challenges this might present for the conduct of monetary policy.

Table 1 below summarises in greater detail the main stylised findings from a comprehensive review of the existing research. It illustrates that climate change and its mitigation could affect several key economic variables in different, possibly contradictory ways. Thus, transition risks need to be assessed differently from extreme weather events and gradual warming because transition risks are subject to policy uncertainty and therefore depend on different factors.

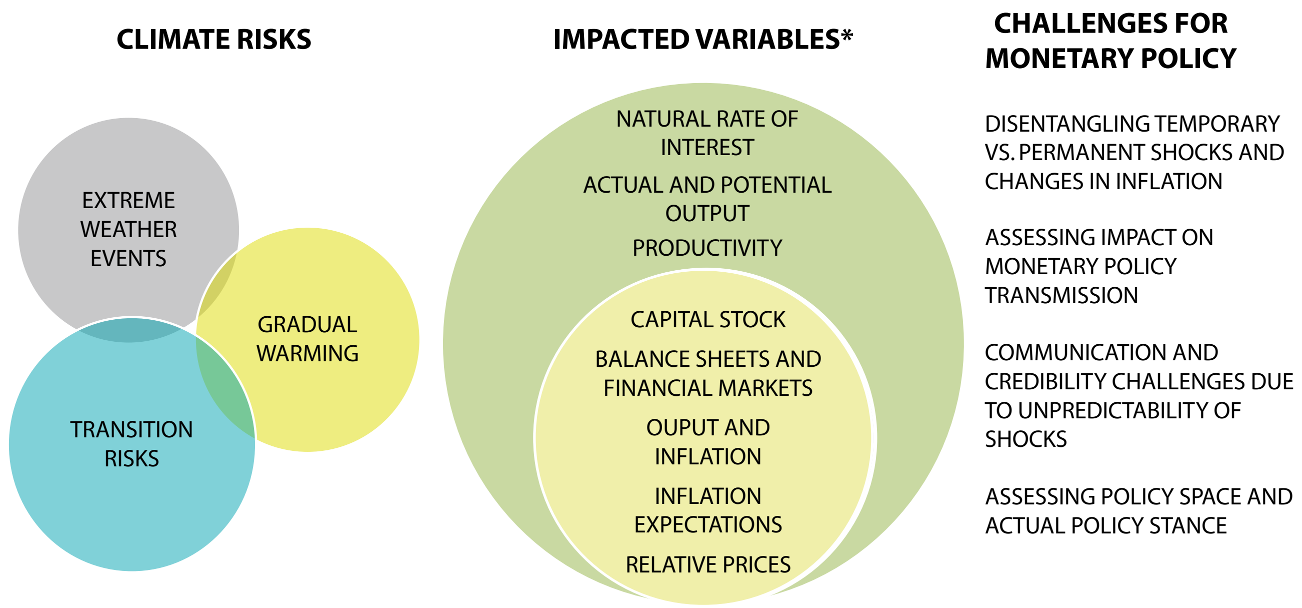
This review finds that the uncertainties surrounding climate change and its mitigation complicate the economic assessment. Predicting the timing and intensity of the economic consequences of climate change with any great accuracy is a challenging endeavour. The timing and interaction of governments' policy responses, and the question of whether they go far enough, in terms of transitioning to carbon-neutral economies, adds more layers of complexity. Taken together, these factors further complicate central banks' analyses of (i) the position of the economy in the business cycle, (ii) the nature and persistence of shocks hitting the economy, and (iii) potential growth.

While some of these challenges are not unusual in a monetary policy context, they could become more acute due to the non-linear nature of climate change, i.e. "tipping points" in the climate system, leading to irreversible effects, and the long time horizons.

Takeaway 1

The NGFS recommends that central banks consider the possible effects of climate change on the economy. These effects may be relevant to monetary policy even if they only materialise beyond the conventional three- to five-year policy horizon. Central banks should acknowledge that climate change already is part of their monetary policy contexts.

