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Climate change challenges for central banks and financial regulators

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Finance and climate change: what role for central banks and financial regulators?

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*[**Abstract**]*

The academic and policy debate regarding the role of central banks and financial regulators in addressing climate-related financial risks has rapidly expanded in recent years. This Perspective presents the key controversies and discusses potential research and policy avenues for the future. Developing a comprehensive analytical framework to assess the potential impact of climate change and the low-carbon transition on financial stability appears to be the first crucial challenge. These enhanced risk measures could then be incorporated in setting financial regulations and implementing central banks' policies.

*[**Main text**]*

Achieving the objectives of the Paris Agreement will require a large-scale shift towards low-carbon technologies. However, socio-technological transitions often involve disruptive adjustments, even when they are ultimately beneficial to human welfare.[1,2] This process of 'creative destruction' is likely to take place also during the low-carbon transition, with potentially significant repercussions on economic dynamics and financial stability.[3,4] Societies thus face the challenging task of achieving a rapid structural shift to a low-carbon economy, while concurrently avoiding excessive economic losses and safeguarding the stability of the financial system (see Table 1).

[TABLE 1 ABOUT HERE]

Central banks and financial regulators have started examining the implications of climate change and the low-carbon transition in recent years. In 2015, Mark Carney, the Governor of the Bank of England and Chairman of the Financial Stability Board, first discussed the 'tragedy of the horizon' embedded in

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the different time spans that characterize monetary and financial stability policies (2-3 years and up to a decade, respectively) and the much longer-term perspective required to deal with climate-related risks.[5] This was followed by related speeches by other central bankers and regulators.[6–12] More recently, a group of eight central banks and financial regulators from both high-income and emerging economies have formed a 'Network for Greening the Financial System'.[13] Researchers in academia, international institutions, and civil society organizations are also investigating the dynamic links between central banks, financial systems and the low-carbon transition.[14–20]

This *Perspective* critically discusses the main features of the debate, and identifies avenues for future research and policy implementation. First, we present the rationale for central banks and financial regulators to be interested in climate and the low-carbon transition. Second, we analyze their potential role in promoting a better understanding of climate-related financial risks. Third, we discuss the appropriate scope of their role in mitigating these risks. Options range from supporting voluntary risk disclosure by private companies and investors to mitigating climate-related risks, or even actively promoting low-carbon investments. Finally, we discuss how these activities would fit into their current mandates, and present open questions for further research.

Central banks and climate change

Central banks are public institutions with specific objectives determined by their national governments or legislators. They are typically responsible for monetary policy, which influences the supply and the demand of money and credit in the economy. Monetary policy is often aimed at achieving price stability, defined in terms of an explicit inflation rate target. In addition, several central banks also have a mandate to maintain the stability of the financial system and to regulate and supervise individual financial institutions. Additional objectives of central banks may include exchange rate stability, employment creation and economic growth.[18]

Some central banks have started studying the implications of climate change and the low-carbon transition for the financial sector, primarily due to their responsibility for financial regulation and supervision. Recent research suggests that, in addition to large physical and economic losses, unmitigated climatic change could also affect the stability of the financial system.[21–23] For instance, the increase in climate-induced *physical risks* (e.g. heat waves, floods and storm surges) could have a direct effect on the insurers that cover them. If these risks are uninsured, the deterioration of the affected households' and corporates' balance sheets could lead to losses for their lender banks.

To avoid physical damages and the associated financial instability, a transition to a carbon-free economy is ultimately necessary. However, the transition itself might increase the risks of economic dislocation and 'stranded' assets (*transition risks*). For instance, meeting the 2°C temperature threshold will probably require a large portion of existing reserves of oil, gas and coal to remain in the ground[24,25], and thus be written off from the balance sheets of the companies that own them. Other physical assets that could lose value include part of the electricity generation capacity, real estate, transportation infrastructure and carbon-intensive industrial technology.[26–28] Such asset stranding could not only lead to economic losses and unemployment, but could also affect the market valuation of the companies that own these assets, thus negatively impacting their investors, and potentially triggering cascade effects throughout the interconnected financial system.[4,29]

While some disruption at the sectoral level is inevitable, the transition as a whole could represent an opportunity for sustainable and inclusive economic prosperity.[30,31] However, this is likely to be possible only in the presence of a comprehensive and harmonized set of policies aimed at supporting the low-carbon transition and managing its complex dynamics.

