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Lena Boneva, Gianluigi Ferrucci,
Francesco Paolo Mongelli

To be or not to be “green”:
how can monetary policy react
to climate change?

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Abstract

Climate change has profound effects not only for societies and economies, but also for central banks' ability to deliver price stability in the future. This paper starts by documenting why climate change matters for monetary policy: it impacts the economic variables relevant to setting the monetary policy stance, it interacts with fiscal and structural responses and it can generate dislocations in financial markets, which are impossible for monetary policy to ignore. Next, we survey several possible ways central banks can respond to climate change. These range from protective actions to more proactive measures aimed at mitigating climate change and supporting green finance and the transition to sustainable growth. We also discuss the constraints and trade-offs faced by central banks as they respond to climate risks. Finally, focusing on the specific challenges faced by inflation-targeting central banks, we consider how certain design features of this regime might interact with, and evolve in response to, the climate challenge.

JEL classification: E52, E58, Q54

Keywords: climate change, monetary policy, environmental economics, green finance, sustainable growth economics.

Non-technical summary

Climate change is the greatest challenge humankind is facing this century, and its impact is becoming increasingly evident.

The Paris Agreement of 2015 represented a significant milestone in the international response to it. The signatories agreed to limit global warming to well below 2°C above pre-industrial levels. Climate models predict this requires cutting net carbon emissions to zero by around the middle of the 21st century, which makes significant structural transformation of the global economy unavoidable.

Governments and parliaments have the primary responsibility and tools for addressing climate change.

But within their mandates, central banks also need to tackle climate change, both to safeguard their ability to conduct policy smoothly and deliver on their mandates, and to ensure that they remain resilient to emerging climate-related financial risks. Depending on their policy remits, central banks could also consider going beyond a pure risk management perspective and seek to ensure that their operations do not undermine the transition to a low-carbon economy or actively support it.

While several central banks have recognised the implications of unchecked climate change for financial stability and supervision, the implications for monetary policy have received less attention until recently.

Our paper aims to fill this gap by considering various reasons why climate change is an important influencing factor for monetary policy and reviewing the emerging literature on how climate change considerations can be incorporated into the conduct of monetary policy and central banks' operational frameworks.

We start by reviewing the direct and indirect links between climate change and central banks' policies and objectives and survey a wide range of actions that are currently being debated in the literature.

These actions range from passive responses deployed to protect central banks' balance sheets from emerging climate-related financial risks, to more proactive policies aimed at supporting the transition to a low-carbon economy. The distinction between alternative approaches is not always clear cut, as it depends, not least, on how the measures are calibrated.

Differing approaches may also entail potential conflicting aims.

For example, a tension may arise between their effectiveness in pursuing the central bank's mandate and supporting the transition, their feasibility and operational complexity, and the risk implications for the balance sheet. Any action will require policymakers to carefully weigh and balance the different trade-offs. These are also analysed, together with the constraints faced by central banks in taking action to deal with climate risks.

Some measures are controversial,

since they can be seen as extending central banks' mandate beyond traditional boundaries, encroaching in some cases upon economic policies and raising issues of legitimacy and risks for central bank independence. The exact form central banks' reactions take will depend on their

mandates, the prevailing institutional setting, legal and technical considerations, societal preferences and how various trade-offs pan out in each individual case.

The final part of the paper focuses on the specific challenges faced by inflation-targeting central banks. We consider how climate change could affect certain design features of this monetary policy regime and how it might evolve as climate risks unfold.

Climate disruptions will pose specific challenges for inflation-targeting central banks. These may require policymakers to re-examine the relative merits of some design features of the framework, in particular the definition of the inflation target, the type of inflation measure used in central bank communications and how to appropriately calibrate the “medium-term” horizon of monetary policy. However, the slow-moving, long-term nature of climate change and our still limited knowledge of its possible consequences for the economy and financial system suggest that more precise indications of the impact on inflation-targeting central banks will only emerge over time.

1 Introduction

Climate change is profoundly affecting our societies and economies. Adapting to it and mitigating its consequences requires a swift transition to a low-carbon economy. Climate change is also posing new challenges for central banks (NGFS, 2020a and 2021). While several have recognised the implications of unchecked climate change for financial stability and supervision, the implications for monetary policy have received less attention until recently. Our paper aims at filling this gap.

This paper makes several contributions. We start by reviewing the direct and indirect links between climate change and central banks' policies and objectives and survey a wide range of actions that are currently being debated in the literature. These range from passive responses deployed to protect central banks' balance sheets to proactive policies aimed at supporting the transition to a low-carbon economy. The constraints and trade-offs faced by central banks in taking action to deal with climate risks are analysed. The final part of the paper focuses on the specific challenges faced by inflation-targeting central banks. We consider how climate change could affect certain design features of this regime and what measures policy makers can take to respond to it.

There is a scientific consensus that the earth's climate is warming and that this trend may be accelerated by tipping points and non-linearities, making the future difficult to predict (Stern, 2007; IPCC, 2018 and 2021). Global warming stems from the unabated accumulation of greenhouse gas emissions in the atmosphere, which originates from carbon-intensive human activities induced by the under-pricing of carbon emissions so these do not reflect their social cost (Nordhaus, 2019).

Given this challenging trend, a global policy response is embodied in the 2015 Paris Agreement (COP25). Implementation of this agreement has lagged behind stated objectives. Presently the world is not on track to limit global warming to 1.5°C, or even 2.0°C, by the middle of this century.¹ Market failures are exacerbated by slow and difficult progress by governments in delivering their climate goals. Steps in the right direction have been set also as part of the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow in November 2021. However, strong implementation on all fronts will be key to reach the 1.5°C goal.

The primary responsibility for responding to the market failure inherent in the climate challenge rests with governments. They are publicly legitimised and have a broad spectrum of policy levers at their disposal such as setting the necessary price of carbon emissions, defining a regulatory framework to reduce emissions, undertaking needed investments, and providing guarantees.

Governments' determination in pursuing ambitious carbon reduction targets and global coordination is key to establish whether the world will successfully

¹ [Climate Action Tracker \(2021\)](#), based on data provided by the National Aeronautics and Space Administration (NASA, 2020) and the National Oceanic and Atmospheric Administration (NOAA, 2019).

avoid the worst consequences of climate change. If the needed policies to decarbonise the economy are undertaken globally, then the case of an early, orderly and coordinated transition will ensue, as penned out in a recent report by the NGFS (2020b). If governments intervene to internalise carbon prices and change incentives of firms and consumers, then the underlying structure of the economy will change and that might bear implications for monetary policy that we also discuss.

If global implementation is inadequate to meet the needed climate targets, then a late, disorderly and uncoordinated transition will follow. The features of such a disorderly transition are also sketched in NGFS (2020b). In this case, new global threats will emerge. Indeed, there is already concern about possible “green swan” catastrophic events (Bolton et al., 2020).² The severity of such possible effects requires international coordination of climate policies as well as steady domestic policy actions (Krogstrup and Oman, 2019).

But government action alone may not be sufficient. The complexity and scale of the economic transformation required to achieve the 2015 Paris climate goals (COP25) have led many observers to ask whether a comprehensive policy package involving fiscal, structural and financial policy instruments would be more effective in addressing this planetary emergency. In particular, calls have intensified for central banks to support an orderly transition to a low-carbon economy not only in their financial stability capacity, but also with monetary policy measures of the kind we review in this paper (Schoenmaker, 2021; Monnin, 2018; de Grauwe, 2019; Honohan, 2019; Lagarde, 2021; Schnabel, 2021a).³

The paper is organised as follows. Section 2 reviews the various channels through which climate change affects monetary policy and may impinge on central banks’ ability to fulfil their mandates. Section 3 reviews a wide range of policies central banks can deploy to respond to the challenges posed by climate change. Constraints and trade-offs faced by central banks, as well as genuine questions about the effectiveness of monetary policy interventions to tackle climate change, are discussed in Section 4. Section 5 presents some specific challenges for inflation-targeting central banks. Section 6 concludes and presents key areas for future research.

² This postulates that current climate-economic models do not anticipate accurately enough the form that unfolding climate-related risks will take. If such risks were to escalate, extremely disruptive financial events could unfold generating a systemic financial crisis, the “green swan” risks (Bolton et al., 2020).

³ There is now growing attention to the repercussions of physical risk for the banking sector, which plays a key role in the transmission of monetary policies. For example, Pagliari (2021) quantifies the reduction in the profitability of banks exposed to climate events leveraging on a locational database, which matches information about the frequency and severity of flood events in 19 European countries over the period 1980-2014, with balance sheet data of territorial banks, i.e. banks mainly operating in the areas where they are headquartered. Such findings shed light about the impact on central banks’ assets once adverse climate events materialise.

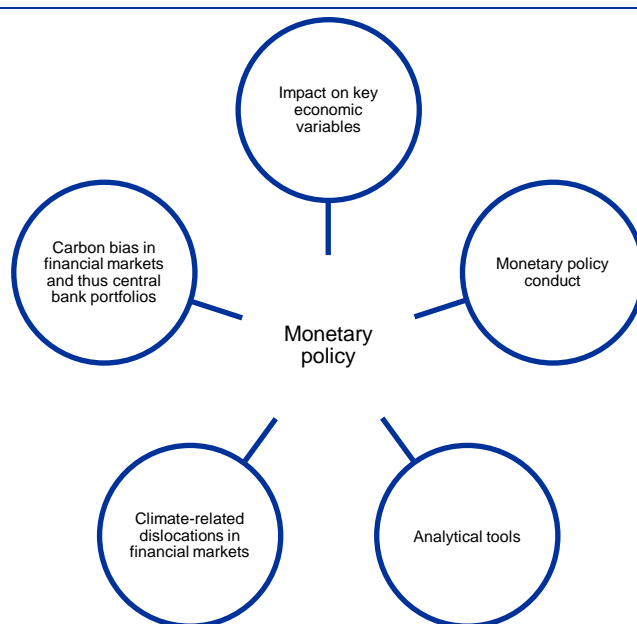
2 Why does climate change matter for monetary policy?

