STUDY

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Climate change considerations in monetary policy implementation

Compilation of papers

Economic Governance and EMU Scrutiny Unit (EGOV)
Directorate-General for Internal Policies
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Climate change considerations in monetary policy implementation

Compilation of papers
Monetary Dialogue November 2023

Abstract

Climate change and monetary policy are becoming increasingly intertwined. The relationship between climate risk and inflation is non-trivial, presenting the ECB with a number of trade-offs in its monetary policy operations. Lately, the ECB has stepped up its efforts to embed climate change considerations at the heart of its monetary policy framework, yet recent inflationary pressures threaten to water down the effectiveness of its actions, including the tilting of its bond portfolio towards green issuers.

Four papers were prepared by the ECON Committee's Monetary Expert Panel on the integration of climate change considerations in the conduct of monetary policy by the ECB.

This document was provided by the Economic Governance and EMU Scrutiny Unit at the request of the Committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 27 November 2023.

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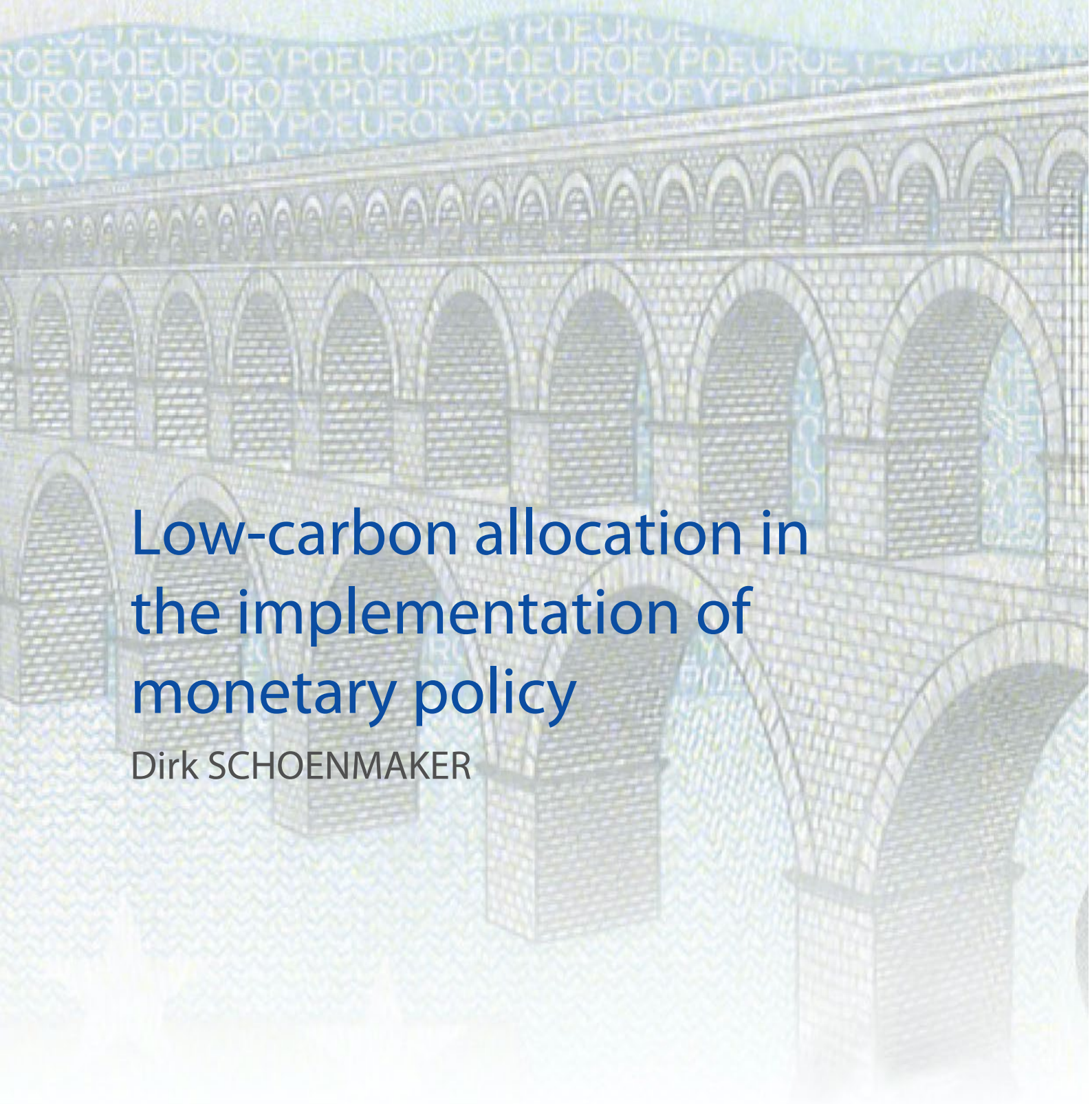

Low-carbon allocation in the implementation of monetary policy

Dirk SCHOENMAKER

Abstract

This paper analyses how the European Central Bank (ECB) can incorporate climate change considerations into its implementation of monetary policy. It reviews the impact of climate shocks on inflation, and the instruments available to decarbonise the ECB's asset and collateral portfolio. The paper concludes with recommendations to the ECB that would increase the low-carbon allocation in its monetary policy framework. This will in turn speed up the green transition and reduce the euro area's fossil-fuel dependency.

This document was provided by the Economic Governance and EMU Scrutiny Unit at the request of the Committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 27 November 2023.

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LIST OF ABBREVIATIONS

APP	Asset purchase programme
CSRD	Corporate Sustainability Reporting Directive
ECB	European Central Bank
EP	European Parliament
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
HICP	Harmonised index of consumer prices
IPCC	Intergovernmental Panel on Climate Change
QE	Quantitative Easing
SREP	Supervisory Review and Evaluation Process
TLTRO	Targeted longer term refinancing operations
USD	US dollar

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EXECUTIVE SUMMARY

- **Climate change can have a major impact on economic activity and prices.** This paper analyses three climate shocks: (1) climateflation: physical risks from climate change, including extreme weather events, leading to bad harvests and higher food prices; (2) greenflation: transition risks arising from green investments leading to higher metals and minerals prices; and (3) fossilflation: rising fossil-fuel prices leading to inflation. We find that volatile energy prices are a major contributor to inflation dynamics.
- **The European Central Bank (ECB) faces trade-offs in its policy response.** To reduce greenflation, the ECB may slow down the implementation of monetary policy instruments that reduce the allocation of its asset and collateral pool to carbon-intensive assets. By contrast, the ECB can implement monetary policy instruments to increase the allocation to low-carbon assets, in line with other European Green Deal regulatory policies. Another trade-off is that high interest rates to combat inflation may hamper green investments, which are sensitive to financing conditions. Paradoxically, the vulnerability to price instability caused by fossil fuels would be preserved in this way. To soften the impact of energy prices on inflation and speed up the energy transition, the ECB can incentivise private banks to lend more money for green investment and/or tilt its assets and collateral portfolio towards low-carbon assets. This would reduce the reliance on fossil fuels.
- **The current euro-area financial system has a carbon bias.** Without adjusting its monetary policy instruments, the ECB would reinforce this carbon bias. Investment in, and lending to, carbon-intensive companies reinforces the long-term lock-in of carbon in production processes and infrastructure. There is thus a need for the ECB to adopt low-carbon allocation in its monetary policies.
- **As the ECB is phasing out quantitative easing (QE), action is now shifting to the ECB's collateral framework**. We find there is scope to expand the already introduced low-carbon allocation from corporate bonds to bank bonds. This would more than double the effect of steering the ECB's collateral pool towards low-carbon assets.
- **The ECB could introduce green Targeted Longer Term Refinancing Operations (TLTROs) to soften the impact of high interest rates on green investment.** Lower interest rate on green refinancing operations would provide an incentive to banks to increase their green lending. This would keep the energy transition on track.
- **A well-functioning financial system is crucial for the smooth transmission of monetary policy.** Climate change shocks may threaten the stability of the financial system. This paper recommends a capital surcharge for high-carbon companies, to reduce the risk of stranded assets for banks and to reduce the systemic risk of climate change. From a financial stability perspective, the ECB should also consider macroprudential limits on carbon-intensive assets.

1. INTRODUCTION[1]

Climate shocks have had a major impact on inflation over the last two years. Increased physical risks, including extreme weather events, have caused bad harvests, pushing up food prices. The green transition has led to sharp rises in the prices of metals and minerals, while the rise in oil and gas prices brought about by Russia's invasion of Ukraine has had a major impact on inflation. Climate change considerations are thus relevant for the European Central Bank's primary objective of maintaining price stability.

Higher interest rates are important to combat inflation. But the new 'higher for longer' interest rate environment has a detrimental effect on the green transition, which depends to a great degree on upfront investment. Slowing down the green transition reinforces the current carbon bias in the financial system and the long-term lock-in of carbon in production processes and infrastructure.

The ECB's policy challenge is to regain price stability while not hampering the energy transition, which would reduce the euro area's dependency on fossil fuels and thereby its exposure to volatile energy prices. This paper **reviews the options the ECB has in pursuing a low-carbon allocation approach in its asset and collateral pool (as part of its monetary policy implementation framework)**, while maintaining price stability. **We tackle this review from three angles**.

First, we analyse the asset and collateral base underlying the ECB's monetary policy implementation procedures. High-carbon companies are more capital intensive and issue more stocks and bonds than low-carbon companies. **Current monetary policy implementation procedures mirror this carbon bias.** In its quantitative easing strategy, the ECB has started to tilt its asset portfolio towards low-carbon corporate bonds. However, this has been halted, as QE is being phased out. The question is how the ECB can shift its focus to low-carbon allocation in its collateral pool and increase the scope from corporate bonds to bank bonds, which form a major part of the collateral pool.

Second, we take an investment perspective. High interest rates have a significant impact on the green transition because it requires major upfront investments in infrastructure, production processes and the built environment (real estate). Therefore, differentiation between the financing conditions for high-carbon investments and low-carbon investments is crucial to prevent a slowdown in green investments. A first question is the division of labour between the government providing subsidised green loans, and the central bank providing lower interest rates for green loans. Another question is how the ECB could provide such lower interest rates, without affecting the monetary policy stance it is taking to combat inflation.

Third, from a financial-stability perspective, the smooth transmission of monetary policy requires a stable banking system. Transition risks may lead to abrupt changes in the value of carbon-intensive assets, turning them into stranded assets. The ECB is already conducting stress tests showing the vulnerability of individual banks and the wider banking system. The question is whether the ECB should move from the analysis, monitoring and warning stage, to the action stage to address the risk of stranded assets for the banking system. As a banking supervisor, the ECB could use capital surcharges for high carbon assets, starting through pillar 2. And in its financial stability role, the ECB could introduce macro-prudential limits on high-carbon exposures.

[1] The author thanks Juan Mejino-Lopez for excellent research assistance and Nathan de Arriba-Sellier and Rens van Tilburg for very useful suggestions and comments.

This paper is structured as follows. Section 2 analyses the impact of climate change on implementation of monetary policy. Section 3 addresses structural factors that are relevant for the ECB to be able to incorporate climate change considerations into its monetary policy framework. Section 4 reviews several monetary policy instruments that the ECB could employ to deal with climate change. Section 5 concludes.