The primary responsibility for strategic planning rests with governments, which have a variety of policy options at their disposal. For instance, they can introduce environmental regulations (e.g. standards on fuel efficiency); implement climate-friendly infrastructure investment programs (e.g. smart electrical grids); and design market-based policies to shift the preferences of households and companies towards low-carbon activities. The main proposed policy instrument has been carbon pricing, which could be implemented either through the introduction of a tax on the carbon content of goods and services, or the creation of a cap-and-trade system of emission allowances.[32,33] Other market-based instruments, such as the introduction of subsidies for clean technologies and a phasing-out of fossil fuel subsidies, also follow a similar logic.

Whether a well-designed set of fiscal and environmental policies by the government will prove sufficient to meet Paris climate objectives is subject to debate. Certain market failures existing in financial systems might not be properly addressed by pricing mechanisms, thus providing inadequate incentives to mobilize low-carbon investments at the scale and pace required.[14] More importantly, government climate policies might not by themselves prevent financial instability during the transition; in fact, they might exacerbate transition risks, if implemented too abruptly and without the necessary precautions. Finally, the perception that carbon pricing could damage businesses and consumers often makes it a politically unpalatable choice for governments constrained by the electoral cycle, thus leading them not to act with the strength that would be required to ensure a smooth transition.

The complexity of the transition has led researchers to start investigating what central banks and financial regulators could do to support a rapid and orderly transition. The rest of this *Perspective* will critically evaluate the debate over the appropriate scope of their interventions. Four broad types of interventions have been either adopted by, or suggested for, financial regulators and central banks in dealing with climate-related risks. First, they can develop methodologies and tools that would promote a better understanding of these risks and their economic and financial implications. Second, investors can be encouraged or required to disclose their exposure to climate-related risks. Third, these risks can be explicitly taken into account in setting financial regulations. Fourth, central banks can take into account climate-related risks in their policy toolkit (e.g. monetary policy). Table 2 gives an overview of these potential actions.

[TABLE 2 ABOUT HERE]

Assessing climate-related financial risks

Some central banks have started assessing the exposure of their domestic financial system to climate-related risks. For instance, De Nederlandsche Bank (DNB) has recently conducted two studies of the Dutch financial system showing that, while the exposure to fossil fuel producers is relatively small, the broader exposure to carbon-intensive sectors is large enough to pose potential systemic risks, and that

some of these risks are already materializing.[26,34] Insurers and banks could also experience significant losses as a result of severe climate-related events. The Bank of England reviewed the exposures of the UK insurance sector to climate-related financial risks in 2015, and is conducting a similar review of the banking sector.[35] Other institutions that have examined the potential impact of climate change or the low-carbon transition on financial stability include the European Systemic Risk Board, Sweden's Finansinspektionen and Banque de France.[29,36,37] Researchers have also started developing 'climate stress-testing' methods, highlighting how exposures among investors can exacerbate the impact of the low-carbon transition on the financial system.[4,38]

However, the assessment of the climate-related financial risks faces various challenges. First, the data required to perform a comprehensive climate stress test are often absent or insufficiently granular, and hard to access for researchers outside financial regulatory bodies. Second, an integrated evaluation of climate-related financial risks cannot rely only on static snapshots: it requires the modelling of the dynamic interactions between the macroeconomy, the financial system, climate change and environmental policies.

This is not a trivial task. Integrated Assessment Models (IAMs), traditionally used to study economy-climate interactions, typically lack a representation of the financial system. Despite some exceptions, Dynamic Stochastic General Equilibrium (DSGE) models, often used by central banks in macroeconomic and monetary policy analysis, normally abstract from climate change and environmental policies.[39] Moreover, benchmark DSGE models featuring representative agents, rational expectations, and a rapid reversal to equilibrium in response to shocks are not appropriate for assessing the complex and dynamic implications of a large-scale structural change. Analyzing these effects will require a framework which features an accurate description of real and financial interactions between heterogeneous agents, and incorporates the role of fundamental uncertainty in their decision-making process. Stock-Flow Consistent (SFC) and Agent-Based Models (ABM) might provide valuable alternatives.[40–43] These models analyze the macroeconomy as a complex adaptive system, in which non-linearities and disequilibrium phenomena play a key role. They can also incorporate network effects that stem from the interactions between agents, and are able to represent the process of endogenous money creation by commercial banks through bank loans.[44] Some central banks have started developing such models, although without an environmental focus.[45,46] However, these are relatively new methodological approaches and the techniques for estimating and calibrating them are still in development. Establishing a framework, or a plurality of frameworks, for assessing and quantifying the macro-financial impacts of climate change and the low-carbon transition thus remains an area that requires further research.