Monetary policy has traditionally not been considered relevant for long-term climate change mitigation efforts. The 2015 speech by Bank of England Governor, Mark Carney, on “Breaking the tragedy of the horizon” cast a critical eye on rising physical risks and the impact of financial losses stemming from natural disasters for the financial sector. Central banks started turning their attention to the systemic implications of climate risks for financial institutions and financial market mispricing of climate risks.⁴

More recently central banks’ monetary policy function has also been brought into the picture. Attention has focused both on the role of monetary policy as a witness of the deep transformation that will profoundly affect the setting in which central banks operate and, at the opposite side, on the possible contribution that monetary policy can make to addressing environmental challenges. This requires gauging an understanding of the possible channels through which monetary policy and climate change interact.

Climate change is likely to affect central banks’ ability to deliver on their price stability mandate in multiple ways. The literature has identified five distinct channels, which we now review in turn (Figure 1).

Figure 1
Climate change impact on monetary policy



Source: ECB.

⁴ See Brunnermeier et al. (2020), Campiglio et al. (2018), and Campiglio (2016), among others.

2.1 Impact on key economic variables

Unabated climate change is likely to render extreme weather events more frequent and disruptive and exacerbate the global warming trend. This physical risk will in turn change the nature and frequency of the shocks affecting the economy (as discussed by McKibbin et al., 2020; Debelle, 2019; Coeuré, 2018).⁵ Climate change will have both demand and supply effects. At present it is still unclear whether demand or supply shocks will be dominant, thus both must be assessed.

Extreme weather events can be primarily thought of as supply shocks, which tend to increase prices and lower output.⁶ Supply shocks are difficult to counter from a central bank perspective as they present policymakers with a dilemma between stabilising inflation and maintaining economic activity. Traditionally, central banks calibrate their response depending on the size and persistence of the shock. If it is assessed to be short-lived and unlikely to affect the medium-term inflation outlook relevant for monetary policy, central banks may “look through” the shock. That is, they may tolerate its temporary effects on inflation without taking any action, in order not to cause undue volatility in output and employment. If the shock is more persistent and there are risks that it may lead to a dis-anchoring of inflation expectations, monetary policy action may be warranted. However, as climate change amplifies the frequency and severity of supply shocks, making them more persistent, “looking through” such shocks may become increasingly difficult for central banks (Batten, 2016; Batten et al., 2018; Rudebusch, 2019).

Extreme weather events can also cause knock-on effects on demand, generating demand shocks on top of the supply shocks mentioned above. For example, extreme weather events may increase uncertainty, creating a drag on investment (see Andersson et al., 2020). Uncertainty may be exacerbated by a government’s inability to commit to its climate policies beyond the next electoral cycle. As a result, identifying the type of long-term shocks affecting the economy might become harder for policymakers and require a stronger analytical toolkit (Coeuré, 2018).

Monetary policy is affected not only by climate shocks but also by climate policies (adaptation policies to address physical risks and mitigation policies to support the transition to a low carbon economy).⁷ This transition, even if smooth, is likely to have substantial effects on economic and financial activities, relative prices and inflation, output growth and productivity and hence on the optimal

⁵ Physical risk originates from extreme climate events (generating unanticipated shocks to components of demand and supply) and persistent global warming (impacting potential productive capacity and growth). Transition risk pertains to the shift to a low-carbon economy: this requires addressing the market failure propelling climate change and correctly pricing carbon emissions by means of climate policies, sustainable finance and clean technologies, amongst others (NGFS, 2020a).

⁶ Empirical estimates of the potential economic damage from climate change vary widely. Hsiang et al. (2017) provide a quantification for the United States. The European Commission has funded an ambitious project to quantify the costs of climate change to Europe and estimates can be found in Feyen et al. (2020).

⁷ An orderly transition with substantial mitigation (<1.5°C-2°C) is the scenario underpinning this paper, accompanied by reduced physical risk and adaptation costs. Lack of mitigation and adaptation policies will expose the global economy to a “hot house world” with extremely high costs: i.e. harm stemming from soaring physical risk. Between these extreme scenarios, there might be “disorderly” transitions (NGFS, 2020a and 2021).

response from monetary policy. Specifically, there might be a persistent positive bias in inflation during the carbon transition.

In terms of transition and mitigation, correcting for the all-pervasive market failure requires strong policy choices by national governments, international policy coordination and a successful implementation of the outcome of Glasgow 2021 (COP26). Several studies postulate that the carbon transition might lift the general level of prices (inflation bias), but also render inflation more volatile and less predictable overall. For example, a carbon tax or a permit system with sufficiently scarce permits is likely to generate upward pressures on inflation. Under a permit system, inflation could become more volatile and more difficult to forecast. Extreme weather events may also lead to upward pressure on commodity and food prices, and hence on headline inflation.

All in all, there is pervasive uncertainty about the effects of climate change and climate policies on the inflation process, in terms of both higher price volatility and a persistent inflationary bias during the carbon transition. As we argue later, the inflation process, and thus ensuring price stability, will depend on the timing of the deployment of climate policies, including their scope, thrust and impact on growth.

2.2 Monetary policy conduct

When it comes to setting the monetary stance, more volatile inflation and possibly an inflation bias during the carbon transition will complicate the task of central banks (see ECB, 2021c).

Climate change in its various dimensions (physical risk and transition risk) could increase the riskiness of the assets held on central banks' balance sheets, potentially leading to financial losses. Climate change risks can translate into higher credit risk by affecting the ability of counterparties, issuers and other debtors to service their obligations. Central banks are exposed to such risks directly and over potentially long horizons, through their holdings of financial assets, such as those arising from asset purchases for monetary policy purposes. They can also be exposed indirectly over shorter horizons, for example through collateral pledged by counterparties. To the extent that these risks are not appropriately priced by the markets or incorporated in credit ratings, central banks would be required to adjust their risk management models and frameworks to account for the implications of climate change for their risk exposure.

Climate change could make it harder to identify a monetary policy stance that is considered “neutral”. The natural rate of interest (r^*) provides an important benchmark for the central bank when assessing how accommodative its monetary policy stance is given the level of the policy rate. Several risks related to climate change may imply a dampening force on r^* , on top of the factors that have already

driven its secular decline over the past few decades.⁸ At the same time, green investment and new technologies could push r^* up, all else being equal. The net effect of these two opposing forces is uncertain ex ante, but the current best guess is that the net effect should be negative (NGFS 2020a). Should this be the case, climate change could impinge on central banks' policy space, affecting their ability to provide monetary accommodation and deliver low and stable inflation, full employment and financial stability at the same time.

The conduct of monetary policy may be affected at business-cycle frequency by the transition to a carbon-neutral economy. Physical risk and transition risk related to the climate could combine with existing financial and fiscal fragilities. These themselves could be the result of the materialisation of climate risks, and could significantly restrict the ability of monetary policy to respond to standard business cycle fluctuations.

Climate change may weaken the transmission channel of monetary policy through financial markets and the banking sector.⁹ The stranding of assets and sudden repricing of climate-related financial risks could generate losses in the financial system and impair financing flows to the real economy. Less efficient transmission related to financial fragility could complicate the conduct of monetary policy.

Climate change might also have important implications for the design and calibration of the monetary policy framework, including the formulation of the price stability objective, the horizon over which the central bank is expected to meet its target and the degree of flexibility embedded in the framework. However, our still limited knowledge of the possible effects and the long-term nature of climate change suggest that more precise indications on the impact for the strategy may only emerge over time.

2.3 Analytical tools

A key challenge for central banks is that their analytical toolkit is primarily oriented to the short- and medium-term projection horizon (i.e. for forecasting purposes). Typically, only a limited role is assigned to natural resources and the depletion of the environment (i.e. the social costs of carbon). However, as discussed, climate change will impact the distribution of shocks to prices and output in the economy, and so will climate policies. Longer-term structural changes in the economy will increasingly matter for projections and policy analysis and they should therefore be reflected in central banks' analytical toolkits.

Reflecting on these challenges and near- and long-term trends, the framework and modelling tools used by central banks for their policy analysis, forecasting and the

⁸ These include, for example, lower productivity and labour supply due to heat stress and higher morbidity.

⁹ See Laubach and Williams (2015); Brand et al. (2018); NGFS (2020a).

design of economic scenarios need to be extensively adapted to incorporate the effects of climate change on the economy and financial markets (see ECB, 2021c).

2.4 Climate-related dislocations in financial markets

Repricing of climate risks, “stranding of assets” and a disorderly transition to a low-carbon economy may trigger sudden adjustments in financial markets (Carney, 2015; Lane, 2019) with spill-overs to the real economy and implications for monetary policy. The literature discusses various reasons why financial markets may not yet fully reflect climate risks in traded prices. For example, Bolton and Kacperczyk (2021) argue that data gaps may prevent investors from fully pricing risks related to climate change. Uncertainty about the future policy framework may also pose challenges when evaluating the implications for asset prices, which may be compounded by data limitations and information asymmetries. Additionally, as Carney (2015) points out, some climate risks are expected to materialise beyond the holding period of the typical financial investor.

2.5 Carbon bias in financial markets and central bank portfolios

The climate-related financial risks in central banks’ asset portfolios and collateral frameworks could be more adequately assessed and controlled. The policy portfolios of all major central banks have grown in recent years due to protracted outright asset purchase programmes – a form of quantitative easing – deployed to achieve monetary policy objectives when the policy rate has hit its lower bound. Many central banks carry out these purchases in proportion to outstanding market shares. It has been argued that this practice gives rise to a “carbon bias” in central banks’ portfolios because carbon-intensive companies are usually also capital-intensive and so have a larger weight in corporate bond markets compared to their less carbon-intensive peers.

While avoiding undue market distortions, purchases that closely track the market are understood as instilling a carbon bias in central banks’ portfolios. Matikainen et al. (2017) calculate that 62.1% of the ECB’s corporate bond purchases (under the CSPP) are in manufacturing and electricity and gas production (see also Papoutsi, et al., 2021). These sectors are responsible for 58.5 % of euro area greenhouse gas emissions, but only 18% of euro area gross value added. A similar picture emerges for the Bank of England’s corporate bond purchase programme (the CBPS). Given “climate change market failure”, traditional benchmarks for central banks assets purchases in the form of market neutrality might not be appropriate (Schoenmaker, 2021).

Climate externalities may require central banks to reconsider the notion of market neutrality. Schnabel (2021b) argues that given market failures, adhering to market neutrality principles may reinforce pre-existing inefficiencies giving rise to a

suboptimal allocation of resources, thus supporting a market structure that hampers a transition to a low carbon economy and a greener allocation of resources. In view of such market failures, she proposes replacing market neutrality with a market efficiency principle. This would recognise that a supposedly “neutral” market allocation may be suboptimal in the presence of externalities. It would make it possible to acknowledge that market failures may drive a wedge between market prices and efficient asset values that reflect externalities.