2. IMPLICATIONS OF CLIMATE CHANGE FOR THE IMPLEMENTATION OF MONETARY POLICY

Climate change has implications for implementation of monetary policy implementation in several ways. Starting with the economic channel, a major impact is the effect of climate change on price stability (Schnabel, 2022). Rising energy prices and food prices are major drivers of the recent bouts of high inflation, in response to which, the ECB has increased its key interest rates. Rising interest rates have an impact on the financing of renewable energy projects. Investment in renewables is hampered by high financing costs.

Moving to the financial channel, the make-up of the financial system is crucial for the transmission of monetary policy. The current set-up of the European financial system has a bias towards high-carbon assets (Cosemans and Schoenmaker, 2022), which reinforces climate change. The stability of the financial system is also important for a smooth monetary transmission.

2.1. Impact of climate change on price stability

Climate change can have a major impact on economic activity and prices[2]. Schnabel (2022) distinguished three separate shocks that put upside pressure on inflation. **The first shock is the impact of climate change itself, dubbed as *climateflation*.** Physical risks from climate change are already happening through natural disasters and extreme weather events, including droughts, floods and storms. The severity of these events has intensified, causing bad harvests, which in turn increases food prices. As food forms a central part 15.7% of the consumption basket (see Table 1), food prices are a major driver of inflation.

A second shock is related to investments and policies for greening the economy ('*greenflation*'). The aim of the low-carbon transition is to limit the impact of global warming in the future. As companies shift to low-carbon technologies for their production processes (e.g. power generation or steel production) and their final products (e.g. electric cars), demand will increase for metals and minerals, such as lithium for batteries. As the supply is fixed in the medium term[3], this increased demand put an upward pressure on metal of 20% on an annualised basis over the 2020-2023 period (see Figure 3)[4]. Climate-mitigation policies put another upward pressure on prices. The European carbon price – based on emissions trading – increased from about €20 in 2018-2020 to more than €80 in 2023 (see Figure 4 in section 3.3). This increase is a direct (and intended) effect of the European Green Deal.

The third shock refers to fossil-fuel prices ('*fossilflation*'). Russian's invasion of Ukraine has increased energy prices, as embargos in Europe and the United States have reduced oil and gas imports from Russia. This increase in fossil-fuel prices has led to further increases in prices, given that EU economies are still carbon-intensive. Oil and gas prices have been rising excessively in this oligopolistic market, with artificial supply restrictions (Schnabel, 2022). An important way to mitigate the impact of fossil fuel prices on inflation is to reduce the European economy's reliance on fossil fuels.

2.1.1. Relative importance of shocks

Figure 1 shows the impact of the shocks on the Harmonised Index of Consumer Prices (HICP), which is used to measure consumer price inflation in the euro area. **The bulk of the inflationary pressure has**

[2] See Claeys (2024) for overview of the impact of climate change on economic activity and prices.

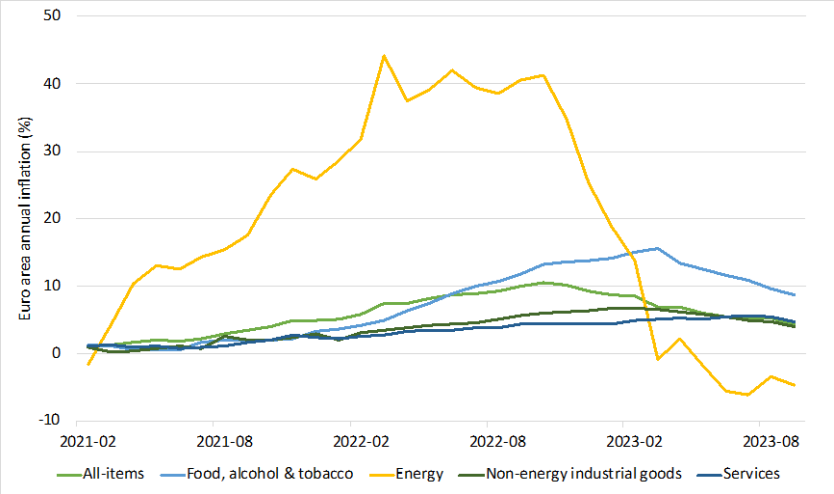
[3] It typically takes five to ten years to develop new mines (Schnabel, 2022).

[4] This number is based on global metal prices, so without minerals.

come from the rise in energy prices (fossilflation), with increases of up to 40% on an annual basis. The inflationary effects of food prices (climateflation) shows increases of up to 15% (which are partly caused by higher input prices for energy). Table 1 shows the relative contributions to annualised inflation during the high inflation period from March 2021 to March 2023. Energy counts for 2.8 percentage points (p.p.) of the 6.2% inflation rate over this period, i.e. almost half. Food contributes 1.1 (p.p.) of the 6.2% inflation rate.

The relative contribution of metal and mineral prices (greenflation) cannot be calculated as this component is not separately counted in the Eurostat HICP statistics. But it is a small category, with a minor contribution to overall inflation. Figure 2 shows the development of global metal prices. Temporary increases in metal prices are not unusual, and happened before in 2007 and 2012.

Figure 1: Euro-area annual inflation and its components (2021-2023)



Source: Bruegel calculations based on Eurostat.

Notes: The inflation data used are the Harmonised Index of Consumer Prices (HICP) for the euro area.

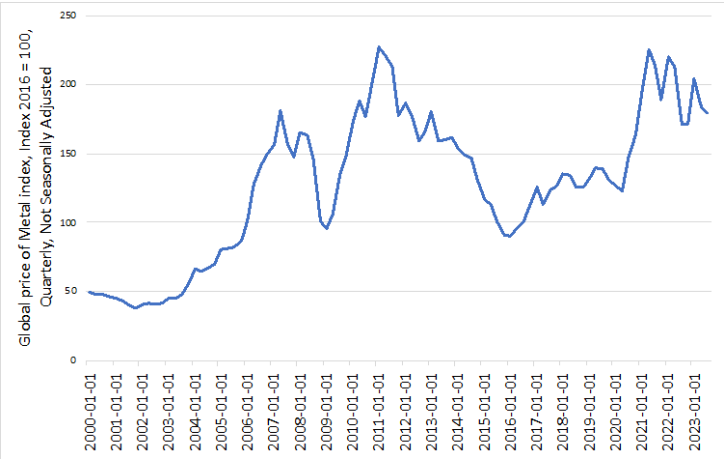
Table 1: Size of inflation components (March 2021 – March 2023)

	% of consumption basket (1)	Average annual inflation in % (2)	Contribution to HICP inflation in p.p. (1)*(2)
All items	100.0	6.2	6.2
Food	15.7	6.8	1.1
Energy	10.9	25.6	2.8
Non-energy industrial goods	28.0	3.6	1.0
Services	45.4	2.9	1.3

Source: Bruegel calculations based on Eurostat.

Notes: The first column shows the importance of the inflation component of the HICP consumption basket. The second column depicts the average annual inflation over the March 2021 – March 2023 period. The third column is the relative contribution (in percentage points) to HICP inflation.

Figure 2: Global price of metals (2000-2023)



Source: Bruegel calculations based on FRED (Federal Reserve Economic Data).

Notes: The data shows the global price of metals index (2016 = 100).

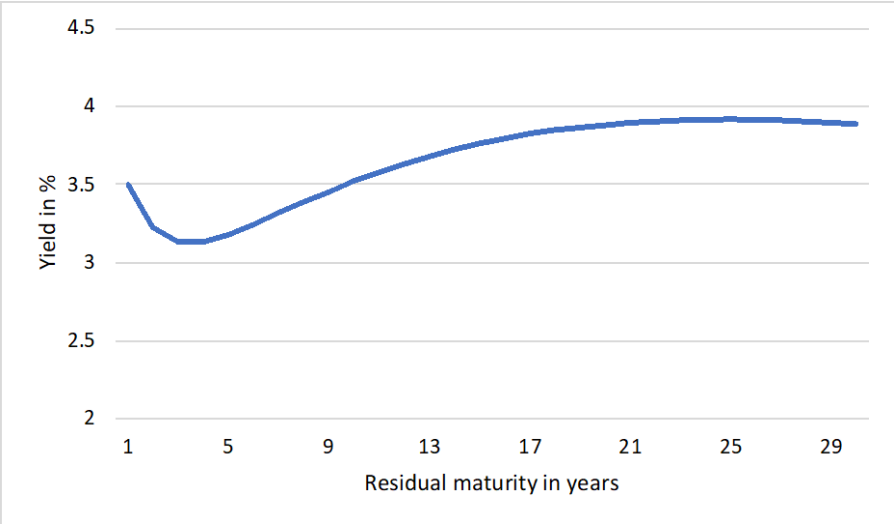
2.2. High interest rates for renewables

The euro-area economy is moving from a 'low for long' to a 'higher for longer' interest rate environment. The euro-area yield curve indicates that interest rates are expected to stay high at 3% to 4% for a period up to 30 years (Figure 3). High interest rates increase the capital cost of new investment. When inflation expectations are above target, central banks set high interest rates to reduce new investments. The reduced economic activity will in turn reduce inflationary expectations.

However, this process hurts investments in renewables more than average. Renewable energy technologies, like solar and offshore wind projects, and climate adaptation projects, often face high upfront costs, making financing conditions highly relevant (Egli, Steffen and Schmidt, 2018). Rising interest rates combined with rising materials prices undermine significantly the business case for renewables and climate adaptation, leading to sharp declines in green investment projects (Van Tilburg, 2023). Thomson Reuters reports large outflows from global renewable energy funds[5]. As a result of declining green investments, both the energy transition and climate resilience are at risk.

[5] See 'Renewables funds see record outflows as rising rates, costs hit shares', Thomson Reuters, 10 October 2023 https://www.reuters.com/sustainability/climate-energy/renewables-funds-see-record-outflows-rising-rates-costs-hit-shares-2023-10-09/.

Figure 3: Euro-area yield curve (in %)



Source: Bruegel calculations based on ECB.

Notes: The graph shows the average yield of all bonds at different residual maturity on 2 November 2023.

2.3. Carbon bias in the financial system

The guiding principle in the implementation of monetary policy has been 'market neutrality', whereby the ECB buys sovereign, corporate and bank bonds proportionally to outstanding debt in its asset purchase programme. The idea is that such a market-neutral approach will not disturb (relative) prices. An asset purchase or collateral framework and its criteria and/or requirements should not lead to the preferential treatment of distinct asset classes, issuers or sectors, and should avoid market distortion (Bindseil *et al*, 2017).

However, there is evidence that the current market-neutral approach towards private companies (buying private securities in proportion to the market index) is not carbon neutral. As carbon-intensive companies, such as fossil-fuel companies, utilities, car manufacturers and airlines, are typically capital intensive, market indices for equities and corporate bonds, as well as bank lending, are overweight in high-carbon assets (Cosemans and Schoenmaker, 2022; Colesanti Sennit *et al*, 2023). The ECB's application of market neutrality thus leads the Eurosystem's private sector asset and collateral base to be relatively carbon intensive (Matikainen *et al*, 2017; Schoenmaker, 2021). Investment in carbon-intensive companies reinforces the long-term lock-in of carbon in production processes and infrastructure.