The push for risk disclosure

A key obstacle to the achievement of a smooth low-carbon transition is the low awareness of companies and investors about their exposure to climate-related financial risks. The majority of companies are not used to assessing how these risks impact their business models, while most investors are unaware of how exposed their portfolios are. The recent international effort has thus primarily focused on improving information flows by supporting the disclosure of climate-related risks by private actors. For example, the Financial Stability Board established a Task Force for Climate-related

Financial Disclosures. Its final report makes sector-specific recommendations on how companies could *voluntarily* disclose climate-related financial risks, in order to better inform their investors, lenders and insurance underwriters.[47] The French Energy Transition law goes further and *requires* listed companies to disclose information on their exposures to climate-related risks and the measures adopted to reduce them, and requests banks to conduct climate-related stress testing on their portfolio of loans and disclose the results.[48] Several industry- or academia-led initiatives aimed at improving climate-related information available to financial investors also exist.[49] However, while central banks have been supportive of disclosure of climate-related risks by private firms, to date they have not disclosed the exposure of their own asset portfolios.

The support for the development of voluntary disclosure standards is in line with the wider strategy of encouraging the financial industry to appropriately price climate-related risks, while respecting the freedom of enterprise and market dynamics. However, it is still uncertain what the effects of voluntary disclosure will be. Many large investors appear reluctant to request companies to assess and disclose how they would be affected by a 2°C-compliant scenario.[50] Despite recent progress, climate-related risk disclosures by firms may not become sufficiently comprehensive, meaningful and comparable in the near term. Investors may also fail to pay attention to the disclosed information if they are not available in formats that are easy to understand and comparable across firms.

Thus, further research is needed in refining methodologies for assessing and disclosing climate-related financial risks facing individual firms.[47] Over time, this could lead to more standardized, comparable disclosure which allows investors to take these risks into account in allocating their capital. Such research is also likely to contribute to better classification schemes for 'green' assets, and more informative labelling of such assets for investors.[51] Concurrently, the development of spatially-detailed integrated databases of physical assets could improve risk assessment, even in the absence of disclosure.[52]

However, existing research suggests that a combination of behavioral biases and misaligned professional incentives may lead financial markets to be excessively focused on short-term returns and thus not to fully price climate-related risks, even when information about these is available.[53–55] Therefore, risk disclosure and asset-level data might be made more effective by measures that promote the use of longer-term horizons in investment decisions.[56]

Climate-aligned financial regulation

It is in principle possible to go further and adapt financial regulations to take into account climate-related risks. Macro- and micro-prudential policies (e.g. the Basel III regulatory framework designed in the aftermath of the financial crisis) encompass a range of regulatory instruments aimed at limiting systemic financial risk, or specific financial risks facing individual financial institutions. The tools at their disposal vary across jurisdictions, and could include reserve, liquidity, and capital requirements, caps on loan-to-value ratios and ceilings on credit growth, in some cases aimed at specific sectors.[57,58] In some cases institutions holding riskier assets are required to satisfy more stringent regulatory requirements, e.g. to fund their assets with more equity than otherwise. Recent research suggests that this might have negatively affected the willingness of banks to lend to low-carbon projects, because of

their higher perceived risk, low liquidity and long tenor.[59] However, current prudential regulation does not explicitly account for climate-related risks. Implementing a more comprehensive assessment of risk could instead lead to a higher capital requirement on carbon-intensive assets, in consideration of their higher transition risks.[60,61] If this in turn leads to an increase in the cost of financing high-carbon activities, it could also have the effect of re-directing lending towards low-carbon activities.