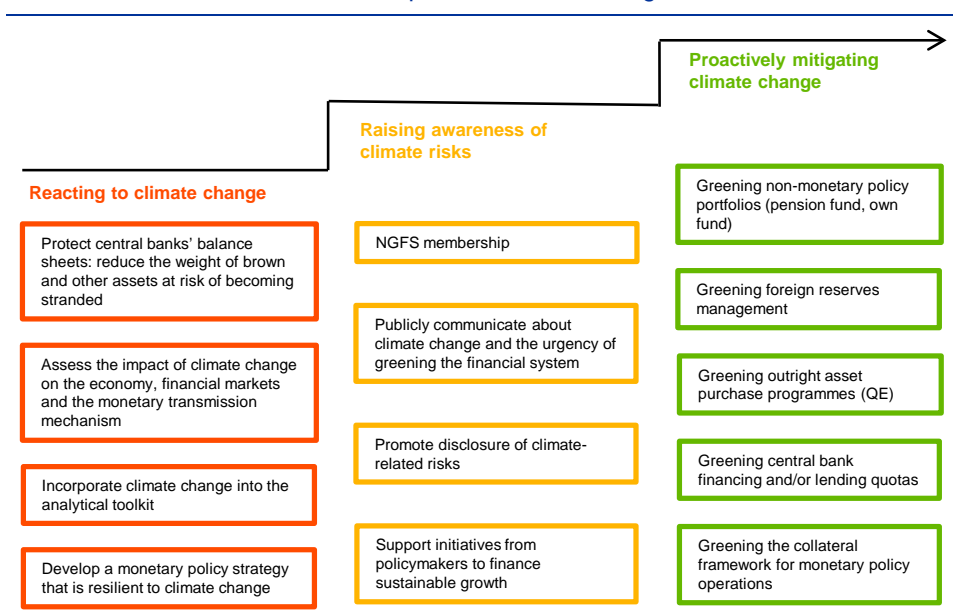
3 How can central banks respond to climate change?

The literature on the policy options that are available to central banks to respond to climate change is vast and still fragmented. To provide some structure, we classify the various options into three categories ranging from passive to proactive depending on the aim of the policy action. There are overlaps and synergies between the various options. Some are controversial, since they can be seen as extending central banks' mandate beyond the traditional boundaries of monetary and financial stability, encroaching in some cases upon economic policies and raising issues of legitimacy, which we discuss in Section 4.

3.1 Reacting to climate change: passive or defensive actions

The first category of measures includes protecting central banks' balance sheets and preserving their ability to deliver on their price stability mandate against materialisation of climate risks. Measures aimed at expanding and enhancing the central banks' analytical toolkit to gain a better understanding of the impact of climate change on the economy over long horizons also belong to this category (Figure 2, left-hand panel).

Figure 2
Possible central bank actions to respond to climate change



Source: ECB.

Defensive and reactive action is generally regarded as supporting central banks' price stability mandate and, as such, does not raise legitimacy concerns. Indeed, the Network for Greening the Financial System (NGFS) reports a

growing consensus among its members for the idea that, at the very least, central banks must assess, and where appropriate adopt, appropriate risk management measures to protect their balance sheets against emerging climate-related financial risks (see NGFS, 2021). However, a consensus has yet to form as to what adjustments would be optimal, reflecting data gaps and the large uncertainty surrounding climate change and transition policies, as well as the possible losses these may cause. Reactive and protective measures are therefore likely to be on the to-do list of all central banks, including those that are not currently considering active use of their monetary policy tools to support mitigating climate change and fostering the transition to a low-carbon economy.

One example of a reactive strategy consists in scaling up the analysis of the effects of climate change on the economy and the financial system and, as a consequence, monetary policy (Rudebusch, 2019; Powell, 2019; Lane, 2019; Brainard, 2019; Dietrich et al., 2021). This involves developing new analytical tools and models designed to assess the impact of climate change on the economy and financial markets. Practical examples include research papers published by central banks on the potential consequences of climate change for the macroeconomy and financial markets (NGFS, 2020a and 2021; Batten et al., 2020; Banque de France, 2019; see also Figure 3).

Central banks also have a duty to preserve the integrity of their balance sheets and prudently manage the resources entrusted to them as a means of ensuring that they are consistently able to deliver on their price stability mandate over time. In this respect, policies could be considered to reduce the weight of polluting assets and other assets at risk of becoming “stranded” in central banks’ portfolios, provided there is evidence that these risks are not correctly understood and priced by the markets and that such assets can be objectively identified.¹⁰ Defensive actions to protect central banks’ balance sheets against undue climate-related financial risks in their portfolios are in line with sound risk management practices and, as such, are consistent with central banks’ primary mandate (Monnin, 2018).

Central banks could also review their monetary policy frameworks to assess how they may adapt to the above risks and shocks (i.e. if they are “fit for purpose” in a world where the impact of climate change will rise over time). For example, climate-related supply shocks may put upward pressure on inflation, subdue growth and affect the natural rate of interest. Fratzscher et al. (2020) find that inflation targeting outperforms other monetary policy regimes in stabilising the economy after a natural disaster. A deeper dive on the implications of climate change for inflation targeting is provided in Section 5.

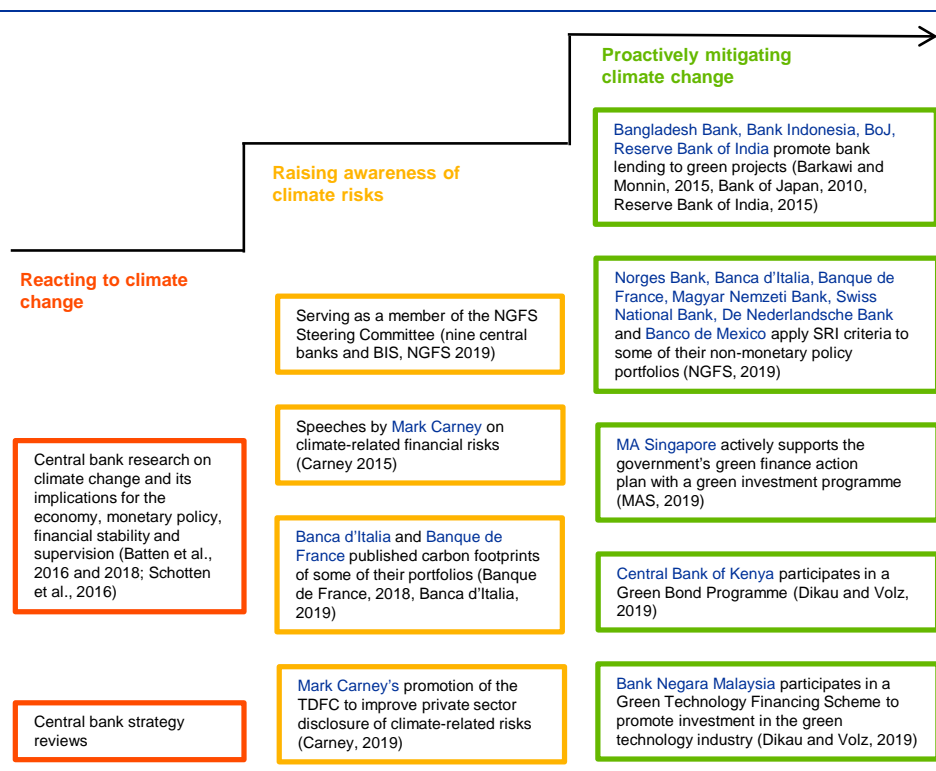
¹⁰ The pricing of climate risk into financial assets may have relevant implications for portfolio allocations, including for central banks. Multiple studies find evidence of investors requiring compensation for holding financial assets of high-carbon emitters – a carbon risk premium – albeit mainly in the wake of the Paris Agreement. The existence of a carbon premium is not universal across countries, but it appears well established in North America, Asia and Europe. In Europe, Alessi, Ossola and Panzica (2021) find evidence of a negative risk premium linked to a firm’s greenness and environmental transparency. Benmir, Jaccard and Vermandel (2021) discuss theoretically why environmental considerations matter for asset pricing.

3.2 Raising awareness of climate risks

The second category of central bank measures to mitigate climate change includes actions aimed at raising awareness of climate risks. These actions could also help to promote green finance and sustainable growth but without the central bank having to make active use of its balance sheet (Figure 2, middle panel). This covers a range of policies, from communicating with the public and financial community about climate risks to informing financial markets and the public, disclosing the carbon footprint of the central bank's own balance sheet and promoting disclosure of climate-related financial risks. The latter requires developing classification schemes for polluting and green investments (e.g. the EU Taxonomy and ESG criteria and standards), and promoting more efficient market pricing of climate risks.

Central bank communications raising awareness of climate-change related risks in the financial markets and among the general public fall into this category (Monnin, 2018). They include speeches by central bankers, discussions of the economic and financial implications of climate change in central bank bulletins and other official communications, promoting research and organising conferences and seminars to inform and advance the debate in the field (Figure 3). This is particularly important given that climate risks are systemic and can pose a threat to global financial stability (Pereira da Silva, 2019), with the potential of triggering a global recession (Lane, 2019).

Figure 3
Possible central bank actions to respond to climate change: some specific examples



Source: ECB.

A cautionary view about the thrust of communication about climate change has also been formulated. In a recent book, Lomborg warns against “climate change panic” that costs, hurts and fails to fix problems (Lomborg, 2020). One important channel is that the effects of climate change might manifest – in the short run – through changes in the public’s expectations and their impact on the natural rate of interest. If that is the case, policymakers who actively communicate on the topic without following up their words with adequate policies, could generate part of the negative effects on the economy that they are actually trying to avoid with their communication. The point is substantiated by empirical and theoretical evidence (Dietrich et al., 2021).

Many central banks are also actively contributing to the work of the Network for Greening the Financial System (NGFS), a forum of central bankers and financial supervisors which voluntarily shares best practices, promotes the development of climate risk management in the financial sector and mobilises mainstream finance to support the transition towards a sustainable economy.