2.4. Impact of climate change on financial stability

The impact of climate change on financial stability is relevant for monetary policy implementation. **A stable financial system is an important prerequisite for the smooth transmission of monetary policy.**

The second ECB economy-wide stress test introduced granular sectoral dynamics and energy-specific considerations by country relevant to transition risk (Emambakhsh *et al*, 2023). **Banks and other financial institutions are subject to transition risk in so far they have exposures to carbon-intensive companies, energy-inefficient real estate and fossil-fuel related infrastructure.** When the transition sets in, for example induced by higher carbon prices and/or reduced costs of renewables,

these carbon-intensive assets will decline in value. Colesanti Senni *et al.* (2023) find that 80% of bank lending was extended to carbon-intensive companies during the 2020-2021 period.

By comparing different transition scenarios, the ECB stress test showed that acting immediately and decisively would provide significant benefits for the euro-area economy and financial system, not only by maintaining the optimal net-zero emissions path (and therefore limiting the physical impact of climate change), but also by limiting financial risk. The ECB stress test further finds that an accelerated transition to a carbon-neutral economy would be helpful to contain risks for financial institutions, and would not generate financial-stability concerns for the euro area, provided that firms and households can finance their green investments in an orderly manner.

An important finding is that accelerating the transition reduces overall transition risk. If action is further delayed, the only way to reduce carbon emissions compatible with net-zero targets is to act more precipitously at a later stage. This 'too late – too sudden' scenario (ASC, 2016) may lead to abrupt changes in the value of carbon-intensive assets, turning them into stranded assets (Caldecott, 2018).

3. STRUCTURAL CONSIDERATIONS

Before reviewing the instruments of monetary policy implementation, **we address some structural factors**. We discuss the legal mandate, how to counter the carbon bias, and coordination between fiscal and monetary policy.

3.1. Legal mandate

Article 127(1) of the Treaty on the Functioning of the European Union (TFEU) clearly prioritises price stability: *"The primary objective of the European System of Central Banks (hereinafter referred to as 'the ESCB') shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Union with a view to contributing to the achievement of the objectives of the Union as laid down in Article 3 of the Treaty on European Union."* The reference to general economic policies means the ESCB's actions cannot be measured in terms of specific policies, but rather by its support for the underlying trends in economic policy (Smits, 1997).

Article 3(3) of the Treaty on European Union (TEU), meanwhile, specifies that the EU should *"work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment."* This wording leaves room for the greening of monetary policy, as long as it does not contradict the primary objective. It supports a broad definition of economic growth that recognises that economic policies also affect society and the environment, and that sustainability considerations should be included in financial decision-making (Schoenmaker and Stegeman, 2023).

Another key consideration is Article 11 of TFEU, which provides that *"Environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, with a view to sustainable development"* (Solana, 2019).

Following Smits (1997), **we argue that the Eurosystem should refrain from favouring assets of particular sustainable projects, agencies or companies.** Such individual choices are the domain of elected policymakers. **But the ECB can adopt a general approach towards low-carbon assets in support of the EU's general policies on reducing carbon emissions.** It would only support (instead of hinder) the EU's Green Deal policies to move to a low-carbon economy. **The ECB's strategic review indicates that the ECB is ready to move away from a strict interpretation of market neutrality** (ECB, 2021). Schnabel (2021, p. 55) argued that *"it seems appropriate, then, to replace the market neutrality principle with one of market efficiency that more fully incorporates the risks and societal costs associated with climate change* […]*, taking into account the alignment of issuers with EU legislation implementing the Paris Agreement."*

3.2. Allocation approach needed for monetary policy

A fundamental point is whether the ECB should follow only a risk-based approach, which looks at the exposure of an asset to climate-related risks, or an allocation-based approach, which favours allocation towards low-carbon assets. Green economics, also called ecological economics (Daly, 1996), stresses the need to operate within planetary boundaries and respect ecological constraints. The government is in the driving seat for 'greening' the economy. In Europe, the EU institutions – the European Commission, the Council and the European Parliament – have endorsed the European Green Deal, which sets ambitious policy targets for greening the economy (European

Commission, 2019). Given the primary role of EU institutions, the question is what is the appropriate role for the ECB in addressing the emergent sustainability risks?

There is consensus that the ECB should help 'de-risking the financial system' in its financial policy roles (see section 3.4). Monetary policy has by nature an allocative impact, influencing supply and demand conditions in the economy with the aim to bring inflation expectations back to target. **The question then is how the ECB can allocate its monetary policy instruments (e.g. purchasing assets under QE or taking collateral in its operations) more to low-carbon assets and less to high-carbon assets**, in order to operate within planetary boundaries.

3.3. Coordination between fiscal and monetary policy

The first-best solution to address climate concerns is to tax the climate change externality caused by carbon emissions. An appropriate carbon tax provides an 'official' price for carbon risk and would spur the move from high- to low-carbon investments. The good news is that the European carbon price – based on emissions trading – has risen from about €20 in the 2010s to about €80 in 2022/23 (Figure 4). Nevertheless, this market price is still below the shadow price of €157, which reflects the abatement cost at which carbon emissions can be reduced to stay within the 2°C temperature rise limit[6], and covers only around 45% of the EU's greenhouse gas emissions (Schoenmaker and Stegeman, 2023). **In this second-best world, which lacks a sufficiently high carbon tax, the question is how private companies, investors and public sector bodies (like central banks) can contribute to reducing carbon emissions.**

Figure 4: European carbon price in euros (2018-2023)

Source: Bruegel calculations based on Tradingeconomics.com.

Notes: Emissions trading is a market-based approach to controlling pollution. Under the emissions trading scheme (ETS), companies buy or receive emissions allowances or carbon permits, which they can trade with one another as needed.

Coordination between the fiscal and monetary authorities is needed to come to an 'appropriate' carbon tax for the euro area. What is the optimal fiscal-monetary policy mix? On the monetary policy side, the institutional framework of the ECB allows, in principle, adoption of the monetary policy stance most appropriate for the euro area as a whole. This in turn takes into account the fiscal policy stance for

[6] This means that the temperature rise should not exceed 2°C compared to the pre-industrial temperature.

the euro area as a whole (Orphanides, 2017). In the case of the transition to a low-carbon economy, this means the lower the carbon tax, the stronger the low-carbon allocation in monetary policy (and the higher the tax, the looser the low-carbon allocation). It should be noted that fiscal policy (i.e. setting the carbon tax) and regulatory policy under the Green Deal are far more powerful in mitigating climate change than any monetary policy low-carbon allocation can ever be.

3.4. Risk-based approach in a banking-based system

As suggested, **the ECB's approach for the financial system should be risk based.** The structure of the European financial system matters. When market financing dominates, tradeable bonds form a larger part of portfolios and are thus more important for monetary policy implementation. However, when bank financing leads, banks loans are more important. As it happens, Europe is bank-based (Langfield and Pagano, 2016). The bank-market ratio, defined as the ratio of total bank assets to stock and private bond market capitalisation, is close to 4 for Europe[7]. This high ratio suggests that up to 80% of financing takes places through bank loans. By contrast, the bank-market ratio for the United States is less than 1, which indicates markets play a large role. In this United States, markets provide more than 50% of financing and banks less than 50%.

The bank bias in Europe's financial structure highlights the important role of the banking system in the transmission of monetary policy. A stable banking system is a precondition for smooth monetary policy transmission. In the review of instruments, we therefore include the ECB policies and instruments to preserve financial stability.

[7] Europe refers to all European countries, including Iceland, Norway, Switzerland and the United Kingdom.

4. WHICH INSTRUMENTS COULD THE ECB EMPLOY?

This section **reviews several monetary policy instruments that the ECB could employ to deal with climate change**. We **also discuss financial policy instruments**, because a stable financial system is crucial for the smooth transmission of monetary policy.

4.1. Maintaining price stability remains the priority

We start with the need to accelerate the energy transition. According to the Intergovernmental Panel on Climate Change (IPCC, 2023) has indicated that current projections of global greenhouse-gas (GHG) emissions imply the 1.5^{0}C warming limit will be exceeded, and make it harder to keep global warming below 2^{0}C. Our analysis in section 2 shows that volatile energy prices are the main contributor to inflation dynamics. These facts together suggest that green investment should be stepped up to reduce fossil-fuel dependency, and thereby bend the current trend in greenhouse-gas emissions downward.

The most important contribution that the ECB can make to green investment is a favourable investment climate with stable prices (Lagarde, 2023). Predictable prices avoid spikes in costs. This is in particular important for green investment, which has a medium- to long-term horizon. The ECB could help the energy transition most by delivering on its primary objective of price stability.

4.1.1. Trade-offs in policy responses

Central banks may face trade-offs when reacting to the inflationary shocks from climate change, reviewed in section 2. Climate and fossil-fuel related shocks are supply-side shocks, reducing economic activity while increasing prices (Claeys, 2024). This may lead to difficult trade-offs for central banks. As monetary policy only affects the economy with a lag, central banks adopt a medium-term perspective and ignore temporary supply-side shocks. But when supply-side shocks become more permanent, inflation expectations are dis-anchored and feed inflation further (Coeuré, 2018). Central banks have than no other option than to react with monetary policy to bring inflation expectations back to target. This happened over 2022-2023, when the ECB had to react to the large rise in energy prices by increasing its key interest rates.

Green investment is a demand-side shock. Investments in low-carbon technologies boost economic activity as well as prices. Central banks face no trade-off (Claeys, 2024). They can increase the key interest rates when the demand shock is positive.

Russia's invasion of Ukraine has increased energy prices. This has led to further increases in prices, considering that euro-area economies are carbon-intensive. Higher capital costs through monetary and financial policy instruments for carbon-intensive assets would raise (otherwise high) inflation, which would conflict with the ECB's primary objective of price stability.

Broadly speaking, **two opposite policy responses are possible** (Schoenmaker and Stegeman, 2023). **The first is to slow down the phasing in of monetary and financial policy instruments to reduce the allocation to carbon-intensive assets**. Industry is also advocating a slow-down of the energy transition. However, that is just a postponement of the inevitable energy transition and a continuation of the euro area's exposure to oil price fluctuations. Moreover, fossil-fuel companies currently experience lower costs of capital due to the high profits, while renewables face higher costs of capital because of higher interest rates and rising material costs.

The second response would be to implement monetary and financial policy instruments to increase the allocation to low-carbon assets, as scheduled, in line with other European Green Deal

regulatory policies. To soften the impact of volatile energy prices on inflation and to speed up the energy transition (reducing the reliance on fossil fuels), the ECB can incentivise private banks to lend more money for green investments and/or tilt its assets and collateral portfolio towards low-carbon assets. These instruments are discussed in the subsequent sections.

4.2. Quantitative easing becomes less important

The ECB strategy review (ECB, 2021) included criteria for allocation towards low-carbon assets in its asset and collateral framework. The ECB also agreed to perform an assessment of the climate risks embedded in assets, and introduced disclosure requirements for eligible assets (whereby only assets from companies that report under the Corporate Sustainability Reporting Directive (CSRD, 2022/2464/EU) are eligible). **The ultimate aim is to tilt its portfolio towards low-carbon assets by applying carbon factors that favour low-carbon assets, while punishing high-carbon assets** (Schoenmaker, 2021).