Some emerging market central banks have used prudential policies to mitigate environment-related risks or encourage lending to low-carbon activities.[62] For example, *Banque Du Liban* differentiates reserve requirement ratios - i.e. the required ratio of central bank reserves held by private banks to their stock of deposits – according to the amount of bank lending flowing to renewable energy and energy efficiency projects.[63] *Banco Central do Brasil* requires commercial banks to incorporate environmental risk factors into their governance framework and demonstrate how these risks are evaluated when calculating their capital needs.[64] The People's Bank of China is in the process of incorporating green financing into its 'Macro-Prudential Assessment' (MPA) framework.[65]

The idea that financial regulations could take into account climate-related risks more explicitly appears to be gaining political traction also in high-income countries. The EU High-Level Expert Group on Sustainable Finance has recently suggested to explore the option of introducing 'brown-penalizing' or 'green-supporting' factors on capital requirements depending on the sustainability risks carried by the borrowing sectors.[56,66] The European Commission has proposed that the European Supervisory Agencies integrate environmental, societal and governance (ESG) criteria into their work, in order to enable them to monitor how financial institutions identify, report and address the risks that such factors may pose to financial stability.[67]

There are still several areas of concern over the effectiveness of such measures. First, there is the danger that reducing capital requirements on bank loans to low-carbon investments could jeopardize prudential policy objectives. More in general, the role of capital requirements is to mitigate risks; their design should thus remain risk-based. Second, climate-aligned prudential policy could be too blunt a tool if applied to banks' exposures to entire productive sectors or companies, as it would not be able to discriminate within carbon-intensive sectors (e.g. utilities) those companies that engage in low-carbon investments. However, estimating banks' capital requirements based on the 'greenness' of specific investment projects might overburden banks with assessment exercises they are not familiar with. Third, high-carbon companies could bypass the tightening of prudential policy in one jurisdiction by raising funds on the international financial markets, unless such policies are implemented across all major jurisdictions.

Given the concerns above, financial regulators in high-income countries may not consider reflecting climate-related financial risks in the calibration of prudential policy tools unless there is compelling evidence that the exposure of the financial sector to these risks is sufficiently large. This calls for further innovative research in the field of climate stress-testing and macroeconomic modelling aimed at quantifying climate-related financial risks.

A 'green' Quantitative Easing?

It has also been proposed that central banks might wish to consider aligning their monetary policy tools to environmental sustainability goals.[68] Prior to the 2007-8 global financial crisis, major central banks operated monetary policy primarily through adjustments of the reference interest rate. In the aftermath of the crisis, many central banks have also initiated 'unconventional' Quantitative Easing (QE) measures in the form of large-scale purchase of financial assets, such as government and corporate bonds, in order to provide additional stimulus to the economy.

Central banks' QE programs are intended to be temporary cyclical tools. As such, they have been designed to avoid 'distorting' the market, while concurrently ensuring that assets being purchased meet high credit standards. The European Central Bank (ECB), for instance, buys sovereign bonds respecting the current maturity distribution, and allocates purchases of corporate bonds across sectors according to the current bond market sectoral weights.[69,70] However, recent research suggests that the 'market-neutral' corporate bond purchases have inadvertently favored large carbon-intensive companies, reflecting their relatively strong credit ratings and the fact that many low-carbon firms are too small to issue corporate bonds.[71] When central banks buy a type of asset in large quantities, market participants might assess this asset category more liquid and less risky than others. This raises a concern that central banks' asset purchases, even if temporary, could have the unintended consequence of perpetuating the current 'carbon lock-in' of the economic system, thus undermining their own effort of encouraging financial markets to better account for climate-related risks.

To mitigate this undesired effect, it has been suggested that central banks could recalibrate QE purchases so to exclude carbon-intensive financial assets and favor bonds issued to fund low-carbon projects.[16,72,73] Alternatively, central banks could keep their current QE programs unchanged and run a parallel independent program focused on purchasing additional low-carbon financial assets. This 'green' QE would have the benefit of providing large amounts of additional liquidity to companies interested in shifting to clean forms of production. The overall purchases by the ECB during 2017, for instance, amounted to around €730 billion, while the total additional annual investment required to achieve EU energy and climate targets are estimated at €170 billion.[55,63] Central banks could expand the proportion of purchases in 'green' bonds, which represent a niche but rapidly expanding market, estimated at €221 billion globally in 2016.[75] These bonds can be issued by companies, development banks, local authorities or, more recently, governments.