Additionally, central banks could promote the disclosure of climate-related risks both among market participants and in their own balance sheets. One framework providing guidelines to this objective is the Task Force on Climate-related Financial Disclosures (TCFD), which recommends disclosing climate risks related to, for example, governance or risk management (TCFD, 2017). Some central banks have already taken initiatives in this field (Banque de France, 2018; Bank of England, 2019; Banca d’Italia, 2019; DNB, 2021).¹¹

In the case of the reactive policies discussed above, the measures described do not pose trade-offs with central banks’ primary mandates. Their widespread adoption should therefore be largely uncontroversial. Finally, central banks can play a catalytic role in greening financial markets and actively advocate support for government activities to the same end (Schnabel, 2020 and 2021 a). In Europe, for example, this takes the form of advocating support for the European Green Deal (European Commission, 2019).

3.3 Proactively mitigating climate change

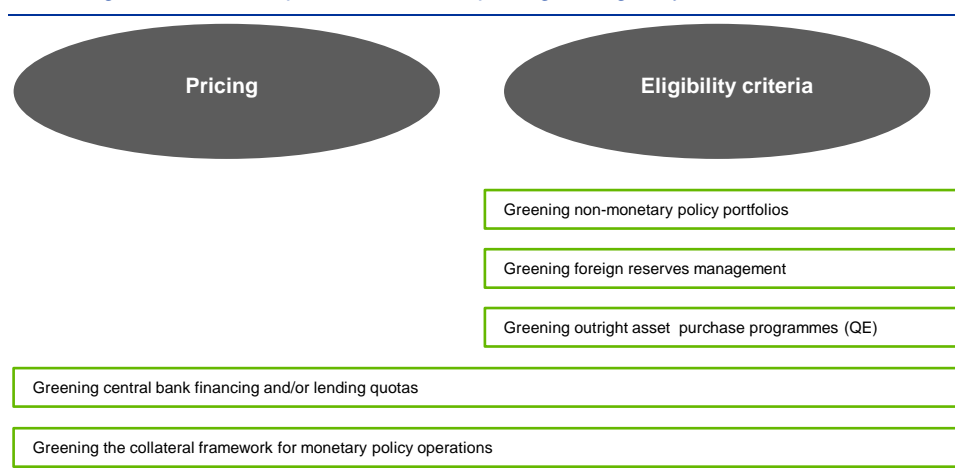
The third category of measures available to central banks to tackle climate change includes action aimed at proactively mitigating climate change and promoting the transition to a low-carbon economy, including through active use of their balance sheets (Figure 2, right-hand panel). Compared to what was discussed above, some of the measures that fall into this category are regarded as controversial and at the mercy of several trade-offs, as discussed in Section 4 below.

Depending on central banks’ legal mandates and operational framework, active support for the transition to a low-carbon economy can be achieved by

¹¹ For example, Banca d’Italia publishes the carbon footprint of some of its portfolios (Banca d’Italia, 2019). Since 2020, the Bank of England has started to disclose how it manages climate-related financial risks across its balance sheet and processes, including in part of its monetary policy portfolios (Bank of England, 2020).

either changing the pricing of central bank facilities or changing the eligibility criteria (Figure 4). Given the size of current central bank balance sheets, the effects of greening central banks' portfolios could be substantial in some cases. Moreover, there could also be important signalling effects for market participants, compounding the direct effects.

Figure 4
Greening central banks' portfolios via the pricing or eligibility criteria



Source: ECB.

3.3.1 Greening non-monetary policy portfolios

Non-monetary policy portfolios, such as staff pension funds and own funds, constitute a suitable starting point for actively greening central banks' portfolios. Because they are not subject to a policy mandate and contain a relatively diverse set of assets, implementing sustainable and responsible investment (SRI) principles is easier for these portfolios, as long as there is no conflict with fiduciary duties or a financial return goal. The NGFS recently published a guide to provide a blueprint for central banks aiming to green their non-monetary policy portfolios (NGFS, 2019).

Many central banks have already taken steps in this direction (DNB, 2017; Banca d'Italia, 2019; Banque de France, 2018; ECB, 2021a; Bank of Finland, 2021).¹² In addition to providing private investment firms with an example of how sustainability principles can be incorporated into portfolio management, such measures reduce the reputational risk that could be associated with central banks not adopting what they recommend to others, e.g. through their supervisory arm, or implementing policies that run counter to societal preferences and government objectives.

¹² De Nederlandsche Bank and Banca d'Italia have integrated ESG criteria in the investment policy for their own portfolios (DNB, 2017; Banca d'Italia, 2019). Banque de France follows an impact-investing approach for its own portfolio as well as for its staff pension fund (Banque de France, 2018).

3.3.2 Greening foreign reserve management

Foreign exchange portfolios constitute an important part of central banks' policy portfolios. Historically, central banks have managed their foreign exchange reserves by balancing return, safety and liquidity considerations (BIS, 2019). Liquidity and safety are particularly relevant if central banks need to stand ready to intervene in foreign exchange markets. More recently, some central banks have allocated part of their foreign reserves to green assets, thereby adding environmental sustainability as a fourth objective. This is likely to create further trade-offs for reserve managers because of the potentially lower liquidity of green bonds and their still relatively small market share (BIS, 2019). However, in an illustrative exercise, BIS (2019) finds that holding both green and conventional bonds can help central banks improve risk-adjusted returns by reaping diversification benefits.

3.3.3 Greening outright asset purchase programmes (“green QE”)

As argued in the previous section, central banks' purchases of corporate securities may inherit the carbon bias in fixed income markets, where they follow the principle of market neutrality when implementing monetary policy decisions. Holdings associated with outright asset purchase programmes form the bulk of policy portfolios for several central banks. Because these portfolios are dedicated to achieving monetary policy objectives, the scope for active portfolio management is more limited compared with non-monetary policy portfolios and holdings of foreign exchange reserves. Despite the difficulties, some central banks have started to consider ways to explicitly incorporate green considerations into existing quantitative easing (QE) programmes deployed for monetary policy purposes, although so far no major central bank has attempted to launch outright green QE programmes. Nevertheless, there is a lively debate on whether or not this should be done (e.g. Weidmann, 2019; de Grauwe, 2019).

The Bank of England and the ECB have both recently announced plans to incorporate climate change considerations in their corporate bond holdings under their monetary policy portfolios (Bank of England, 2021; ECB, 2021b). As shown in Table 1, corporate bond holdings represent only a relatively small share of the monetary policy portfolios and overall balance sheet size of the two central banks, and an even smaller share of the stock of marketable debt securities in the United Kingdom and the euro area respectively. Consequently, the direct contribution, by reducing the carbon footprint of these portfolios, to greening the financial markets cannot be expected to be large. Nevertheless, the indirect effects through signalling could be rather important.

Table 1**Size of Bank of England's CBPS and ECB's CSPP**

Bank of England		ECB	
Corporate Bond Purchase Scheme (GBP billions)	19.8	Corporate sector purchase programme (EUR billions)	296.5
As a share of total stock of Bank of England's gilt asset purchase facility	2.5%	As a share of total stock of Eurosystem APP bonds	9.2%
As a share of total consolidated assets of the Bank of England	3.0%	As a share of total consolidated assets of the Eurosystem	4.2%
As a share of UK stock of debt securities	0.5%	As a share of euro area stock of debt securities	1.5%

Sources: Bank of England (2021), ECB and Eurostat.

Notes: CBPS stands for Corporate Bond Purchase Scheme; CSPP stands for corporate sector purchase programme; APP stands for asset purchase programme. Data shown refer to September 2021.

Several proposals in the literature discuss how a green QE programme could be practically implemented. Such proposals have two prerequisites: they rely on changing the eligibility criteria for these programmes and departing from the market neutrality principle. For example, Schoemaker (2021) proposes a tilting approach that steers central bank asset holdings towards low-carbon companies. Practically, this means overweighting low-carbon emitting companies and underweighting high-carbon emitters. Similarly, Jourdan and Kalinowski (2019) suggest that central banks could phase out their holdings of bonds issued by companies involved in the production and distribution of carbon-intensive sectors, except for bonds labelled explicitly as green. At the same time, they could increase their holdings of green bonds and bonds issued by sectors aligned with transition objectives such as railways, subject to the availability of such bonds.¹³

An alternative proposal for implementing a green QE programme is put forward by de Grauwe (2019), Matikainen et al. (2017) and Ferron and Morel (2014), who argue that central banks should buy bonds issued by supranational institutions such as the European Investment Bank (EIB) or national development banks. One advantage of this proposal is that the decision as to which investments to fund is delegated to an independent institution that allocates funding to projects promoting sustainability, relieving the central bank of the responsibility of making the choices. In the view of the proponents, this would soften the oft-heard criticism that by financing green QE programmes central banks may find themselves encroaching on industrial policy.

However, purchasing bonds from supranational and national development banks also faces limitations and legal constraints in some cases. For example, their lending may be subject to predetermined leverage ratios if they wish to retain a high credit rating on their liabilities. This may prevent them from significantly expanding their loan portfolios in the absence of equity support from shareholders (Matikainen et al., 2017).

¹³ Additionally, Jourdan and Kalinowski (2019) propose that central banks make only assets for which the carbon footprint is disclosed eligible for their purchase programme. This would foster system-wide adoption of carbon disclosure and facilitate green investment strategies by private investors.

3.3.4 Greening central bank financing and/or lending quotas

Similar to corporate bonds, bank lending also reveals a carbon bias compared with equity markets (De Haas and Popov, 2019). This finding has implications for both equity holdings within central banks' monetary policy portfolios and central bank financing schemes. For example, including equities in the eligible universe of central banks' asset purchase programmes or collateral pools would improve funding conditions for more environmentally friendly firms.¹⁴ However, there are caveats and limitations to central banks willingness to experiment with this proposal. Even where they are legally feasible, equity holdings create complex governance issues as central banks thereby become shareholders with voting power. Moreover, they expose central banks to the risk of significant capital losses and, in the case of outright purchases, they require an active decision to exit, since they cannot be run off passively.

The carbon bias in bank lending is likely to be inherited by central bank funding schemes such as the ECB's Targeted Longer-term Refinancing Operations and the Bank of England's Funding for Lending Scheme.¹⁵ Unless additional eligibility criteria or pricing incentives are imposed, such schemes could result in indirectly promoting lending to polluting sectors.

3.3.5 Greening the collateral framework for monetary policy operations

Central banks can green their implementation framework by reviewing the pricing or eligibility criteria for collateral they accept as part of lending operations. As discussed for outright purchases, central banks could require that the carbon footprint of eligible collateral be disclosed. NGFS (2021) presents some specific ideas how this can be done. Alternatively, central banks could pursue negative screening for certain types of financial assets when used as collateral, if feasible.