In July 2022, **the ECB agreed to tilt its corporate bond portfolio under quantitative easing (QE)** by only reinvesting in low-carbon assets (ECB, 2022a; Lagarde, 2022). Table 2 contains the ECB's holdings of assets under its Asset Purchases Programme (APP). Corporate bonds are only 10.7% of the ECB's APP portfolio. The tilting could also be applied to covered bank bonds and asset-backed securities (as explained in section 4.3), which would add another 9.9%.

But the ECB decided in May 2023 to discontinue its reinvestments. There is thus currently no scope for the ECB to decarbonise its asset portfolio. Nevertheless, **we recommend that the ECB should expand the tilting towards all relevant asset categories (covered bank bonds, corporate bonds and asset-backed securities)**, in case the ECB reintroduces QE in the future.

It should be noted that tilting the collateral framework has always been more important than tilting asset purchases (Schoenmaker, 2021). Tables 2 and 3 contain the ECB's asset and collateral holdings. First, the collateral framework is permanent. Second, the potential for tilting under the collateral framework amounts to EUR 1,590 billion (89% of 1,787 billion in the bottom row of Table 3), while the potential under the APP only amounts to EUR 637 billion (20.5% of EUR 3,109 billion in the bottom row of Table 2)[8].

[8] Tilting towards low carbon is most relevant for the private sector. Carbon factors in column 4 of Tables 2 and 3 are therefore only applied to private sector securities and claims.

Table 2: Outstanding holdings under Asset Purchases Programme, October 2023

Securities	1. Eligible market securities (in € billions)	2. ECB holdings (in € billions)	3. ECB holdings as share of market (2. as % of 1.)	4. Carbon factors applicable (2. as % of total)
Government securities	9,821.0	2,470.6	25.2%	n.a.
Covered bank bonds	1,807.2	292.0	16.2%	9.4%
Corporate bonds	1,901.5	331.2	17.4%	10.7%
Asset-backed securities	597.6	15.3	2.6%	0.5%
Total	**14,127.3**	**3,109.1**	**22.0%**	**20.5%**

Source: Bruegel calculations based on ECB Eurosystem APP data.

Notes: The second column presents marketable securities that are eligible. The third column presents ECB holdings in the Eurosystem. The fourth column presents ECB holdings as share of eligible market securities. The fifth column indicates whether a carbon factor could be applied to the respective collateral category.

4.3. Much scope to expand carbon factors for collateral

The ECB has been very shy in applying carbon factors to tilt the collateral portfolio. Initially, the ECB applied a risk-based approach by stressing the need to include climate risk in credit ratings (ECB, 2021). But as argued in section 2, this risk-based approach is not sufficient for monetary policy implementation. Next, the ECB started to apply carbon factors to corporate bonds, which form only a very small fraction (2.9% in Table 3) of overall collateral holdings. Bank loans will be added later, which is the most important category with 33.6% of overall collateral (ECB, 2022a).

So, the ECB only includes bonds from, and loans to, non-financial companies. While the carbon emissions of non-financial companies can be assessed directly, it is more difficult to do for synthetic or financial institution securities. The look-through approach can be applied, whereby the underlying beneficiary instead of the intermediary is assessed (Schoenmaker, 2021). In the case of asset-backed securities, the carbon emissions of the assets in the vehicle (for example, real estate underlying mortgage-backed securities) can be measured[9]. In the case of bank loans, the carbon emissions of the borrower can be assessed[10]. In the more general case of bank bonds, the carbon emissions of a bank's total loan and investment portfolio should be evaluated.

Our recommendation is that the ECB should expand the CSRD reporting requirement to bank bonds[11] (covered and uncovered) and asset-backed securities. In addition, the ECB should apply carbon factors to these collateral categories. This recommendation would expand the low-carbon allocation of collateral by 50.4% percentage points, which is made up of 29.9% for bank bonds and 20.5% for asset-backed securities (Table 3).

[9] There are different approaches in place to assess the greenness of a securitisation: use of proceeds versus underlying assets. The look-through approach refers to the underlying assets. The ECB cannot check the use of proceeds in a reliable way when it buys asset-backed securities.

[10] In technical terms, these indirect emissions are called scope 3 emissions from lending and investment activities. These financed emissions are attributed proportionally to a company's financiers.

[11] It should be noted that most banks are already required to report under the CSRD.

Table 3: Collateral data of the Eurosystem, October 2023

Collateral categories	1. Eligible market assets (in € billions)	2. Use of collateral in Eurosystem (in € billions)	3. Collateral as share of market (2. as % of 1.)	4. Carbon factors applicable (2. as % of total)
Central government securities	9,821.0	156.6	1.6%	n.a.
Regional government securities	601.7	39.6	6.6%	n.a.
Uncovered bank bonds	1,984.7	81.1	4.1%	4.5%
Covered bank bonds	1,807.2	453.8	25.1%	25.4%
Corporate bonds	1,901.5	52.5	2.8%	2.9%
Asset-backed securities	597.6	364.9	61.1%	20.4%
Other marketable assets	1,391.6	38.1	2.7%	2.1%
Bank loans		600.1		33.6%
Total	**18,105.3**	**1,786.7**	**9.9%**	**89.0%**

Source: Bruegel calculations based on ECB Eurosystem collateral data.

Notes: The second column presents marketable assets that are eligible as collateral. The third column presents the collateral holdings in the Eurosystem at market values after haircuts applied. The fourth column presents collateral as share of eligible market assets. The fifth column indicates whether the additional carbon haircut could be applied to the respective collateral category.

4.4. Green TLTROs to facilitate green investment

Green investment is under pressure from the high interest rates to combat inflation. As discussed in section 2, green projects are feeling the effects of higher interest rates more strongly than other projects because green projects require high upfront investment.

There are several ways to promote green investment. The first option is to provide a government subsidy for green loans. However, many euro-area countries do not have the fiscal space to provide subsidies at scale (Van den Noord, 2023). The second option is to create dual rates via so-called targeted Longer-Term Refinancing Operations (TLTROs). The ECB introduced TLTROs to stimulate economic activity. Banks that met the condition to maintain their lending to households and business got the option of borrowing from the ECB at more attractive rates. In a similar way, **the ECB could grant green TLTROs at reduced rates to banks that maintain green lending** (Van 't Klooster and Van Tilburg, 2020). The Bank of Japan and the People's Bank of China have already introduced green targeted lending operations[12].

In order to neutralise the negative effects the current high interest rates have on the energy transition, the ECB Governing Council could decide to introduce a lower green interest rate on refinancing operations for banks. This lower green interest rate would incentivise banks to increase their lending for clean-energy production and energy-efficiency operations. Cheaper capital costs for these green investments would directly stimulate the supply of green domestic energy and renovation measures, reducing the reliance on fossil fuels (Van Tilburg, 2023).

[12] See on Bank of Japan: https://greencentralbanking.com/2022/01/20/japan-green-loans-scheme/ and on People's Bank of China: https://greencentralbanking.com/2021/11/10/pboc-launches-targeted-green-lending/.

4.5. Improving financial stability

The financial system plays a key role in the smooth transition of monetary policy. Climate shocks can threaten the stability of the financial system. As shown in section 2, an accelerated transition may lead to abrupt changes in the value of carbon-intensive assets, turning them into stranded assets (Caldecott, 2018). It is thus important to strengthen the resilience of the euro area's financial system, which is predominantly bank-based.

The ECB is among the frontrunners in addressing climate risks (Grunewald *et al*, 2023). It takes climate risks into account in its Supervisory Review and Evaluation Process (SREP), which is part of the Pillar 2 supervisory review process of the Basel Capital Adequacy Framework [13]. In its 2022 SREP cycle, the ECB reviewed these risks on a qualitative basis, resulting in qualitative measures and feedback to individual institutions. Based on the 2022 SREP, the ECB imposed qualitative measures for climate risk, but no capital add-ons yet (ECB, 2022b). A next step would be to introduce higher capital charges for climate risks into Pillar 1 capital adequacy rules. As these Pillar 1 capital rules are part of the wider Basel Capital Adequacy Framework, **we recommend that the ECB as member of the Basel Committee on Banking Supervision should accelerate the discussion on including climate risks in Basel**[14]. The European Banking Authority (EBA, 2023) has recently made recommendations on enhancing the Pillar 1 framework to capture environmental and social risks. Pending higher Pillar 1 requirements, **we recommend that the ECB imposes Pillar II add-ons for banks that are exposed to carbon-intensive companies.** Under the Capital Requirements Directive (2013/36/EU), the ECB has the powers to impose such add-ons (De Arriba-Sellier, 2021).

The ECB could also use macroprudential instruments to reduce the financial sector's exposure to climate risk. Large exposure limits are helpful to reduce the impact of climate risk on banks (Schoenmaker and Stegeman, 2023). Current large exposure rules limit a bank's exposure to individual counterparties to 25% of a bank's eligible capital. Their rationale is to protect the bank against specific shocks, such as the failure of a large counterparty. In the case of climate change, large exposure limits could be set to protect banks against transition shocks and physical shocks. In a joint report on the macroprudential challenge of climate change, the European Central Bank and the European Systemic Risk Board (2022) review several macroprudential instrument to contain large exposures to (also called concentrations in) climate risks. This review includes a macroprudential limit on concentration risk.

To calibrate large climate exposure limits, the ECB needs to identify the appropriate size of the limit and the shocks from its stress-testing. While large exposure rules in banking supervision are set at the micro level against individual companies, large climate-exposure rules for macroprudential purposes are set at the macro level against aggregate exposures. **Higher limits on climate exposures, like 50% or 75% of a bank's eligible capital, are warranted.**

[13] The Basel capital adequacy framework sets the capital requirements for banks. It contains of three pillars. Pillar 1 sets the risk-based capital standards and Pillar 2 refers to the supervisory review of a bank's risk assessment process. A banking supervisor, like the ECB, could apply capital add-ons (as add-on to the pillar 1 requirements) when it observes shortcomings in a bank's risk procedures or considers particular risks which are not sufficiently captured under the pillar 1 requirements.

[14] In the EU, Basel capital adequacy rules are subsequently implemented under legislative procedure through the Capital Requirements Regulation and Capital Requirements Directive.

5. CONCLUSION

This paper has analysed the impact of climate change shocks on monetary policy implementation and the instruments the ECB could employ to deal with climate change.

From the perspective of price stability, volatile energy prices have been the major driver of sharp inflation rises in the euro area over the last two years. The subsequent rises in interest rates to combat inflation have a disproportionate effect on green investment, which requires upfront investment. The policy challenge is to combat inflation in line with the ECB's primary objective of price stability, while not hampering the green transition.

The financial system has an inbuilt carbon bias as carbon-intensive companies have greater financing needs and issue more stocks and bonds. Carbon-intensive companies reinforce the long-term lock-in of carbon in production processes and infrastructure. The carbon bias makes a low carbon allocation in monetary policy implementation even more important.