Among the proposals discussed here, this is probably the one that has raised greatest controversy. This is primarily due to the fact that central banks view QE as a cyclical policy instrument aimed at providing temporary stimulus to the economy. Using it to engineer a low-carbon structural change might overburden central banks with additional responsibilities and potentially compromise their effectiveness in maintaining price stability. Moreover, low-carbon assets often do not meet the existing financial risk standards to be included into the list of eligible assets for central bank purchase, which mainly consist of investment grade bonds – i.e. bonds with low default risk. Purchasing riskier green assets could raise concerns regarding the quality of central banks' portfolio, particularly when central banks do not have the capacity to evaluate the relative merits of new technologies in times of disruptive change. Finally, introducing strict low-carbon requirements for central bank asset purchase

might reduce the universe of purchasable assets. For these and other reasons, the idea of explicitly supporting the low-carbon transition via a 'green QE' has been repeatedly rejected by central bankers.[9]

It should be noted, however, that an indirect form of green QE might already be happening through the purchase of bonds issued by public sector entities that finance low-carbon activities. For example, the ECB allocates around 10% of its Public Sector Purchase Programme to bonds issued by 'supranational institutions', which include several regional and national development banks.[74] Development banks have been at the forefront of climate mitigation financing in recent years.[76,77] For instance, the European Investment Bank (EIB) dedicates a minimum of 25% of its lending to climate action projects.[78] Thus, the ECB might already be indirectly supporting low-carbon investments, although to a limited extent, through the inclusion of EIB-issued bonds in its QE program.

Central bank mandates

Ultimately, what central banks and financial regulators will do to support a smooth low-carbon transition will depend on what their mandate allows, how this is interpreted, and their willingness to act. The mandates and policy tools at the disposal of central banks significantly differ across countries. In particular, a distinction can be drawn between the central banks of high-income regions and the central banks of developing economies.

Most central banks in high-income countries have relatively narrow mandates primarily focused on price stability and, in some cases, financial stability and regulation of individual financial institutions. They are typically granted operational independence in order to achieve specific objectives within their mandate. Thus, they normally avoid interfering either with market dynamics or government policies, unless it is necessary to achieve their objectives. Consequently, they have thus far mainly sought to enhance the resilience of the financial system to climate-related risks by developing and promoting the use of better information and portfolio assessment tools (e.g. climate stress tests). Other measures taken include international collaboration for nurturing green financial markets, including through the Green Finance Study Group of the G20, the Sustainable Insurance Forum, and the Network for Greening the Financial system (NGFS).[13,79,80]

By contrast, central banks in emerging and developing countries have used a wider set of tools to target sectors linked to environmental sustainability, reflecting their mandates that are both broader and more strongly linked to governments' development objectives. For instance, the Reserve Bank of India requires that commercial banks allocate a certain proportion of lending to a list of 'priority sectors', which now include renewable energy.[81] The Bangladesh Bank has introduced a minimum credit quota that financial institutions have to allocate to green sectors, currently set at 5%, and offers refinancing lines to commercial banks at preferential terms for their green loans.[82] While not in an emerging economy, the Bank of Japan's Loan Support Program also offers loans at below market rate to financial institutions in order to support several 'lending priority sectors', including 'environment businesses'.[83]

A key question is whether central banking institutions in high-income countries are likely to modify their mandates in order to start using their policy tools to explicitly support the financing of low-carbon activities. Changes in central bank mandates are far from unprecedented. The first central

banks were established to enhance the financial power of the sovereign during military conflicts.[84] Over time, the responsibilities of central banks have transformed in response to economic events and changing monetary practices. For the majority of the 20th century central banks had a larger range of objectives than today, including high or full employment, exchange rate stability, management of government deficits and support to strategic industrial sectors (in particular in the post-World War II period[85]). With the consent of national governments, they have also often implemented policies supporting or repressing specific sectors of the economy, sometimes stretching beyond their usual boundaries of operation.[86]

However, despite this historical experience, it seems unlikely that central bank mandates in high-income countries will be modified to include wider societal goals, such as supporting a low-carbon transition. Moreover, the question of whether this would be appropriate requires further examination. On the one hand, there is an increasing recognition that climate change and the low-carbon transition might pose system-wide risks to the macroeconomic and financial system, which may justify more proactive interventions by a wider set of public institutions, including central banks and financial regulators. On the other hand, widening their mandate – for example to support credit to low-carbon investment projects – could risk overburdening central banks with excessive responsibilities, which could take up management capacity to the detriment of their primary objectives of maintaining monetary and financial stability. Moreover, as unelected institutions, it may be undesirable to confer central banks additional powers and responsibilities over a broad range of social and environmental issues for which credible accountability frameworks are difficult to design.