When pricing collateral used in operations, central banks could apply additional haircuts related to the carbon intensity of the issuer (Dafermos et al., 2021). They could impose a penalising "add-on" factor on the price of certain financial assets used as collateral, to account for the fact that their market price does not fully reflect the climate risks to which they are exposed (as discussed in NGFS, 2021).

Haircuts are commonly used by central banks to protect their balance sheets against the risk of a decline in the value of the collateral after a counterparty default. They usually reflect specific and measurable financial risk characteristics that are likely to materialise in the short to medium run, whereas there is still

¹⁴ For example, the Bank of Japan has been purchasing Exchange Traded Funds (ETFs) since December 2010.

¹⁵ A carbon bias in bank lending is documented, for example, in van 't Klooster and van Tilburg (2020). See also NGFS (2021); De Haas and Popov (2019); and Matikainen et al. (2017).

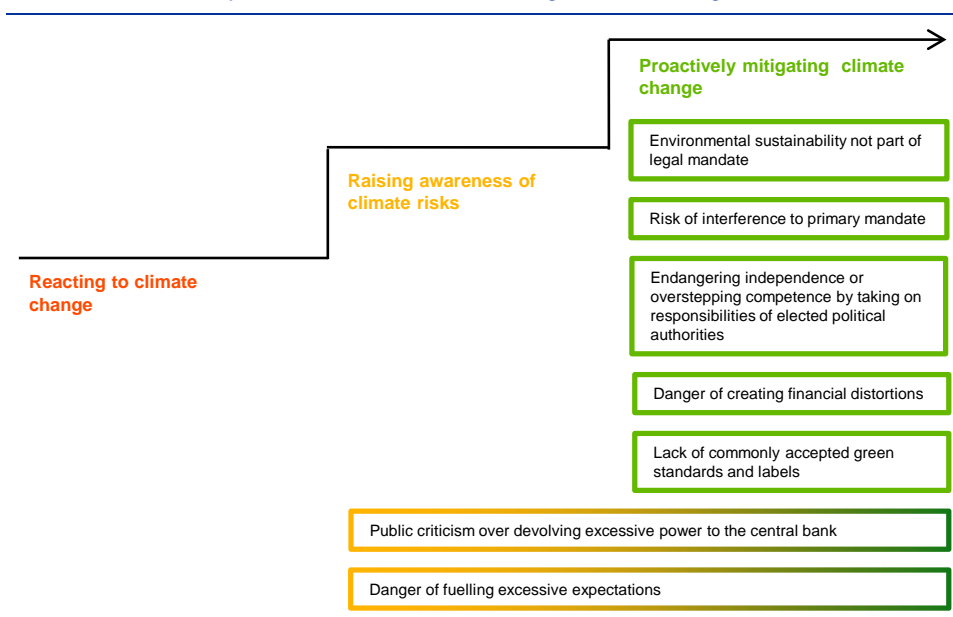
significant uncertainty associated with the different types of climate risk and the horizon over which they are expected to materialise.

4 Criticisms, constraints and trade-offs

Options available to central banks to respond to climate change can be subject to constraints and trade-offs. The main exceptions are reactive strategies, where the central bank does not face any major constraints (Figure 5, left-hand panel).

Central banks taking an active role in raising awareness of climate risks are likely to encounter diverse constraints (Figure 5, middle panel). For example, publicly communicating about the urgency to green the financial system could be perceived as an attempt to acquire more tasks and accumulate more powers.¹⁶ By presenting themselves publicly as leaders in climate matters, central banks risk fuelling excessive expectations about what they can effectively achieve. Overall, these challenges can be met by careful communication with the public and policymakers, for example. There are no apparent constraints or trade-offs associated with joining the NGFS.

Figure 5
Constraints faced by central banks when tackling climate change



Source: ECB.

By contrast, activities classified as proactively mitigating climate change are the most controversial and face a range of material constraints on top of those mentioned above. Most central bank mandates do not explicitly reference sustainability (Dikau and Volz, 2021), raising the issue of whether central banks have the legitimacy to deploy their monetary policy tools to support sustainability objectives. However, around half of the central banks surveyed in this study have an

¹⁶ After Carney's (2015) speech, some commentators noted that he should "stick to his day job as governor".

indirect mandate to support the policy objectives of their respective governments. This raises the question of whether an indirect mandate is sufficient to cover a more active role by the central bank in tackling climate change. The issue is debated in Fischer (2020), Schoenmaker (2021) and Solana (2018).

For the ECB, two main arguments have been presented in the literature to support the case that an active role in mitigating climate change is within its legal remit. Fischer (2020) and Schoenmaker (2021) refer to the ECB's mandate, which specifies price stability as the primary objective, but also states that it "shall support the general economic policies in the Union with a view to contributing to the achievement of the objectives of the Union [...]" provided that doing so is "without prejudice" for price stability (Article 127[1] TFEU). The "objectives of the Union" can be defined as meaning that the EU internal market should "work for the sustainable development of Europe based on balanced economic growth and price stability, aiming at full employment and social progress, and a high level of protection and improvement of the environment" (Article 3[3] TEU). Taking these two legal provisions together, they conclude that the treaties leave room for the ECB to support the green objectives of the EU.

Solana (2018) provides an additional argument. It builds on the requirement that "Environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, in particular with a view to promoting sustainable development" (Article 11 TFEU). As European institutions, Solana argues, the ECB and the Eurosystem are bound by Article 11 TFEU to take environmental objectives into account when implementing monetary policy.

For any central bank wishing to incorporate climate change considerations into its monetary policy framework, the overarching objective should be to deliver the desired monetary stance in a green way. Provided that the different configurations of the monetary policy instruments are all equally conducive to price stability, a central bank may wish to choose the configuration that best supports the environmental objectives of the government, or at least a configuration that does not jeopardise those objectives. This is still a new area for central banks. For example, in an expansionary phase of the monetary policy cycle, a central bank that already has an asset purchase programme in place might decide to "overweight" less-polluting issuers for a given level of purchases, provided that the impact on the stance is unaffected by the composition of purchases. Where there is a package of policy measures, and as long as some green measures constitute a tightening of the stance (e.g. negative screening or exclusion measures), their undesired effects could be offset by finetuning other parameters of this policy package.

However, there may be limitations to this approach. For some measures, their timing or phasing-out could be affected by the particular phase of the monetary policy cycle. The fact that an asset purchase programme is expected to be wound down as inflation sustainably reverts back to a level consistent with the central bank's inflation target means that this type of instrument cannot be used as a permanent tool for the central bank to support climate-related objectives. Clear communication is therefore imperative for those measures which are not permanent and are intended to be discontinued once a change in the stance dictates.

For central banks without a sustainability remit, proactively mitigating climate change could expose them to risks to their independence. Action to mitigate climate change has a political dimension pertaining to elected politicians who are accountable to their voters (Cochrane, 2019). Central banks can play a role in dealing with climate change, but they cannot bypass necessary debates in civil society on fundamental changes in production and consumption habits. This is a concern particularly as greening monetary policy could have significant distributional effects. A widespread concern is that if central banks engage with climate change, other objectives deemed worthy of social consideration may be added, without a clear endpoint in sight, to an ever-expanding remit of central bank responsibilities.

On more practical grounds, greening monetary policy could distort financial markets, especially given the current scarcity of green bonds (Schnabel, 2020 and 2021a). The transmission of monetary policy could also be hampered. Moreover, in the absence of a clear taxonomy and accepted market standards of what is green and what is a polluting investment, and without implementable guidelines, central banks lack an objective definition and possibly a legal underpinning to ground their green policies. They could develop internal classifications and definitions, but this might open the door to accusations of arbitrary discriminations and of pursuing industrial policy objectives by favouring some sectors over others. Given these constraints and trade-offs, central banks need to carefully balance the costs and benefits of any activity aimed at proactively mitigating climate change.

Over and above the issues concerning the interpretation of central banks' mandates, a legitimate question is whether "conventional" monetary policies can work to combat climate change. The literature on this topic is still in its infancy and the issue is widely debated. The main arguments can be summarised as follows.

Textbook monetary policy theory suggests that conventional monetary policy smooths the fluctuations in the economy around its long-run growth trajectory but does very little to affect the trend itself (Woodford, 2003). Applying this to climate change – if over time, climate change depends on the cumulative stock of greenhouse gas emissions, which are the result of how, structurally, the economy produces and consumes – there is a presumption that conventional monetary policy tools should not have a structural impact on climate change.¹⁷ In other words, a slow-moving variable that depends on structural parameters does not respond to any policy aimed at smoothening business cycle fluctuations.¹⁸

However, even if we accept that monetary policy, by nature, cannot structurally affect emissions in the long run, the case can still be made that it may have an impact on the green transition beyond the near term. For example, monetary policy may reduce the transition costs for firms that invest to cut these

¹⁷ Various recent papers examine this issue using structural models in which variables are represented in deviations from the long-run trend. They concur that monetary policy alone is generally ineffective in stemming climate change. For example, Ferrari and Nispi Landi (2020) show that green QE has a very limited impact on reducing the stock of emissions and, therefore, on pursuing climate objectives (a similar conclusion is reached for interest rate policies by Ferrari and Pagliari, 2021).

¹⁸ Instead, policies that change the incentives of agents appear to be more effective, as argued by Nordhaus (2008).

emissions. In this way, monetary policy may not only contribute to lowering emissions in the short run, but it may also ease the path for the economy towards carbon neutrality, thereby generating some long-lasting effects. Similarly, it could be argued that while monetary policy alone cannot determine the structural changes needed to tackle climate change, it can help accelerate the transition towards a green steady state supported by fiscal policy and regulation.

Monetary policy could also have a lasting impact on this transition by supporting disclosure practices in financial markets. As discussed in the previous section, central banks could subject the acceptability of certain securities and financial assets in their monetary policy operations, or the eligibility of certain counterparties, to specific disclosure requirements and information standards, such as the EU green taxonomy in Europe and the practices promoted by the TCFD. This would nurture better market practices and standards and foster data dissemination. Furthermore, central banks would thereby enhance the resilience of their monetary policy implementation frameworks and would play a catalytic role in financial markets. This could be useful in situations where effective collective action is needed to achieve binding environmental targets but heterogeneous market practices and standards, market inefficiencies or other hindrances still stand in the way.