We reviewed **four monetary policy instruments:**

- The ECB's most powerful instrument is to **maintain price stability**. A stable investment climate without run-off costs is crucial for green investments with a medium- to long-term horizon.
- **As QE is phased out, the importance of greening QE is fading**. Nevertheless, we recommend expanding the low-carbon allocation in QE to more asset categories, for future instances of QE.
- **There is much scope to expand the low-carbon allocation of collateral.** The carbon factors for a low-carbon allocation are currently only applied to corporate bonds and bank loans. We recommend **application of carbon factors also to bank bonds and asset-backed securities**, which form half of the collateral pool.
- **Finally, green TLTROs are instrumental in softening the impact of high interest rates on green investment.** We recommend introduction of green TLTROs, which offer a lower interest rate on green refinancing operations. This provides an incentive to banks to increase their lending to clean-energy production and energy-efficiency renovations.

Climate risk can also hit the financial system, which is crucial for smooth monetary transmission. The ECB is already performing climate stress tests. The ECB should now shift gear from analysing and monitoring, to addressing the vulnerability of the financial system to climate risk. Measures for banks are particularly important, as the European financial system is bank-based.

We propose **two financial policy instruments**

- As **banking supervisor**, the ECB enforces the **capital adequacy rules** for banks. The ECB could already apply **capital add-ons** to banks with high climate exposures in the Supervisory Review and Evaluation Process. At the same time, the ECB should make the case for **high capital requirements for climate risk** in Basel and the EU.
- In its role of **maintaining financial stability**, the ECB should set **macroprudential limits on a bank's aggregate exposure to high-carbon companies**. These limits protect the banking system against banks that are overexposed to transition risk.

The transition to a green economy depends on green investment as well as brown divestment. These policy proposals would speed up the allocation towards green investment and the phasing out of brown investments.

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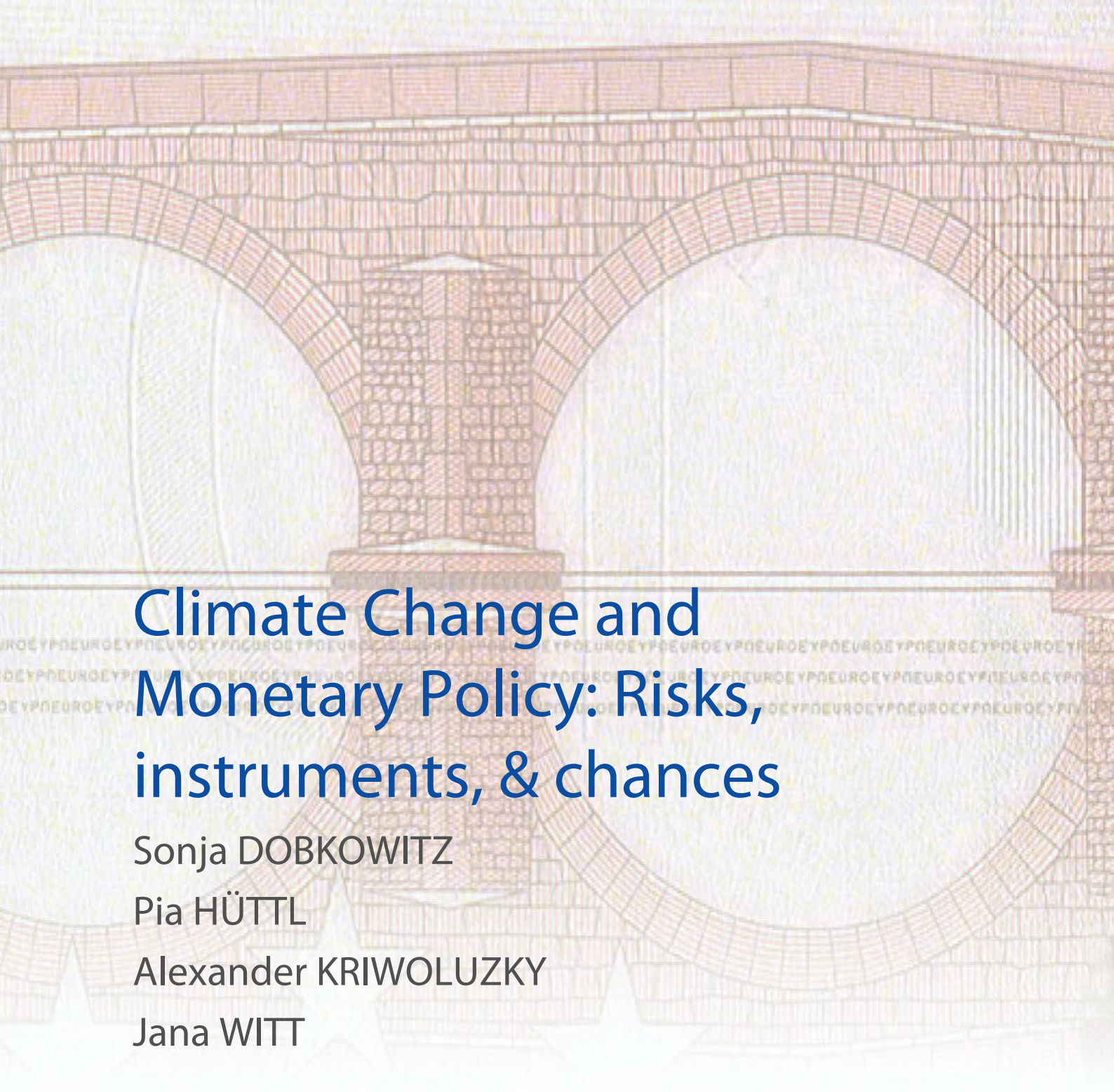

Climate Change and Monetary Policy: Risks, instruments, & chances

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Abstract

Rising inflation complicates the alignment of the ECB's policies with the Paris Agreement. This paper provides novel evidence for inflationary pressures arising from natural disasters. We then discuss the effectiveness of monetary instruments to boost a green transition, concluding that the scope of policy measures used thus far is limited. As additional measures, we advise active rebalancing of the ECB's bond holdings towards greener issuers, enforcing stricter disclosure standards, and differentiating lending facilities in favour of green investments.

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CONTENTS

LIST OF ABBREVIATIONS

ABSPP	Asset-backed securities purchase programme
APP	Asset purchase programme
CBPP3	Third covered bond purchase programme
CRED	Centre for Research on the Epidemiology of Disasters
ECB	European Central Bank
EP	European Parliament
ESG	Environmental Social Governance
EU	European Union
GDP	Gross domestic product
HICP	Harmonised index of consumer prices
IPCC	Intergovernmental Panel on Climate Change
PEPP	Pandemic emergency purchase programme
PSPP	Public sector purchase programme
PSVAR	Panel structural vector autoregression
TLTRO	Targeted longer-term refinancing operations
TPI	Transmission protection instrument
CSPP	Corporate sector purchase programme

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EXECUTIVE SUMMARY

- Since 2020, European Central Bank (ECB) Executive Board Members have become increasingly vocal regarding monetary policy and climate change. Indeed, rising inflation complicates the alignment of the ECB's policies with the Paris Agreement. Novel research shows that **natural disasters have a positive effect on average inflation rates in euro area countries**. Zooming in on sub-indices, effects are dispersed: **price increases in product categories that are especially important for low-income households are more pronounced**.
- The ECB is contributing to fighting climate change within its secondary mandate. **Current inflationary pressures narrow the scope for climate-targeted policies**: the phasing out of the asset purchase programme (APP) prevents a further tilting of the ECB's bond holdings to greener alternatives. Additionally, higher interest rates disadvantage investment in innovation and renewable energies due to high up-front costs in these areas.
- Furthermore, **the ECB's bond holdings under the corporate sector purchase programme (CSPP) display a bias towards climate-harming sectors.** However, the CSPP has both an important impact on reducing the cost of debt financing for eligible firms and on the issuance activity of eligible firms.
- **Any reinvestment tilted towards climate-friendlier issuers will be small in comparison to the large stock of existing overall holdings.** The ECB has implemented the greening of its corporate bond holdings as of October 2022. However, reinvestments under the larger APP stopped as of July, and the remaining reinvestments under the PEPP represent only 12% of the ECB's total corporate sector bond holdings.
- **The ECB should rebalance its portfolio by actively selling positions** since a tilting of the portfolio towards climate-friendly issuers - absent any reinvestments in the near future - remains necessary to decarbonise the bond portfolio.
- **As regards its collateral framework, the ECB should favour both the eligibility of bonds and loans stemming from corporates with a superior climate-performance to boost a green transition.** Changes in the ECB collateral framework have a sizeable impact on the real economy. So far, the ECB's collateral framework implicitly encourages fossil fuel companies to tap bond markets. Preferential treatment of green bonds in the collateral framework, in particular, boosts the supply of green bonds, leading to an increase in green investment.
- **More action in terms of disclosure standards is appropriate**. Concerns regarding the quality of emission disclosure and the credibility and comparability of disclosed information have been raised. Research finds that **mandatory carbon disclosure significantly lowers the cost of capital for reporting companies**. Total emissions fall upon firm disclosure, suggesting a certain degree of disciplining effect coming from disclosure requirements.
- **More favourable interest rates should be offered for climate-friendly investments.** This measure does not conflict with price stability since the ECB can react to inflationary pressures as mandated by means of its main refinancing operations. Fostering investment in green technologies and innovation allows for a quicker transition to a green economy. Reducing the dependence on fossil sectors, in turn, diminishes the exposure of the euro area to supply shocks in this sector, an important driver of rising inflation rates - as recently experienced due to the war in Ukraine.

1. INTRODUCTION

Since taking office, European Central Bank (ECB) President Christine Lagarde has consistently highlighted the ECB's intention to fight climate change within the scope of its mandate. In July 2021, the ECB announced concrete actions by, for instance, making green considerations part of its collateral framework, its asset purchases, its forecasting, and its policy making[15]. One year later, the ECB started adjusting the reinvestments of the corporate bond holdings based on a climate score, reflecting the issuers climate performance.

In this briefing paper, we first discuss evidence that necessitates a reconsideration of monetary policy making in light of climate change (section 2). Relying on data from 1996 to 2021, Beirne et al. (2023) find that, in the short run, natural disasters raise headline and core inflation on average across countries. As climate change advances, the frequency and intensity of natural disasters is expected to rise[16], most likely increasing upward pressure on inflation. Moreover, the impact of natural disasters on more granular price indices is dispersed: goods especially important for low-income households see a more pronounced price increase. This gives rise to distributional concerns.

Next to the relevance of climate change for monetary policy considerations, another question that arises is how the ECB can contribute to mitigating climate change. Current inflationary pressures constrain the further use of instruments employed thus far. As a side effect of its ambitions to reduce its balance sheet, tilting of the ECB's corporate bond holdings to climate-friendly alternatives through reinvestments drops out of the ECB's toolkit[17]. Furthermore, to counter inflation, the ECB has been increasing interest rates. However, high interest rates discriminate against technological innovation and the production of renewable energy due to large up-front costs in these sectors[18].

Therefore, in this briefing, we discuss alternative green monetary policy instruments that could be used and that do not conflict with the current need to fight inflation (section 3). We point to the importance of an active re-shuffling of the bond portfolio to climate-friendlier issuers. The collateral framework is another margin the ECB employs to align its operations with the Paris Agreement. Importantly, research attests implications on the real economy and on emissions to a greening of the collateral framework. Finally, we stress the current shortcomings of disclosure standards and the importance of high-quality data for all climate-related monetary policies and their direct impact on emissions.