Incorporating climate-related risks

While a change in mandate seems unlikely, this may not be necessary in order for central banks in high-income countries to support the transition to a low-carbon economy. In case climate-related financial risks are found to be material to the stability of the financial system, this could ultimately justify the implementation of measures aimed at mitigating them across all central banking operations.

Central banks could incorporate climate-related criteria in assessing whether an asset should be eligible for central banks' asset purchase as part of their standard portfolio management. The DNB already applies ESG criteria and purchases green bonds for own-account investments.[87] The Swiss National Bank has its own ethical criteria to exclude a certain set of companies from its foreign equity purchase.[88] The Norges Bank has ESG criteria for the government's pension fund that it manages, and explicitly excludes companies involved in coal-based energy production or responsible for severe environmental damage.[89] Central banks could consider applying these criteria to cyclical policy measures, such as the current QE programs. The objective would not be to support financing of low-carbon investments, but to prevent the purchase of assets that do not satisfy financial risk standards, where risk is assessed using more comprehensive methodologies that include climate-related criteria.

The same principle could be applied to central banks' collateral frameworks. The collateral framework defines assets that financial institutions can pledge in order to borrow from the central bank, as well as the amount that they can borrow against those assets. The criteria used by central banks to establish the eligibility of an asset as collateral and the 'haircut' imposed could have deep impact on the desirability - and thus price - of the asset.[90] Being included in the collateral framework

gives an incentive to issue such financial instruments in larger quantities, which could in turn have an impact on the economy.[91,92] Central banks could therefore consider incorporating climate-related risks explicitly in determining the list of eligible collateral and the size of the haircut.

Conclusions and future avenues of research

The primary responsibility for managing the transition to a low-carbon economy rests with the elected governments. However, if it is true that climate change is indeed 'the greatest and widest-ranging market failure ever seen',[93] the effort for a smooth low-carbon transition will require the implementation of a comprehensive set of policies, some of which might require the collaboration of central banks and financial regulators.

This cooperation will not require a modification of central banks' mandate. Supporting the development of more comprehensive measures of financial risk to include climate physical and transition risks is well within their present mandate of ensuring effective functioning of financial markets. These more comprehensive measures can then be applied to test and disclose the climate-related exposure of both the financial system as a whole and individual financial institutions. If these risks are evaluated to be material to the stability of the financial system, central banks and financial regulators should consider reflecting them in their regulatory and asset eligibility assessment frameworks.

Several open questions and research gaps remain. First, despite the recent growth of work on the topic,[94] further progress is needed in developing robust methodologies and collecting comprehensive data for evaluating climate-related risks which companies and investors are exposed to. The push for risk disclosure, the development of asset-level databases and the refinement of climate stress-test techniques will all contribute in filling this gap. Progress in this direction will help firms to disclose climate-related risks in a comparable manner, and support central banks and financial regulators to better assess the exposure of both individual financial institutions and the financial system as a whole. Further research in these areas will also help central banks to evaluate climate-related risks in their own asset portfolios. It will also contribute to developing a definition of green or sustainable investment, which is both widely accepted and used by investors. Having a clear and widely accepted methodology and taxonomy could also help central banks in considering the case for disclosing climate-related risks in their own asset porfolios.

Second, there is the need to develop models that enable a forward-looking assessment of climate-related risks and their social and macroeconomic repercussions. This is particularly relevant for the evaluation of the potential effects of the policies discussed in this article on growth, employment, distribution and financial stability. The analysis of these effects is challenging since policies are likely to involve time-dependent trade-offs and might have undesirable or unexpected implications (e.g. rebound effects). This will require combining dynamic macroeconomic modelling (possibly using a plurality of methodological approaches: IAMs, ABMs, DSGE and SFC models), financial data and modelling, climate scenarios, historical analysis and political economy considerations. Central banks can be instrumental in supporting such efforts and facilitating the exchange of best practices across modelling communities.

Making progress in the directions outlined above is urgently needed in order to sustain the momentum in "greening" the financial system, which will require collaboration across the research community, financial market participants, financial regulators and central banks. Researchers can best contribute in this process by developing practically and immediately useful methodologies for evaluating climate-related risks and their wider economic impact, and refine these over time.

*[**End**]*

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Author contributions

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