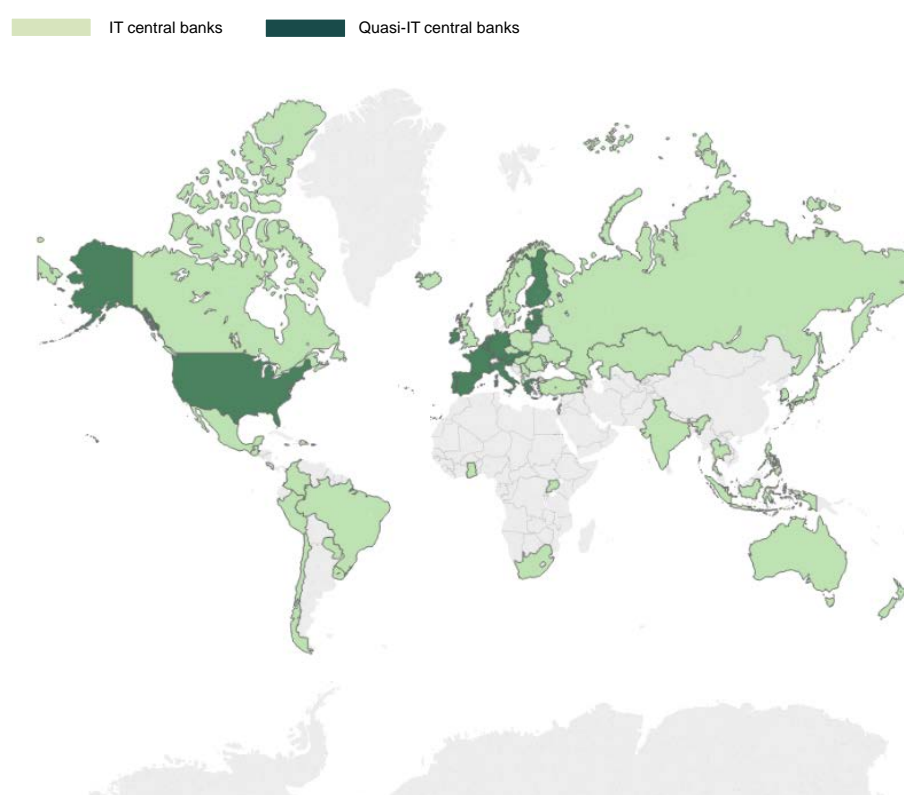
Finally, central banks might need to adapt their policies to a new macroeconomic and financial environment in which climate policies are introduced. If the structural dynamics of the economy are compelled to adapt and mitigate climate change at a sustained pace (e.g. post COP26 in Glasgow), central banks might need to change their optimal response functions in order to meet their mandate under the “new normal”. Moreover, the transition to a “greener” economy is unlikely to be smooth and without economic costs. To the extent that such economic costs and frictions affect inflation dynamics, they cannot be ignored by monetary policy. Such yet unseen scenarios offer ground to argue that central banks should engage in “proactively” integrating climate change considerations in their policies.¹⁹

¹⁹ Several recent studies point in this direction, which is to say that once climate policies are in place, monetary policy can play a role in supporting the transition (see Ferrari and Nispi Landi, 2021; Ferrari and Pagliari, 2021; Benmir and Roman, 2021; Annicchiarico and Di Dio, 2015). In particular, active climate-mitigating fiscal policies could change the volatility of output and inflation which, in turn, implies changes to the optimal policy response of central banks (see Ferrari and Pagliari, 2021).

5 Inflation targeting and climate change

This section discusses how certain features of inflation targeting (IT) might interact, adapt and evolve, as climate risks unfold. Our analysis focuses on the 41 central banks officially classified as fully-fledged inflation targeters by the IMF (see Figure 6). It delves into the definition of the price stability goal and the time horizon over which inflation has to return to target following a shock.

Figure 6
Inflation targeting central banks



Source: The definition of inflation-targeting (IT) central banks can be found under IMF (2019), Table 2, pp 5-6.
Note: The ECB and the Federal Reserve System are classified as quasi-IT central banks, as they do not describe their strategies as inflation targeting but nevertheless share several key features of IT.

5.1 Target measure: core versus headline

For IT central banks, the inflation target may be set in terms of either headline or core inflation, the latter defined as a measure that excludes certain more volatile components, such as food and energy. Conceptually, headline inflation is more familiar to the public but it is influenced by factors beyond the control of the central bank, such as oil prices, commodity prices and indirect taxes. By contrast, core inflation is less volatile, as it excludes prices that are driven by other forces (see Niedźwiedzińska, 2018). Although monetary policy can control overall inflation in the long run, it does not have the ability to control relative price movements such as

those of food and energy (Mishkin, 2007). Yet core inflation is not representative of the typical consumption basket purchased by consumers and, as such, it may lack credibility with the public. The choice between headline and core inflation boils down to a trade-off between ease of meeting the policy goal and representativeness and public acceptance of the target.

In the early years of IT, price stability targets tended to be formulated in terms of core inflation, but nowadays this is more the exception than the rule (Table 2). The vast majority of IT central banks (39 out of 41) currently base their targets on headline inflation, with only Sweden and Uganda targeting some kind of exclusion measures.

Yet most central banks also regularly monitor a host of core inflation measures as indicators of underlying price pressures in the economy and to gauge trends in inflation in the medium term. This allows IT central banks to combine the benefits of both indicators: a definition of the inflation target based on preserving the purchasing power of consumers, which is therefore credible with the public, and an emphasis on inflation measures that allow the central bank to look through short-term volatility.

Looking ahead, a pragmatic definition of the inflation target may be expected to become more relevant as climate-related natural disasters and government policies to mitigate climate risks increase inflation volatility and make inflation shocks more frequent. In this way, IT central banks can benefit from the credibility of a target expressed in terms of headline inflation which fully reflects welfare considerations, while still retaining the flexibility to look through temporary shocks that do not threaten the anchoring of inflation expectations. Appropriate communication emphasising the relative stability of underlying inflation measures may be needed to underpin the case for a policy stance that looks through those shocks.

5.2 Point versus range target

In theory, the inflation target may be set as a point target, with or without an explicit band for deviations, or as a band target, with or without an explicit midpoint. Conceptually, a point target is precise and gives a strong signal of the central bank's inflation goal to the public, leading to a better anchoring of inflation expectations. A key drawback, however, is that it is almost impossible for the central bank to systematically keep inflation at the target, which may result in credibility losses. Conversely, with a target band it is easier to steer inflation between the lower and upper limit and meet the target. A disadvantage is that it gives less clarity about the inflation aim that the central bank seeks to achieve. The trade-off in this case is between the precision of the target and how easily it can be achieved.

In practice, the majority of IT central banks surveyed by the IMF have opted for a mixed approach, with 25 expressing the target as a point within a tolerance

band. Nine (including Japan, Norway, Russia, Sweden, and the UK) have simple point targets while the remaining seven have a target range (see Table 2).

In a world where climate shocks and shocks related to government mitigation policies become increasingly relevant, IT central banks may need to reassess the relative merits and drawbacks of the two definitions. On the one hand, if inflation becomes more volatile, the point target could be helpful to clearly communicate the policy aim of the central bank and ensure a better anchoring of the public's inflation expectations. On the other hand, tolerance bands could convey the sense that the central bank has imprecise control over inflation, allowing policy space to accommodate temporary shocks to the price level and permitting a certain degree of output stabilisation. An explicit tolerance band could facilitate communication, giving the central bank additional flexibility to respond to inflation shocks while putting it less often in the position of having to explain why the target has been missed.

5.3 The time horizon to meet the target

As a forward-looking framework for implementing monetary policy, an important feature of IT is the time horizon for meeting the target. The literature distinguishes between point-in-time targets, to be attained over a specific horizon, and continuous targets, which have to be maintained at all times. In practice, as keeping inflation to target at all times may imply undue costs in terms of output volatility and financial stability, IT central banks typically stabilise inflation around the target level in the “medium term”. The length of the medium term is often not defined, giving central banks flexibility to decide how quickly or slowly inflation should be brought back to the target, depending on the nature of the shock (Niedźwiedzińska, 2018).

Depending on the time horizon for meeting the target, two approaches can be identified: strict and flexible IT. Strict IT means that the central bank is determined to meet the inflation target at all times, irrespective of the costs this may entail for the economy in terms of output losses and volatility. Under flexible IT the central bank pursues price stability while at the same time attempting not to cause undue volatility in output. Whenever inflation deviates from the target, the central bank decides within what time horizon it will bring inflation back to target, while minimising the cost for the real economy.

Strict IT may be inevitable when inflation expectations are dis-anchored and the monetary authority does not have a track record of delivering on its price stability mandate. In these cases, strict IT may be the instrument through which the central bank can build a reputation for delivering on its mandate.

In all other cases, there is a broad consensus in the literature that flexible IT has some advantages relative to strict IT (see Hammond, 2012 for an overview). Indeed, flexible IT is the way the majority of central banks reported in Table 2 have chosen to implement IT. The target horizon extends to a medium term

of unspecified length (22 central banks) or is sufficiently long (18 months or longer) to allow some short-term divergence of inflation from the target when shocks hit the economy (eight central banks).

Svensson (2009) and Walsh (2009) argue that in the presence of supply shocks, a long target horizon limits the decline in output and employment and mitigates their volatility as well as that of the exchange rate and interest rates.

This result also holds for supply shocks caused by climate change and government mitigation policies. However, under flexible IT, the credibility of the central bank may be at risk if the time horizon is extended too much into the future and inflation misses become the norm rather than the exception. Clear communication about the policy intentions of the monetary authority is essential to mitigate credibility losses. In addition, climate-related “escape clauses” may be envisaged, where the central bank states upfront the conditions under which it will accept temporary deviations of inflation from the target, since striving to meet the target would cause undesirable macroeconomic volatility.

5.4 Level of the inflation target

Nowadays, central banks of advanced economies typically aim for an inflation target of between 1% and 3%, with most aiming for the centre of the range (2%, see Table 2). This reflects the current consensus about the plausible level of inflation that is neither too high, so as to impose welfare costs on society, nor too low, so as to outweigh the advantages of a positive inflation target.

Since the global financial crisis, a number of prominent economists have floated the idea of raising the inflation target to 4% (most notably Blanchard et al., 2010). The key argument is to allow more scope for inflation to fall below the target in the event of a negative shock while still avoiding deflation. This, in turn would create more policy space for central banks to cut nominal interest rates in the event of a downturn, reducing the risk of hitting the effective lower bound in interest rates.