All in all, it is questionable whether these measures suffice to align ECB policy with its climate-related targets[19] - even more so in the light of an existing carbon-bias in the ECB's balance sheet and disadvantageous high interest rates. Therefore, we close by suggesting ways that monetary policy can be further geared towards supporting the EU's compliance with the Paris Agreement (section 4). Offering advantageous refinancing facilities for climate-friendly investments qualifies as such an instrument[20]. They would help alleviate the negative impacts of the current contractionary monetary policy on green investment. Importantly, differentiated lending facilities can be implemented without violating the ECB's mandate of price stability. In contrast, they would boost a transition away from the fossil fuels that have caused inflationary turmoil in the past.

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15 ECB (2021c).

16 IPCC (2023). For a brief overview see: https://www.ipcc.ch/report/ar6/syr/resources/spm-headline-statements/ .

17 Schnabel (2023).

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2. THE EFFECTS OF CLIMATE CHANGE ON INFLATION

"Climate change affects inflation, and inflation is the beast that all central bankers — whether they wear a green jacket or not — want to tame and discipline."

Christine Lagarde, Summit for a New Global Financing Pact, Paris, June 23, 2023.

Climate change represents one of the major threats to our societies, both today and in the future. Despite this, it was only recently that the ECB made a decision to include climate change within its decision-making and monetary policy operations[21]. Up to now, little is known about the potential effects of climate change – and the implied surge in the prevalence and severity of climate-associated disaster events[22] – on the ECB's main objective of preserving price stability. In this section, we discuss findings from Beirne et al. (2023), who contribute to this debate and estimate the effects of natural disasters on inflation rates in euro area countries from 1996 through 2021.

2.1. Transmission Channels

Natural disasters, as posited by theory, can exert upward and downward pressures on inflation rates through different transmission channels[23]. Inflation may rise due to the destruction of infrastructure, harvests, and buildings or because of production and supply chains being disrupted[24]. These negative shocks can increase domestic production costs and create spillovers to foreign importing countries. Moreover, damages to the infrastructure and the potential need to replace domestically produced goods by imported ones may lead to surges in transportation costs, thereby inducing price increases and spillover effects to other countries[25]. Natural disasters may also create upward price pressures via the demand side: efforts to rebuild destroyed infrastructure can cause a temporary rise in prices for reconstruction goods.

Conversely, inflation may also decrease following a natural disaster[26]. As an illustration, firms may suffer a decline in profit-earning capacity after the destruction of production plants or physical capital. Likewise, the destruction of private homes reduces wealth. Both may lead to declines in investment by firms and household consumption[27]. In addition, increased defaulting of loans after the occurrence of natural disasters may reduce credit supply by banks, further exacerbating the reduction in investment and consumption.

Given these upward and downward forces on prices, the reaction of inflation to natural disasters is unclear. Whether the price level ultimately rises or falls depends on which countervailing dynamic dominates. Furthermore, prices for some items might decline, while others may rise. The empirical analysis seeks at clarifying which of these pressures are predominant for core and headline inflation, and for their 12 primary sub-indices.

21 ECB (2021a, 2021b).

22 IPCC (2012) and Simola (2020).

23 This section draws on Dafermos et al. (2021).

24 See Batten et al. (2020) and Simola (2020).

25 Klomp and Sseruyange (2021).

26 Doyle and Noy (2015).

27 This may still hold true even if firms and individuals have been insured against disaster-related losses; first, since insurance costs might decrease investment and consumption and, second, because the cost of insurance might rise, if the frequency and severity of natural disasters increases due to climate change.

2.2. Empirical Evidence

To estimate the effects of natural disasters on headline inflation and its main sub-indices, Beirne et al. (2023) use monthly data from January 1996 through March 2021 for 19 euro area countries[28]. Details on the empirical methodology are presented in the Annex.

The authors employ disaster-related data on droughts, floods, storms, temperature extremes, wildfires, earthquakes, and volcanic activity alongside their estimated monetary damages[29]. To standardise across countries, damages are divided by monthly gross domestic product (GDP) of the respective economy, following Fratzscher et al. (2020). Consequently, the disaster variable measures the monetary damage of an event in percent of GDP[30]. To assess the effects on core and headline inflation, as well as on the 12 sub-indices thereof, Beirne et al. (2023) employ data from the Harmonised Index of Consumer Prices (HICP) for countries in the euro area. This approach benefits from the fact that the statistical data compilation methods are standardised across countries, allowing for better cross-country comparability than data from national sources. In addition, the HICP represents the main target variable pertaining to ECB monetary policy.

To begin with, the authors discuss how headline and core[31] inflation are affected by estimated monetary damages resulting from natural disasters in euro area countries. Figure 1 illustrates that a disaster shock of one percentage point of monthly GDP significantly raises average monthly headline inflation rates in euro area countries by almost 0.2 percentage points immediately after the disaster strikes[32]. This suggests that upward forces on prices, originating from resource constraints after infrastructure, harvests, and buildings have been destroyed, are predominant in the immediate aftermath of a disaster. Downward price pressures continue to bite also over the subsequent month before the effects become insignificant and dissipate three months after the disaster. For average core inflation rates, a comparable pattern emerges as for headline inflation.

As the focus on headline and core inflation cannot reveal potentially opposing price responses in different sectors, we next zoom in on a more disaggregate level. Figure 2 shows the effects for the 12 sub-indices of headline inflation. There is substantial heterogeneity in the inflation response to disaster shocks, with consumer prices rising in some sectors and falling in others. More precisely, prices for clothing, education, electricity, food, health, household equipment, housing, restaurants, as well as for miscellaneous goods increase significantly following a disaster. This indicates that supply-side effects prevail for these consumption categories. On the other hand, communication and transport prices decline instantaneously after disasters, which implies that the demand for the goods and services produced by these sectors is more susceptible to disaster events. For other sub-indices, no meaningful effects are discerned. Consistent with the results obtained for average core and headline inflation rates

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28 Croatia is excluded from the analysis as this country became part of the euro area only in 2023.

29 The data is retrieved from the EM-DAT database and collected by the Centre for Research on the Epidemiology of Disasters (CRED). In the considered sample, the EM-DAT database contains 245 natural disasters with reported estimated monetary damages. Earthquakes and volcanic activity are not directly related to climate change, but rather result from tectonic processes. As they make up less than 9% of disasters in the sample and excluding them does not significantly change the results, they are kept in the analysis.

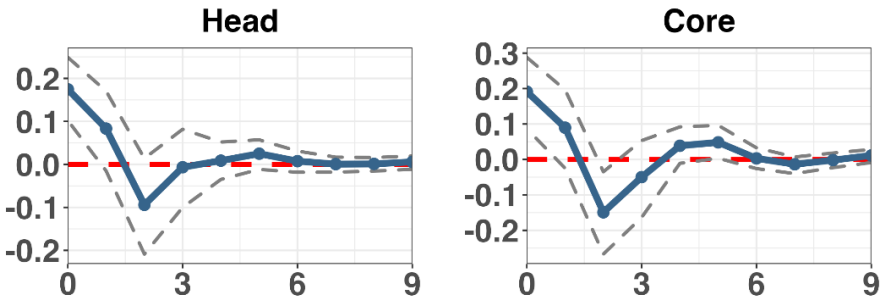
30 The average estimated damage per disaster amounts to 1.58% of monthly national GDP, with values ranging from 0 to 35.87% (for the Athens earthquake from 1999).

31 Core inflation excludes items from the more volatile sectors of energy, food and beverages, as well as of alcohol and tobacco.

32 More precisely, Figure 1 displays the impulse response functions of average monthly headline and core inflation to natural disaster shocks, together with 95% confidence intervals. Confidence intervals are generated by Monte Carlo simulations using 500 repetitions. Impulse responses describe the reaction and evolution of inflation rates in response to a shock to the disaster variable. The probability that the true value of inflation rates lies within the area of the dashed lines, the confidence intervals, is at 95%. Beirne et al. (2023) look at monthly inflation rates following Heinen et al. (2018), while the ECB's main target variable is year-on-year inflation. To achieve a 2% yearly inflation rate requires a month-over-month inflation rate of only 0.17%, suggesting that moderate month-over-month effects on inflation rates suffice to aggregate to significant changes in year-on-year inflation.

in euro area countries, the sub-index responses of inflation to natural disasters tend to diminish after two months and converge to zero after three to four months.

Figure 1: Effects of natural disaster shocks on headline and core inflation



Source: Beirne et al. (2023).

Notes: Impulse response functions are displayed, together with 95% confidence intervals in dashed lines. The size of the disaster shock amounts to one percentage point of monthly GDP. The horizontal axes show the months after the disaster strikes.

Beirne et al. (2023) detect notable price increases for some sub-indices, such as for food and beverages. This sharp rise in food price inflation following natural disasters also raises concerns about the distributional effects. Since low-income households tend to allocate a larger proportion of their income to food expenditures[33], they are also more adversely affected when food price inflation rises compared to high-income households.

Overall, the study's results on the inflationary effects of natural disasters in euro area countries can be summarised by the following three points:

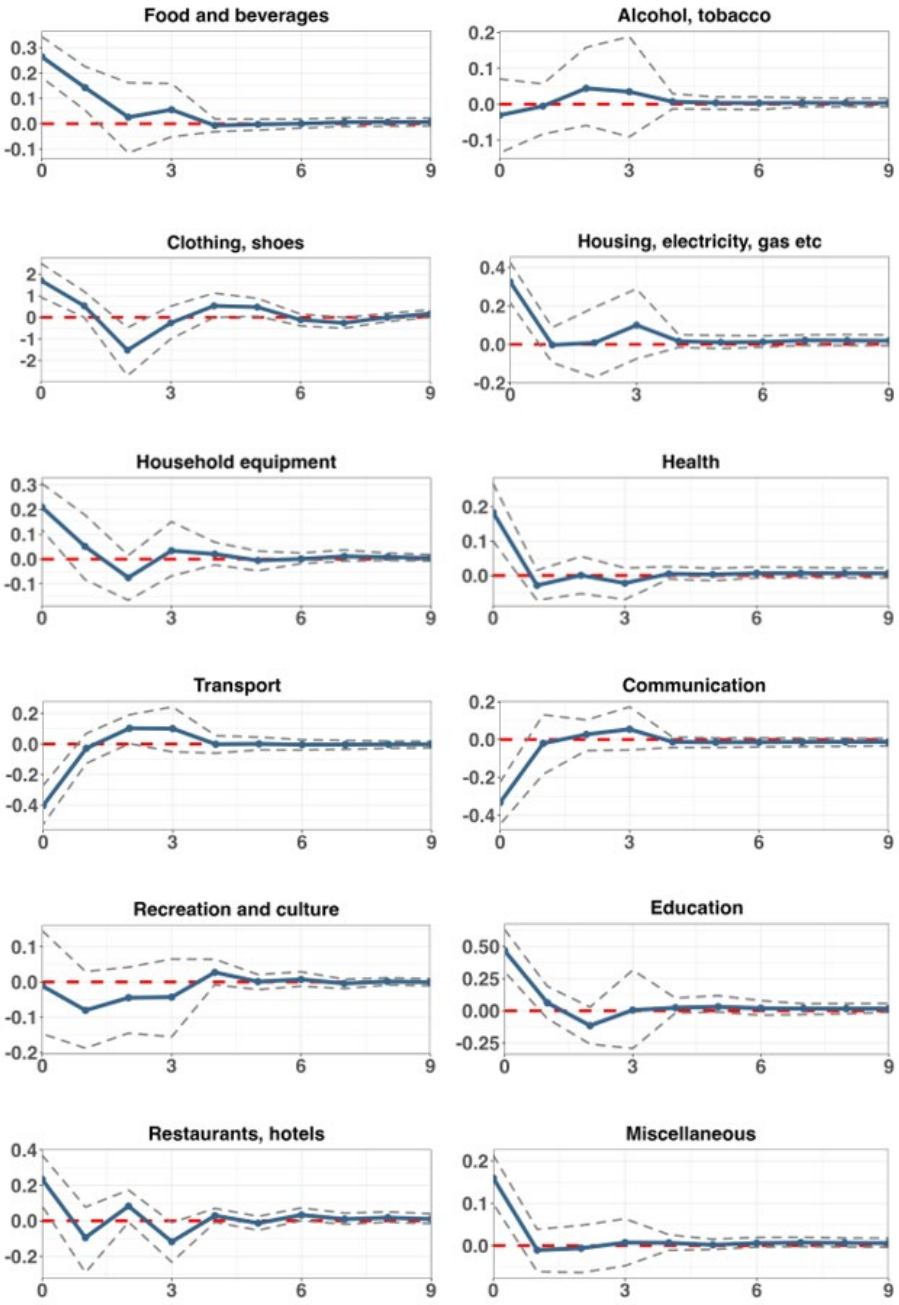
- Natural disaster shocks result in significant increases in both core and headline inflation rates.
- Substantial disparities occur across sub-indices, with strongest increases in prices for clothing, education, food and beverages, and housing.
- These price effects cause surges in inflation rates and may thereby jeopardise the ECB's efforts to achieve price stability. They also raise distributional concerns.