Figure 1. **Climate risks, macroeconomic variables and challenges for monetary policy**



** For impacted variables, the darker the shade, the shorter the time horizon*
Source: NGFS (internal)

Table 1. **Impact of climate change on key macroeconomic variables: main findings**

Variables	**Types of climate risk** *Timing of effects* *NB: The short- to medium-term impacts of extreme weather events and gradual warming need to be assessed differently from those related to transition risks, which are subject to policy uncertainty and therefore depend on different factors*		
	Physical risk: extreme weather events *Short- to medium-term*	**Physical risk: gradual warming and more volatile temperatures and precipitation patterns** *Medium- to long-term*	**Transition risk: transition to low-carbon economies** *Short- to long-term*
Output	Lower due to physical destruction (crop failures, destruction of facilities and infrastructure, disruption of supply chains and tourism).	Lower due to lower labour productivity, investment being diverted to mitigation, and arable land losses.	Capital and labour reallocation process could create frictions across sectors as a result of distortive (fiscal) transition policies and/or (fiscal) transition policy uncertainty and associated insufficient/inefficient investment. Mitigated impact depends on the use of proceeds from (fiscal) transition policies.
Consumption	Lower due to increased uncertainty, e.g. surrounding housing wealth and future income prospects. Higher due to increased household demand to replace destroyed goods, or hoarding behaviour.	Higher volatility due to shifts in sectoral demand.	Likely lower due to increased sustainability awareness (e.g. preference for circular economy). Shift towards greener goods and/or services can also spur sectoral shifts, but the impact on aggregate consumption is uncertain.
Investment	Lower due to increased uncertainty, volatility and direct destruction of the capital stock. May pick up following an extreme event, but the effective or useful stock of capital may well be lower. Diversion of investment away from productivity-enhancing investment and towards mitigation.	Shifts in investment towards climate adaptation technologies.	Higher as investment shifts towards climate mitigation technologies. Lower because of higher uncertainty surrounding future policies, the rise in stranded assets, and reduced productivity gains from the international division of labour.

Productivity	Lower labour and capital productivity due to (possibly permanent) capital and infrastructure destruction.	Lower labour productivity because of lower human capital accumulation (as a result of increased health issues and mortality).	Effect on productivity uncertain because technological progress could offset the under-investment that is likely to materialise because of transition policies and the rise in stranded assets.
Employment	Lower because of the destruction of physical assets and the dislocation of people from the immediate vicinity of a disaster area. Potential frictional unemployment, which can be mitigated if labour mobility is sufficient.	Reduction in labour supply in exposed industries such as construction and agriculture, where it becomes less desirable to work in higher temperatures. Increased international migration flows, might raise the labour supply in less affected regions.	Changes in sectoral composition of labour market might trigger a rise in structural unemployment.
Wages	Uneven effects across sectors and economies (agriculture, tourism and construction are most exposed in developing economies). Reallocation of the workforce can generate labour shortages in some sectors where wages could increase temporarily. Wage patterns contingent on the length of the disaster effects (e.g. flooding).	Lower wages could result from lower productivity caused by gradual warming.	Potential shift of workers from one sector to another and their training needs.
International trade	Disruption of import/export flows due to disasters could lead to lower incomes via loss of export markets or higher import costs. Supply chain interruptions can lead to supply disruptions. Tourism may suffer from destruction of infrastructure.	Disruption of trade routes due to geophysical changes (such as rising sea levels). Increases in average temperatures could diminish export values.	Taxes, regulations and restrictions might disrupt import and export routes. Changing international demand for different types of energy products may affect energy exporters and importers differently. Risks of distortion from asymmetric or unilateral climate policies. Robust and open international trade infrastructure can act as a buffer absorbing some of the negative impacts of climate change shocks.
Exchange rate	Depreciation pressure on currencies of economies affected by climate disasters, because of negative terms of trade shocks and lower labour productivity.	Depreciation pressure on currencies of economies frequently affected by climate disasters and/or losses of arable land, because of extreme temperatures.	Freely floating exchange rate may offer an absorption capacity for shocks, especially for economies perceived as being further away from a low carbon standard.
Inflation	Increased inflation volatility, especially regarding food, housing and energy prices. Heterogeneous impacts on headline inflation, with the impact being stronger and more persistent in developing countries. Impact on inflation expectations.	Relative price changes due to shifting consumer demand or preferences and changes in comparative cost advantages.	Energy prices affected most by climate-related transition policies, such as CO_2 allowances and carbon taxes. Policy uncertainty could weigh on inflation through its impact on investment, demand and inflation expectations. Inflationary pressures may be mitigated by technological changes that improve productivity or resilience, or by shifting consumer preferences towards climate-friendly products and services that should gradually enter the consumer basket when the consumer basket weights are updated.
Inflation expectations	More homogenous, sudden and frequent revisions of expectations will be induced. Potential decline in the overall dispersion of inflation expectations (due to a more synchronised response by professional forecasters). Information rigidities tend to disappear following natural disasters (on a major scale).	Longer-term impact of climate-related shocks on actual inflation, e.g. on food and energy prices, may affect inflation expectations (due to reciprocal causality between these two variables).	Formation of inflation expectations will be affected, e.g. through changes in tax measures. Actual inflation impacts of transition policies might also affect inflation expectations.