The case for a higher inflation target depends on the risk that interest rates will hit their effective lower bound in future recessions. In a nutshell, proponents of a higher inflation target believe, not least in light of recent historical experience, that the risk of hitting the effective lower bound is higher if central banks target 2% inflation than if they pursue a higher goal. Defenders of the status quo object that a higher inflation target would harm the economy.

While this debate is still unsettled, a related question is the extent to which climate risks may affect the balance of the two arguments. If the main impact of climate change on the economy is to make inflation more volatile then, whether the inflation target is set at 2% or 4% should have no material impact on the conduct of monetary policy – provided there is sufficient space to lower policy interest rates when a natural disaster shock hits the economy, i.e. assuming a low probability of hitting the effective lower bound. However, if climate change compounds the effects

of existing structural factors that are already driving down the equilibrium natural interest rate of the economy, then targeting too low an inflation rate could be risky. More frequent climate-induced natural disasters hitting an economy that is already experiencing a low natural interest rate for a combination of structural factors would imply a higher probability of hitting the effective lower bound. Under these conditions, targeting a higher inflation rate could provide a buffer against deflation.

Table 2
Individual countries' inflation targets

Country	Target set by	Target measure	Target 2019	Target type	Target horizon	Note
Albania	CB	H CPI	3%	Point	Medium term	
Armenia	G and CB	H CPI	4% \pm 1.5pp	P + T	Three years	
Australia	G and CB	H CPI	2%–3%	Range	Medium term	Adv
Brazil	G and CB	H CPI	4.25% \pm 1.5pp	P + T	Yearly target	
Canada	G and CB	H CPI	2% (mid-point of 1%–3%)	P + T	Six-eight quarters; current target extends to December 2021	Adv
Chile	CB	H CPI	3% \pm 1pp	P + T	Two years	
Colombia	CB	H CPI	3% \pm 1pp	P + T	Medium term	
Costa Rica	CB	H CPI	3% \pm 1pp	P + T	Two years	
Czech Republic	CB	H CPI	2% \pm 1pp	P + T	Medium term, 12–18 months	Adv
Dominican Republic	G and CB	H CPI	4% \pm 1pp	P + T	Medium term	
Georgia	G and CB	H CPI	3%	Point	Medium term	
Ghana	G and CB	H CPI	8% \pm 2pp	P + T	Medium term	
Guatemala	CB	H CPI	4% \pm 1pp	P + T	End of year	
Hungary	CB	H CPI	3% \pm 1pp	P + T	Medium term	
Iceland	G and CB	H CPI	2.5%	Point	On average	Adv
India	G (with CB)	H CPI	4% \pm 2pp	P + T	On average over three consecutive quarters	
Indonesia	G	H CPI	3.5% \pm 1pp	P + T	Medium term	
Israel	G and CB	H CPI	1%–3%	Range	Within two years	Adv
Japan	CB	H CPI	2%	Point	At the earliest possible time	Adv
Jamaica	G	H CPI	4%–6%	Range	Medium term	
Kazakhstan	CB	H CPI	4%–6%	Range	Medium term	
Korea	CB (with G)	H CPI	2% \pm 1pp	P + T	Medium term	Adv
Mexico	CB	H CPI	3% \pm 1pp	P + T	Medium term	
Moldova	CB	H CPI	5% \pm 1.5pp	P + T	Annually	
New Zealand	G and CB	H CPI	1%–3% (focus on 2% mid-point)	Range	Medium term	Adv
Norway	G	H CPI	2%	Point	Medium term	Adv
Paraguay	CB	H CPI	4% \pm 2pp	P + T	Medium term	
Peru	CB	H CPI	2% \pm 1pp	P + T	At all times	
Philippines	G and CB	H CPI	3% \pm 1pp	P + T	Two years	

Country	Target set by	Target measure	Target 2019	Target type	Target horizon	Note
Poland	CB	H CPI	2.5% ±1pp	P + T	At all times	
Romania	G and CB	H CPI	2.5% ±1pp	P + T	Medium term	
Russia	G and CB	H CPI	4%	Point	Medium term	
Serbia	G and CB	H CPI	3% ±1.5pp	P + T	Medium term	
South Africa	G (with CB)	H CPI	3%–6%	Range	On a continuous basis	
Sweden	CB	H CPIF	2% (with a variation band of 1%-3%)	Point	Normally two years	Adv
Thailand	G and CB	H CPI	2.5% ±1.5pp	P + T	Medium term	
Turkey	G and CB	H CPI	5% ±2pp	P + T	Year-end	
Uganda	CB	C CPI	5%	Point	Medium term, i.e. 1-2 years	
Ukraine	CB	H CPI	5% ±1pp	P + T	Medium term	
UK	G	H CPI	2%	Point	At all times	Adv
Uruguay	G and CB	H CPI	3%–7%	Range	24 months	

Source: Adapted from Hammond (2012), updated using information from central banks' websites.

Notes: The list of fully-fledged inflation targeting central banks is in line with IMF (2019), Table 2, pp 5-6. CB = Central bank; G = Government; H CPI = Headline CPI; C CPI = Core CPI; H CPIF = Headline CPI with fixed interest rate. P+T = Point with tolerance band. PP = percentage point(s). Adv = advanced economy.

6 Final remarks and future research

Climate scientists are warning us about the consequences of unabated climate change for our societies and economies. We have discussed various reasons why climate change is an important influencing factor for monetary policy and reviewed the emerging literature on what monetary policy can do about it. We grouped the various proposals into three categories, ranging from defensive actions to protect central banks' balance sheets from climate risks through to actions aimed at proactively mitigating climate change and favouring the transition to a low-carbon economy, including through active use of the balance sheet.

Some measures are controversial since they can be seen as extending central banks' mandate beyond traditional boundaries, encroaching, in some cases, upon economic policies and raising issues of legitimacy and risks for central bank independence. The exact form of central banks' reactions will therefore depend on their mandates and how various trade-offs pan out in each individual case.

Finally, we argued that climate disruptions will pose specific challenges for inflation-targeting central banks. These may require policymakers to re-examine the relative merits of some design features of the framework, in particular the definition of the inflation target, the type of inflation measure used in central bank communications and how to appropriately calibrate the medium-term horizon of monetary policy.

Our review points to several unexplored areas for future research. Data gaps and the absence of a widely agreed taxonomy for green assets currently prevent researchers from better understanding the impact that greening monetary policy portfolios could have on national and global carbon emissions. In addition, the impact of climate trends on the natural rate of interest needs to be better understood. Finally, more research would be welcome on how climate change affects different monetary policy frameworks and how monetary policy should interact with fiscal, financial and structural policies to meet the challenges posed by climate change.

References

- Alessi, L., Ossola, E., and Panzica, R. (2021), “What greenium matters in the stock market? The role of greenhouse gas emissions and environmental disclosures”, *Journal of Financial Stability*, Vol. 54.
- Andersson, M., Baccianti, C., and Morgan, J. (2020), “Climate change and the macroeconomy”, *Occasional Paper Series*, No 243, ECB.
- Annicchiarico, B., and Di Dio, F. (2015), “Environmental policy and macroeconomic dynamics in a new Keynesian model”, *Journal of Environmental Economics and Management*, Vol. 69, pp. 1-21.
- Banca d’Italia (2019), [The Bank of Italy values sustainability in its financial investments: Information on ESG Criteria](#), May.
- Bank of Japan (2010), *Principal Terms and Conditions for the Fund-Provisioning Measure to Support Strengthening the Foundations for Economic Growth Conducted Through the Loan Support Program*, June.
- Bank of England (2020), [The Bank of England’s climate-related financial disclosure 2020](#), June.
- Bank of England (2021), “Options for greening the Bank of England’s Corporate Bond Purchase Scheme”, *Discussion Paper*, May.
- Bank of Finland (2021), [Annual Report 2020](#).
- Banque de France (2018), [Responsible Investment Report 2018](#), March.
- Banque de France (2019), *Financial Stability Review*, No 23, June.
- Batten, S. (2018), “Climate change and the macro-economy: a critical review”, *Staff Working Paper*, No 706, Bank of England.
- Batten, S., Sowerbutts, R. and Tanaka, M. (2016), “Let’s talk about the weather: the impact of climate change on central banks”, *Staff Working Paper*, No 603, Bank of England.
- Batten, S., Sowerbutts, R. and Tanaka, M. (2020), “Climate change: macroeconomic impact and implications for monetary policy”, in Walker, T., Gramlich, D., Bitar, M. and Fardnia, P. (eds.), *Ecological, Societal and Technological Risks and the Financial Sector*, Palgrave Macmillan, Basingstoke.
- Benmir, G., and Roman, J. (2021), “Policy interactions and the transition to clean technology”, *Working Paper*, No 368, Centre for Climate Change Economics and Policy, LSE.

Benmir, G., Jaccard, I., and Vermandel, G. (2021), “Green asset pricing”, *Working Paper Series*, No 2477, ECB.

BIS (2019), “Green bonds: the reserve management perspective”, *Quarterly Review*, September.

Blanchard, O., Dell’Ariccia, G. and Mauro, P. (2010), “Rethinking macroeconomic policy”, *IMF Staff Position Note*, SPN/10/03.

Bolton, P., Despres, M., Pereira da Silva, L.A., Samama, F. and Svartzman, R. (2020), “[The green swan: central banking and financial stability in the age of climate change](#)”, *BIS and Banque de France*.

Bolton, P. and Kacperczyk, M.T. (2021), “Do investors care about carbon risk?”, *Journal of Financial Economics*, in press.

Brainard, L. (2019), *Why climate change matters for monetary policy and financial stability*, speech at the research conference “The Economics of Climate Change” sponsored by the Federal Reserve Bank of San Francisco, San Francisco, 8 November.

Brand, C., Bielecki, M. and Penalver, A. (eds.) (2018), “The natural rate of interest: estimates, drivers, and challenges to monetary policy”, *Occasional Paper Series*, No 217, ECB.

Brunnermeier, M. and Landau, J. (2020), “Central banks and climate change”, *VoxEU.org*, 15 January.

Campiglio, E. (2016), “Beyond carbon pricing: the role of banking and monetary policy in financing the transition to a low-carbon economy”, *Ecological Economics*, Vol. 121, pp. 220-230.