Despite the backward-looking nature of the analysis, it has important ramifications for the future conduct of monetary policy in the euro area due to an expected rise in disaster risk. As emphasised in the most recent assessment report by the Intergovernmental Panel on Climate Change (IPCC)[34], climate change has non-linear effects: after surpassing the 1.5 degree threshold, the economic costs of climate change are likely to increase.

[33] ECB (2022b).

[34] IPCC (2023).

Figure 2: Effects of natural disaster shocks on inflation sub-indices



Source: Beirne et al. (2023).

Notes: Impulse response functions are displayed, together with 95% confidence intervals in dashed lines. The size of the disaster shock amounts to one percentage point of monthly GDP. The horizontal axes show the months after the disaster strikes.

3. INSTRUMENTS OF GREEN MONETARY POLICY

The ECB has several instruments at its disposal to achieve the goal of actively fighting climate change by "greening" its monetary policy, even in times of high interest rates. This section discusses the mechanisms and the effectiveness of available instruments.

3.1. Corporate Sector Purchase Programme

In the aftermath of the Great Financial Crisis and the sovereign debt crisis in the euro area, the ECB implemented the asset purchase programme (APP) with the objective of supporting the monetary policy transmission mechanism to ensure inflation rates sufficiently close to the target of two percent. Within the APP[35], the corporate sector purchase programme (CSPP) was announced in April 2016 and implemented in June 2016. This programme targeted bonds issued by corporations headquartered within the euro area and aimed at decreasing their borrowing costs on the bond market. Additionally, the ECB rolled out the Pandemic Emergency Purchase Programme (PEPP) in March 2020, a temporary asset purchase programme of private and public sector securities, to counter the serious risks to the monetary policy transmission due to the coronavirus pandemic.

In the following years, purchases were guided by the principle of "market neutrality", thus avoiding market distortions, where purchases mirror the outstanding amount issued in the universe of eligible corporate bonds. At the end of 2022, the corporate holdings amounted to EUR 385.2 billion (Table 1), with APP holdings responsible for 88% of the outstanding amount (EUR 339 billion) and PEPP holdings for the remaining 12% (EUR 46.2 billion).

The CSPP has had both an important impact on reducing the cost of debt financing for eligible firms and on their issuance activity. At the same time, the resulting portfolio of corporate bonds held by the ECB is biased towards more carbon-intensive firms[36]. Such firms have higher investment needs, thereby representing a disproportionate share of the investable universe. As a result, any benefit of eligibility for ECB bond purchases was first and foremost harvested by carbon-intensive firms.

Table 1 provides an overview of the climate risk exposure of the aggregated ECB's corporate sector portfolio. The ECB proposed four main metrics: the weighted average carbon intensity (WACI), carbon intensity, total carbon emissions, and the carbon footprint measured in tons of CO_2-equivalent (tCO_2e) per EUR million invested. Between 2018 and 2022, the climate risk of the ECB's overall corporate portfolio decreased significantly from 238 to 166 tCO_2e per EUR million[37]. This decrease is mainly due to issuers becoming more carbon efficient.

Only since October 2022 has the ECB also been actively contributing to reducing climate risk in its portfolio of corporate assets by actively steering the reinvestment of its asset purchases away from companies with high carbon emissions[38]. This had a sizeable impact on the market: the announcement alone reduced the eligible green bond's yield-to-maturities by 4 basis points relative to eligible conventional bonds and, consequently, increased the issuance of green bonds in the market[39].

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35 The APP consists of the corporate sector purchase programme (CSPP), the public sector purchase programme (PSPP), the asset-backed securities purchase programme (ABSPP), and the third covered bond purchase programme (CBPP3).

36 Papoutsi et al. (2021).

37 For more details, see https://www.ecb.europa.eu/pub/pdf/other/ecb.climate_related_financial_disclosures_eurosystem_corporate_sector_holdings_monetary_policy_purposes2023~9eae8df8d9.en.pdf .

38 The initial press release referring to the announcement is from July 8, 2021 (ECB, 2021c). Regarding implementation, see press release ECB https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220919~fae53c59bd.en.html .

39 Eliet-Doillet and Maino (2023).

However, as of July 2023, the ECB stopped reinvesting the principal payments of maturing corporate debt under the APP and will most likely stop doing so under the PEPP at the end of 2024. Given the relatively smaller size of the PEPP corporate holdings (only 12% of total holdings), any reinvestment tilted towards climate-friendlier issuers will be small in comparison to the large stock of existing overall holdings.

The question arises: what alternative instruments does the ECB have at its disposal to achieve a greener portfolio? One option – in addition to tilting the comparatively small reinvestments in a climate-friendly way for the next remaining months – is to actively rebalance the entire corporate bond portfolio held at the ECB toward issuers with a better climate performance. This is certainly against the "held to maturity" policy underlying the ECB's purchases so far. Re-shuffling the corporate portfolio would imply actively selling positions (and not waiting until maturity). However, such a policy helps to safeguard better financing conditions of green investments even in times of rising borrowing costs, as recently highlighted by Isabel Schnabel, current member of the ECB Executive Board[40].

[40] Schnabel (2023).

Table 3: Financial and climate-related disclosure metrics for the ECB's corporate sector portfolios

	2018	2019	2020	2021	2022
Portfolio size (EUR bn, nominal amounts)	**173.1**	**180.3**	**287.5**	**345.5**	**385.2**
Portfolio size (EUR bn, book value)	180.3	187.7	297.1	357.4	394.7
Weighted Average Carbon Intensity (tCO_2e per EUR million revenue)	372	316	289	267	262
Coverage (percentages)	91%	92%	96%	96%	96%
Total carbon emissions (scope 1 & 2 emissions in mega tCO_2e)	37	32	47	55	60
Coverage (percentages)	90%	91%	95%	94%	94%
Carbon footprint (tCO_2e per EUR million invested)	238	195	173	169	166
Coverage	90%	91%	95%	94%	94%
Carbon intensity (tCO_2e per EUR million revenue)	385	332	310	292	284
Coverage	90%	91%	95%	94%	94%

Source: Climate-related financial disclosures of the ECB's corporate sector holdings for monetary policy purposes, March 2023; Available here: https://www.ecb.europa.eu/pub/pdf/other/ecb.climate_related_financial_disclosures_eurosystem_corporate_sector_holdings_monetary_policy_purposes2023~9eae8df8d9.en.pdf

Note: "Coverage (percentages)" indicates data availability, calculated as the percentage of investments for which all required data (i.e., emissions and financial data) are available. "tCO_2e" stands in for "tons of CO_2 equivalent", the measure of emissions. Values refer to year-end of the aggregate portfolio of corporate assets.

3.2. Green Collateral Framework

Another margin to contribute to climate change mitigation – or at least to not spur greenhouse-gas emissions – is the ECB's collateral framework. It specifies the list of assets banks can pledge to enter the ECB's refinancing operations. Indeed, the ECB only lends to the banking sector against collateral, defined both in terms of asset eligibility and in terms of haircuts applied to the respective assets to compensate for their riskiness. A peculiarity of the ECB's collateral framework is that it accepts various asset classes across a wide range of credit ratings, ranging from corporate and government bonds, covered and uncovered bank bonds, to asset-backed securities.

Recent empirical studies point to collateral framework policies having an impact on the real economy. In terms of eligible loans, the amount of collateral available to banks influences their lending decisions[41]. Firms exposed to banks affected by the change in the collateral framework experience a relaxation of borrowing constraints and increase their real activity. In terms of eligible bonds, research documents an "eligibility premium" on eligible bonds, which decreases their yield-to-maturities

[41] For the household sector, see Van Bekkum et al. (2017). For the corporate sector, see Mesonnier et al. (2021) and Hüttl and Kaldorf (2023).

relative to non-eligible bonds. Subsequently, the issuance of eligible bonds in the market also increases. These are sizeable effects. Preferential treatment of green bonds in the collateral framework, in particular, boosts the supply of green bonds, leading to an increase in green investment. Favouring both bonds and loans stemming from corporations with a better climate-performance could therefore be an important instrument to actively contribute to a green transition of the economy.

Up until recently, however, the existing collateral framework did not have any climate policy dimension. In contrast, the collateral framework of the ECB exerts a carbon bias: companies with high carbon intensity issue 59% of corporate bonds accepted as collateral by the ECB, despite contributing less than 24% and 29% to European Union (EU) employment and Gross Value Added, respectively[42]. Additionally, the collateral framework of the ECB implicitly incentivises fossil fuel companies to tap bond markets, with the four largest (mostly gas) fossil fuel companies relying on bonds that are subsidised by the collateral framework of the ECB for over half of their overall financing[43].

Given the significant ramifications for capital allocation and market prices, a greening of monetary policy crucially depends on greening its collateral framework. The ECB took steps to incorporate the collateral framework in its climate action plan: after kicking off the green monetary policy debate in 2021, the ECB Governing Council strengthened the use of the collateral framework to account for the EU's climate targets in July 2022[44]:

- In terms of assets included, the ECB committed to limiting the pledgeability of assets issued by firms with a high carbon footprint by end-2024. These limits will first apply to corporate bonds, with additional asset classes being added as the quality of climate-related data improves.
- In terms of haircuts, the ECB started considering climate change risks when reviewing haircuts applied to corporate bonds used as collateral.
- In terms of disclosure, the ECB is making climate-related corporate disclosures compulsory for bonds to remain eligible as collateral in refinancing operations by the end of 2026.
- In terms of risk assessment and management, the Eurosystem agreed on a set of common minimum standards for how national central banks' in-house credit assessment systems should include climate-related risks in their ratings. These standards will enter into force by the end of 2024.