2. Climate change could blur a central bank's assessment of its room for manoeuvre (its "policy space")

Typically, central banks estimate the real rate of interest that is consistent with stable inflation when the economy is growing at full employment. The estimation of this "natural interest rate" (NIR) is one element which helps to define the monetary policy stance (accommodative, neutral or restrictive), given a country's position in the economic cycle.

Overall, the effect of climate change on the NIR, via various drivers, is ambiguous (Table 2). If an economy whose NIR is already low is struck by more frequent, severe climate-induced natural disasters, this could imply, all else being equal, that the central bank is more likely to hit the zero – or effective – lower bound on policy interest rates. This would reduce policy space for conventional tools.

Takeaway 2

Overall, while it is acknowledged that the natural interest rate is an unobservable variable and notoriously difficult to estimate, it would be highly valuable for central banks to analyse these issues in greater depth. Central banks would benefit from enhanced assessments of the potential impact on the natural interest rate since they could reveal that policy space is more limited than previously thought, which has implications for the conduct of monetary policy.

Table 2. **Climate change and the natural interest rate (NIR)**

Channel	Potential impact of climate change
Growth	Ambiguous • Lower NIR as climate change might discourage labour supply, lower labour productivity, and shift age composition of population. • Higher NIR for countries attracting migration flows as climate change increases their labour supply.
Technology	Ambiguous • Lower NIR through diversion of resources away from innovation and towards mitigation and adaptation. • Higher NIR as environmental regulation may foster the search for efficiency gains and encourage innovation.
Savings behaviour	Lower NIR through increased preference for savings driven by (i) greater income inequality (the poorest part of the population is typically more exposed to the consequences of climate change), and (ii) higher uncertainty about the future.
Risk premium	Lower NIR as climate change could increase preference for holding safe assets.
Fiscal policy	Higher NIR as government debt rises because of increased mitigation and adaptation investment or higher expenditure to cover health and other costs of natural disasters.

3. Climate change may affect the transmission channels of monetary policy

Climate change may affect the balance sheets of financial intermediaries, asset valuations and the expectations of economic agents. As a consequence, transmission channels of monetary policy may be impaired by the rise in stranded assets and increased credit risks amid more intense climate-related developments. Moreover, as the financial system is at the core of the transmission mechanism, an abrupt repricing of assets potentially triggered by transition measures could put pressure on banks' balance sheets and constrain their ability to provide credit to the economy. Beyond these channels, the expectation channel could also be distorted as climate change intensifies (Table 1).

Figure 2 shows the potential effects of climate change on the various transmission channels relevant for the conduct of monetary policy.