Campiglio, E., Dafermos, Y., Monnin, P., Ryan-Collins, J., Schotten, G. and Tanaka, M. (2018), “Climate change challenges for central banks and financial regulators”, *Nature Climate Change*, Vol. 8, No 6, pp. 462-468.

Carney, M. (2015), “*Breaking the tragedy of the horizon – climate change and financial stability*”, speech at Lloyd’s of London, 29 September.

Carney, M. (2019), “*A new horizon*”, speech at the European Commission conference, “A global approach to sustainable finance”, Brussels, 21 March.

Cochrane, J. (2019), “An apocalyptic view of central banks”, *The Grumpy Economist blog post*, 30 May.

Coeuré, B. (2018), *Monetary policy and climate change*, speech at a conference on “Scaling up green finance: the role of central banks”, organised by the NGFS, the Deutsche Bundesbank and the Council on Economic Policies, Berlin, 8 November.

Dafermos, Y., Gabor, D., Nikolaidi, M., Pawloff, A. and van Lerven, F. (2021), “Greening the Eurosystem collateral framework: how to decarbonise the ECB’s monetary policy”, *New Economics Foundation*.

Debelle, G. (2019), *Climate change and the economy*, speech at the Public Forum hosted by the Centre for Policy Development, Sydney.

de Grauwe, P. (2019), “Green money without inflation”, *Ivory Tower blog post*, 26 February.

De Haas, R. and Popov, A. (2019), “Finance and carbon emissions”, *Working Paper Series*, No 2318, ECB.

Dietrich, A., Müller, G. and Schoenle, R. (2021), “The expectations channel of climate change: implications for monetary policy”, *CEPR Discussion Paper*, No 15866, Centre for Economic Policy Research.

Dikau, S. and Volz, U. (2021), “Central bank mandates, sustainability objectives and the promotion of green finance”, *Ecological Economics*, Vol. 184.

DNB (2017), [Annual Report 2016](#), De Nederlandsche Bank, Amsterdam.

DNB (2021), [Annual Report 2020](#), De Nederlandsche Bank, Amsterdam.

ECB (2021a), “ECB to invest in Bank for International Settlements’ green bond fund”, press release, 25 January.

ECB (2021b), “ECB presents action plan to include climate change considerations in its monetary policy strategy”, press release, 8 July.

ECB (2021c), “Climate change and monetary policy in the euro area”, *Occasional Paper Series*, No 271, ECB.

European Commission (2019), [The European Green Deal](#), website.

Ferrari, A., and Nispi Landi, V. (2020), “Whatever it takes to save the planet? Central banks and unconventional green policies”, *Working Paper Series*, No 2500, ECB.

Ferrari, A., and Nispi Landi, V. (2021), “Towards a green economy: the role of central bank asset purchases”, mimeo.

Ferrari, M., and Pagliari, M. (2021), “No country is an island: international cooperation and climate change”, *Working Paper Series*, No 2568, ECB.

Ferron, C. and Morel, R. (2014), “Smart Unconventional Monetary (SUMO) policies: giving impetus to green investment”, *Climate Report*, No 46, IAEA.

Feyen, L., Ciscar J.C., Gosling S., Ibarreta, D. and Soria, A. (2020), “Climate change impacts and adaptation in Europe”, *JRC PESETA IV final report*, EUR 30180 EN, Publications Office of the European Union.

Fischer, Y. (2020), “Global warming: does the ECB mandate legally authorise a ‘green monetary policy?’”, mimeo.

Fratzscher, M., Grosse-Steffen, C. and Rieth, M. (2020), “Inflation targeting as a shock absorber”, *Journal of International Economics*, Vol. 123.

Hammond, G. (2012), “State of the art of inflation targeting”, *CCBS Handbook*, No 29, Bank of England.

Hsiang, S., Kopp, R., Jina, A., Rising, J., Delgado, M., Mohan, S., Rasmussen, D.J., Muir-Wood, R., Wilson, P., Oppenheimer, M., Larsen, K. and Houser, T. (2017), “Estimating economic damage from climate change in the United States”, *Science*, Vol. 356, Issue 6345, pp. 1362-1369.

Honohan, P. (2019), “Should monetary policy take inequality and climate change into account?”, *PIIE Working Paper*, No 19-18.

IMF (2019), *Annual Report on Exchange Arrangements and Exchange Restrictions 2018*.

IPCC (2018), [Global warming of 1.5°C, Special report](#), Intergovernmental Panel on Climate Change, Geneva.

IPCC (2021), [Climate change 2021, the physical science basis, summary for policymakers](#), Intergovernmental Panel on Climate Change, Geneva.

Jourdan, S. and Kalinowski, W. (2019), “Aligning monetary policy with the EU's climate targets”, *Veblen Institute and Positive Money Working Paper*.

Krogstrup S. and Oman, W. (2019), “Macroeconomic and financial policies for climate change mitigation: a review of the literature”, *IMF Working Paper*, No 19/185, International Monetary Fund.

Lagarde, C. (2021), *Climate change and central banking*, Keynote speech at the ILF conference on Green Banking and Green Central Banking, 25 January.

Lane, P. (2019), *Climate change and the Irish financial system*, Monsignor Pádraig de Brún memorial lecture, NUI Galway, 5 February.

Laubach, T. and Williams, J.C. (2015), “Measuring the natural rate of interest redux”, *Federal Reserve Bank of San Francisco Working Paper*, No 2015-16.

Lomborg, B. (2020), *False alarm*, Basic Books.

Matikainen, S., Campiglio, E. and Zenghelis, D. (2017), “The climate impact of quantitative easing”, *Grantham Research Institute on Climate Change and the Environment Policy Paper*.

McKibbin W., Morris, A., Panton, A. and Wilcoxon, P. (2020), “Climate change and monetary policy: issues for policy design and modelling”, *Oxford Review of Economic Policy*, Vol. 36, Issue 3, pp. 579–603.

Mishkin, F. S. (2007), *Headline versus core inflation in the conduct of monetary policy*, Speech at the Business Cycles, International Transmission and Macroeconomic Policies Conference, HEC Montreal, Montreal, Canada, October.

Monnin, P. (2018), "Central banks should reflect climate risks in monetary policy operations", *SUERF Policy Note*, No 41.

NGFS (2019), [A sustainable and responsible investment guide for central banks' portfolio management](#), *Technical Document*, Network for Greening the Financial System, Paris, October.

NGFS (2020a), [Climate change and monetary policy: initial takeaways](#), *Technical Document*, Network for Greening the Financial System, Paris, October.

NGFS (2020b), *NGFS climate scenarios for central banks and supervisors*, June.

NGFS (2021), *Adapting central bank operations to a hotter world: reviewing some options*, March.

Niedźwiedzińska, J. (2018), "Inflation targeting: institutional features of the strategy in practice", *NBP Working paper*, No 299.

NASA (2020), ["NASA, NOAA analyses reveal 2019 second warmest year on record"](#), press release 20-003, 15 January.

NOAA (2019), ["July 2019 was hottest month on record for the planet"](#), press release, 15 August.

Nordhaus, W. (2008), *A question of balance: weighing the options on global warming policies*, Yale University Press.

Nordhaus, W. (2019), "Climate change: the ultimate challenge for economics", *American Economic Review*, Vol. 109 No 6, pp. 1991-2014.

Pagliari, M. (2021), "LSIs' exposures to climate change related risks: an approach to assess physical risks", *Working Paper Series*, No 2517, ECB.

Papoutsis, M., Piazzesi, M. and Schneider, M. (2021), "How unconventional is green monetary policy?", *JEEA-FBBVA Lecture at ASSA*, January, mimeo.

Pereira da Silva, L. (2019), *Research on climate-related risks and financial stability: An 'epistemological break'?*, speech at the conference of the Central Banks and Supervisors Network for Greening the Financial System (NGFS), Paris, 17 April.

Powell, J. (2019), testimony before the House Financial Services Committee hearing on "Monetary Policy and the State of the Economy", 10 July, Washington, DC.

Rudebusch, G.D. (2019), "Climate change and the Federal Reserve", *FRBSF Economic Letter*, No 9, Federal Reserve Bank of San Francisco.

Schnabel, I. (2020), *When markets fail – The need for collective action in tackling climate change*, speech given at the European Sustainable Finance Summit, Frankfurt am Main, 28 September.

Schnabel, I. (2021a), *From green neglect to green dominance?*, speech given at the “Greening monetary policy – Central banking and climate change” held at the Cleveland Fed conversations on central banking, 3 March.

Schnabel, I. (2021b), *From market neutrality to market efficiency*, speech given at the ECB DG-Research Symposium “Climate change, financial markets and green growth”, 14 June.

Schoenmaker, D. (2021), “Greening monetary policy”, *Climate Policy*, Vol. 21, Issue 4, pp. 581-592.

Schotten, G., van Ewijk, S. Regelink, M. Dicou, D. and Kakes, J. (2016), “Time for transition – An exploratory study of the transition to a carbon-neutral economy”, *Netherlands Central Bank Occasional Studies*, Vol. 14, No 2.

Solana, J. (2018), “The power of the Eurosystem to promote environmental protection”, *University of Oslo Faculty of Law Research Paper*, Vol. 2018-23.

Stern, N.H. (2007), *The economics of climate change: the Stern review*, Cambridge University Press.

Svensson, L. (2009), “Flexible inflation targeting – Lessons from the financial crisis”, in *Towards a new framework for monetary policy? Lessons from the crisis*, De Nederlandsche Bank workshop, Amsterdam, 21 September.

Van ‘t Klooster, J. and van Tilburg, R. (2020), *Targeting a sustainable recovery with Green TLTROs*, Positive Money Europe, September.

Walsh, C. (2009), “Inflation targeting: What have we learnt?”, *International Finance*, Vol. 12, Issue 2, pp. 195-233.

Weidmann, J. (2019), *Climate change and central banks*, welcome address at the Deutsche Bundesbank’s second financial market conference, Frankfurt am Main, 29 October.

Woodford, M. (2003), *Interest and prices: Foundations of a theory of monetary policy*, Princeton University Press, Princeton, United States.

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Lena Boneva

European Central Bank, Frankfurt am Main, Germany; email: lena_mareen.boneva@ecb.europa.eu

Gianluigi Ferrucci

European Central Bank, Frankfurt am Main, Germany; email: gianluigi.ferrucci@ecb.europa.eu

Francesco Paolo Mongelli

European Central Bank, Frankfurt am Main, Germany; email: francesco.mongelli@ecb.europa.eu

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Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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