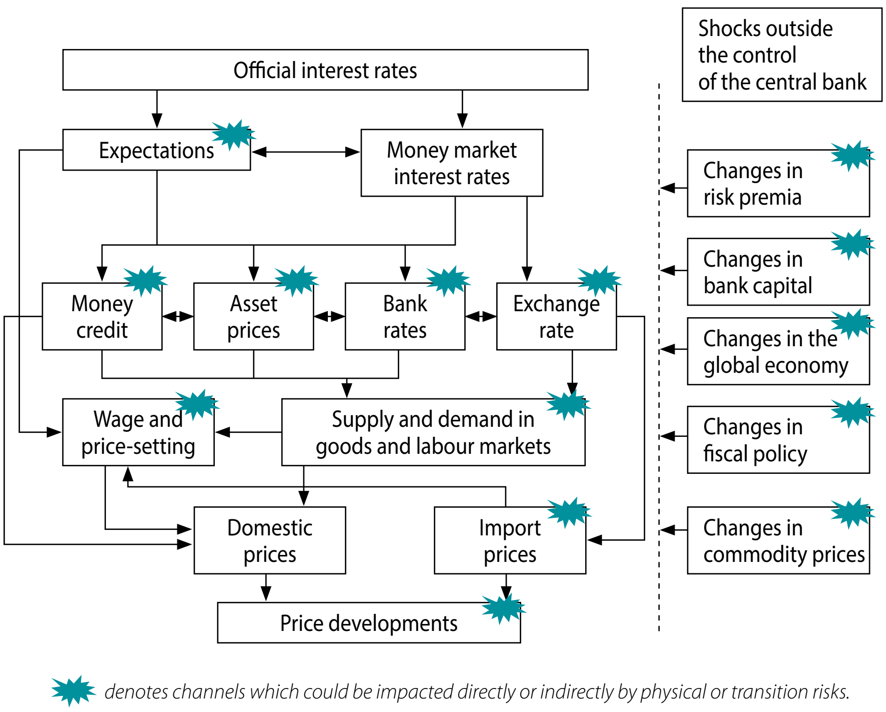
Takeaway 3a

The NGFS stresses the importance for central banks to conduct further in-depth analyses of the impact of climate change on transmission, not least because their credibility hinges on having a good understanding of the effectiveness of their policy instruments.

Takeaway 3b

The NGFS recommends that central banks assess the implications for risk management practices, as climate-related shocks may affect the riskiness of their financial portfolios and market operations. As the NGFS has already stated (NGFS 2019a), climate-related risks are a source of financial risk.

Figure 2. **Impact of climate risks on monetary policy transmission channels**



4. Central banks need to reinforce their analytical toolkit by considering adding climate risks to their macroeconomic models and forecasting tools

With climate change already in evidence, central banks need to consider how they can incorporate the relevant climate-related effects more specifically into their models. That said, the complexity of climate change means that more than one type of model is needed to capture its potential impact. There are a number of modelling methods which central banks could mobilise to this end, only a few of which are covered here.[1]

Central banks could use **integrated assessment models (IAMs)** to assess the medium- to long-term impacts of climate change on the economy. These models may be useful for designing longer-run scenario analyses, in particular for growth and NIR scenarios. However, some characteristics of IAMs make them less suitable for assessing climate change effects, as they lack certain key features which central banks need. Figure 3 briefly highlights how key variables differ in selected IAMs. Central banks looking to incorporate the effects of climate change need a framework that can adequately capture important real and financial market interactions. Current IAMs do not meet these requirements.

Less structural models, such as forecasting or *nowcasting* models, can also be extended to incorporate climate-related data. As less structural models are more data-driven, climate-proofing them would require a large set of high-quality climate data.

Another analytical framework, **scenario analysis**, could help central banks better understand the different possible macroeconomic paths related to climate change and their potential implications for monetary policy. However, IAMs combining economics, energy systems, land use, and climate science have been designed for purposes other than those relevant for assessing the impact of climate change on monetary policy. Economic modelling generally focuses on long-term structural changes (up to 2100) with time-steps of 5 years or more. They tend to ignore shorter-term inflation and business cycle dynamics, and model the macroeconomic impacts of physical risk and transition risk separately. For these reasons, the outputs tend to be of limited use for monetary policy analysis. Moreover, certain design features have come in for criticism because they affect the magnitude of the results, particularly over the longer horizon needed to analyse climate change impacts, where the outcomes can vary significantly depending on the design feature or assumption chosen.

Thus, the various modelling methods have different advantages and disadvantages. Models using historical data (e.g. historical relationships between variables) might not provide enough forward-looking guidance on how future outcomes may evolve, because of the high uncertainty created by climate change.

Therefore, **there is ample room for further work** on creating adequate modelling tools that enable central banks to account for the impacts of climate change, and on gathering relevant climate-relevant data.

Broadly speaking, issues that require model upgrades and are of genuine interest for monetary policy include (i) the estimation of the impact of climate change on the NIR, (ii) the identification and propagation of climate-related shocks, and (iii) the impact of transition policies.

Takeaway 4a

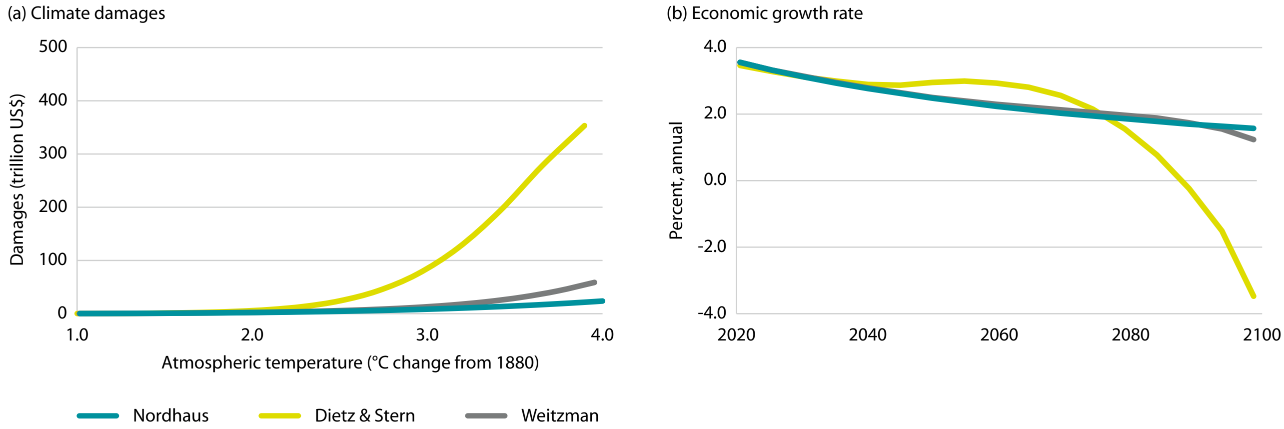
The NGFS recommends that central banks embrace an interdisciplinary approach to research the impacts of climate change, and how to best reflect the above-mentioned trends in macroeconomic models.

Takeaway 4b

Central banks could share their research agenda more broadly and are encouraged to open up to issues that typically lie outside their natural remit, by seeking expertise in environmental economics and extending their analysis to include biophysical stock and flow constraints.

1 See Table 7 in NGFS (2019b), which briefly outlines different economic models with their respective strengths and weaknesses. An overview of economic climate models can also be found in NGFS (2020) *Guide to climate scenario analysis for central banks and supervisors*.

Figure 3. **Comparison of damage functions and their impact on economic growth**



The charts above illustrate how cost/benefit analysis based on IAM models like the dynamic or regional integrated models of climate and the economy (DICE and RICE models) is prone to assumptions related to what is called the "damage function". This function, which is also known as the "damage curve", translates changes in temperature into economic output losses and is perhaps the most contentious aspect of modelling. The "Nordhaus" damage function leads to a relatively modest estimate of US$31 trillion of damage in 2100, while the "Dietz & Stern" damage function estimates a figure of more than US$400 trillion (Chart 3a). The "Nordhaus" approach sees economic growth slowing modestly to around 2% by 2100 (Chart 3b), while the "Dietz & Stern" damage function expects temperature changes to have significantly stronger economic impacts, with stagnation followed by economic contraction by the end of the century if no additional action is taken to mitigate the impacts.

5. All monetary regimes will face challenges because of climate change and its mitigation

No particular monetary regime is ex ante likely to fare better than others in terms of "absorbing" climate-related shocks on the supply or demand side.

As climate change will affect each economy differently, the implications for the design of monetary regimes vary from one country to the next. Moreover, transition policy changes in one economy could also influence economic developments in other regions because of trade ties or other interdependencies. Analysis of the spillover effects of monetary policy actions that takes climate change into account is needed. With limited analysis available to shed light on this issue, the NGFS calls for joint analyses across economies around the globe and enhanced collaboration among central banks on these analytical issues.

Takeaway 5

Work by central banks and the research community is needed to understand whether climate change may have fundamental implications for the design of monetary regimes, including the choice of (i) the central bank's target, (ii) the horizon over which a central bank is expected to meet its target, and (iii) the degree of flexibility embedded in monetary strategy.

6. Possible avenues for further work by central banks

Based on a comprehensive review of the literature and expert analyses summarised in this report, the NGFS encourages central banks to pursue the following aspects in their future work:

Depending on how exposed the economy and the central bank balance sheet are to climate-related shocks, risk considerations need to be investigated in greater detail and may also need to be incorporated into the operational framework of monetary policy.

Beyond risk considerations, central banks need to be attentive and investigate potential implications for their monetary policy strategy. Central banks may also consider best practices for incorporating and fostering enhanced disclosure practices. One step further, central banks that wish to pursue a more proactive policy stance could analyse the potential scope for concrete measures to foster climate change mitigation and adaptation, within each central bank's mandate.

One option could be for central banks to start signalling how climate change may affect their projections or monetary policy decisions under various climate-based scenarios.

Takeaway 6

Central banks should consider enhancing their communication strategies to help accustom households, businesses, governments and financial market participants to the risks that climate change and transition policies (or their absence) may exert on the economy and the financial system.

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