A more climate-friendly collateral framework is especially important under current high interest rates. In an environment with rising interest rates, the green transition is becoming more difficult to implement since financing investments in green technologies and innovation is more expensive. It is, therefore, paramount that the greening of the collateral framework continues – at least – as laid down in the ECB communication, thereby alleviating negative effects of rising interest rates.

3.3. Data Availability

Taken together, the collateral framework, as well as the unconventional monetary policy programmes can contribute to greening monetary policy. Underlying all of this, however, lies the availability of reliable, standardised, accurate data on the climate risk of firms and their financial assets.

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42 Dafermos et al. (2021).

43 Dafermos et al. (2021).

44 In July 2021, the ECB published a first proposal on incorporating climate change into its monetary policy operations (ECB, 2021c). In July 2022, the ECB specified further details regarding climate change and its corporate bond purchases, collateral framework, disclosure requirements and risk management (ECB, 2022a).

Given that loans to the corporate sector are an important part of eligibles in the ECB's collateral framework, any climate-related eligibility criteria must build on the relevant information at the counterparty level and, hence, on banks capacity to identify, manage, and monitor climate risk of their loan portfolio.

A first stocktaking of climate-risk related data availability from the bank's side was the ECB bottom-up climate-risk bank stress test conducted in July 2022[45]. The ECB itself stated the availability of climate-related data as one of the main challenges. Banks use sectoral data instead of firm level data for carbon emissions and emission intensity. However, at the company level, emissions are quite heterogeneous[46]. Similarly, in November 2022, the ECB concluded its thematic review on climate-related and environmental risks of 186 banks and found that, while progress is being made, less than 10% of institutions use sufficiently forward-looking climate and risk information at the counterparty level in their governance and risk management practices[47].

At the same time, researchers and policy makers alike raise concerns regarding diverse approaches in carbon disclosure, the quality of emission disclosures, as well as the credibility and comparability of disclosed information. Recent research finds that mandatory carbon disclosure significantly lowers the cost of capital for reporting companies. Additionally, total emissions fall following firm disclosures, suggesting a certain degree of disciplining coming from disclosure requirements[48].

Together with the Corporate Sustainability Reporting Directive, which expands Environmental Social Governance (ESG) reporting obligations in the European Union, the ECB's quest to make climate-related corporate disclosures compulsory for bonds and loans to remain eligible as collateral in refinancing operations by end-2026 is an important endeavour.

45 ECB (2022d).

46 For a discussion of the stress test see https://wpsf.de/wp-content/uploads/2022/09/WPSF_PB_6_2022-ECB_Stresstest.pdf .

47 ECB (2022c).

48 Bolton and Kacperczyk (2021).

4. CONCLUSION AND POLICY RECOMMENDATIONS

Rising inflation rates in the euro area have called for a contractionary monetary policy response. The ECB has been increasing interest rates and reducing its balance sheet. High interest rates discriminate against technological innovation and the production of renewable energy due to large upfront costs in these sectors[49]. The phasing out of the APP excludes reinvestments that tilt the ECB's bond holdings to more climate-friendly alternatives reflecting a greener monetary policy. These developments complicate the ECB's intention to align its policy with the climate targets stipulated in the Paris Agreement.

In this policy briefing, we show that natural disasters – which will occur more frequently and severely as climate change advances – push inflation up. This underlines the necessity to incorporate climate-change considerations in the ECB's policymaking. Furthermore, inflationary pressures are dispersed across sectors pointing to distributional effects. Further, we note that the current composition of corporate bond holdings and the bias of the collateral framework towards carbon-intensive issuers run counter climate protection.

We next discuss policy options that are still available for the ECB to shift its operations towards climate neutrality. Both the tilting of the remaining reinvestments stemming from the corporate bond holdings as well as the collateral framework are two options. While the collateral framework allows pushing for climate-friendlier assets, thus inducing a diminishing effect on emissions, the tilting options of the remaining reinvestments are, however, limited in scope. These considerations, in combination with disadvantageously high interest rates, let us conclude that additional unconventional policies are inevitable if climate goals should be met. Therefore, we argue for an active re-balancing of the ECB's corporate bond holdings towards issuers with a better climate performance.

Another suitable instrument that has seen less attention in ECB communications is the discrimination of refinancing facilities. More favourable interest rates may be offered for climate-friendly investments. This measure does not conflict with price stability since the ECB can react to inflationary pressures as mandated by means of its main refinancing operations. Fostering investment in green technologies and innovation allows for a quicker transition to a green economy. Reducing the dependence on fossil sectors, in turn, diminishes the exposure of the euro area to supply shocks in this sector, an important driver of rising inflation rates – as recently experienced because of the Russian war in Ukraine. Knowledge on the mechanisms of this unconventional policy is scarce. Filling the gap would be an important endeavour for future research.

After having discussed adequate policy instruments, we think a word of caution is in order. The greening of monetary policy firmly depends on knowledge about emissions associated with financial products. Open questions must be addressed: On what criteria shall a "green bond taxonomy" be founded? What institution should be responsible for the classification? How can "greenwashing" incentives of firms be prevented? Answering these questions is of vital importance for the future conduct of monetary policy in an era of climate change.

[49] Schnabel (2023).

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ANNEX

Empirical Methodology

Beirne et al. (2023) use a panel structural vector autoregression (PSVAR) model to estimate the average monthly response of headline inflation and its main sub-indices to shocks imposed on the natural disaster variable. The model can be denoted as follows, with structural shocks identified by a recursive restriction:

$$Y_{i,t} = A(L)Y_{i,t-1} + \alpha_i + \mu_{i,t},$$

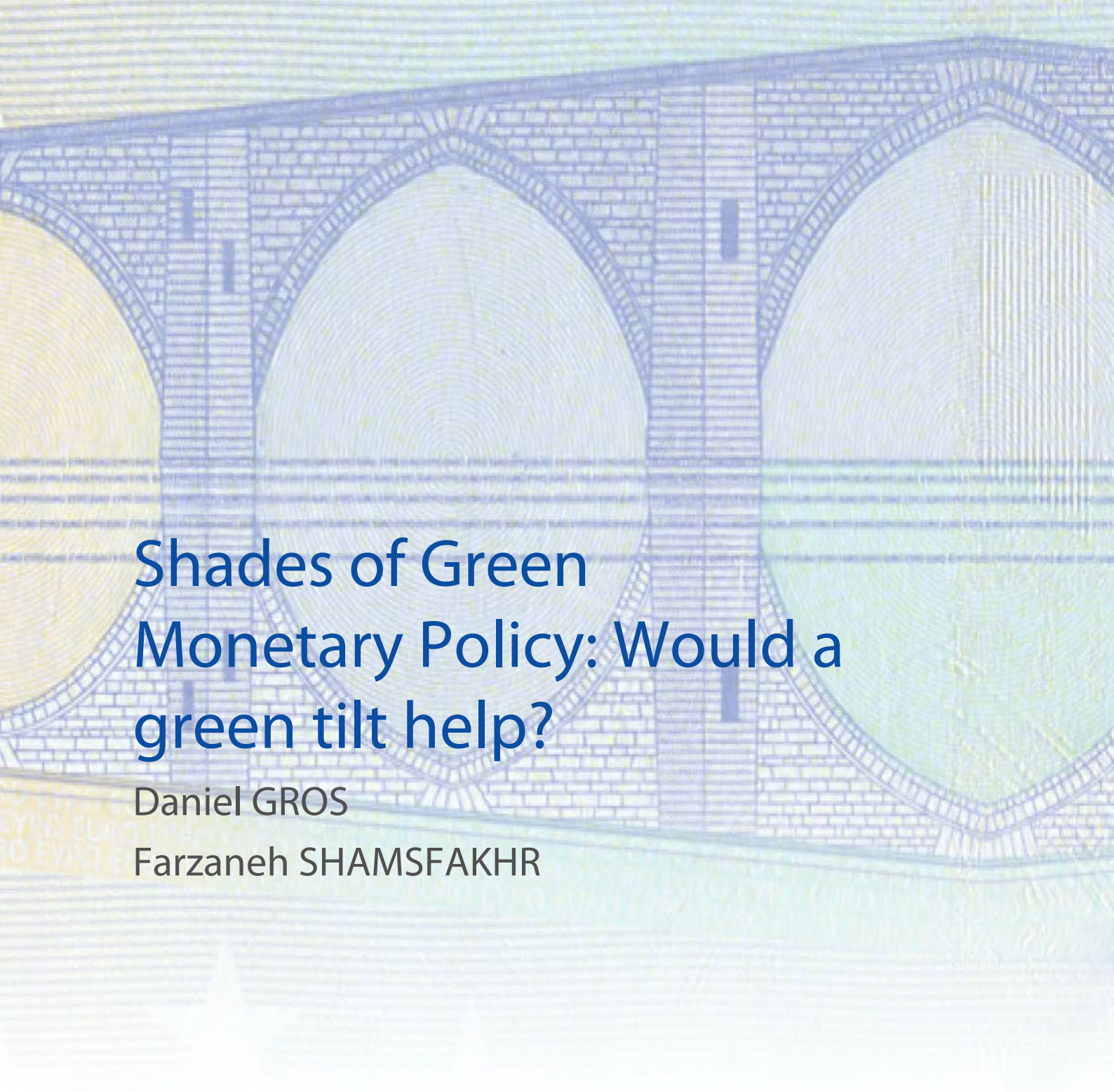
where the variable $Y_{i,t}$ refers to the vector of endogenous variables of country *i* at month *t*. These include the estimated monetary damages caused by natural disasters, a measure of inflation, and other domestic drivers of inflation. $A(L)$ is a matrix of polynomials in the lag operator L while α_i denotes country-specific fixed effects to account for unobserved time-invariant heterogeneity across countries and $\mu_{i,t}$ is a vector of idiosyncratic disturbances. Note that the exogenous nature of the disaster variable allows the authors to employ a recursive identification scheme.

Due to the autoregressive nature of the PSVAR, fixed effects are intrinsically correlated with the regressors. A forward orthogonal deviation procedure proposed by Arellano and Bover (1995) is used to eliminate fixed effects, such that the transformed variables are orthogonal to the lagged regressors. Three lags are included in the PSVAR model, as suggested by the Akaike information criterion.

Following Christiano et al. (1999), the identification strategy is based on a block recursive restriction, which results in the following matrix *A* to fit a just-identified model:

$$A_{m,n} = \begin{pmatrix} a_{1,1} & 0 & \cdots & 0 \\ a_{2,1} & a_{2,2} & \ddots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ a_{m,1} & a_{m,2} & \cdots & a_{m,n} \end{pmatrix}$$

The ordering of the variables imposed in the recursive form implies that the variables at the top will not be affected by the contemporaneous shocks to the lower variables, while the lower variables will be affected by the contemporaneous shocks to the upper variables. The disaster variable is placed at the top of the ordering, which implies that it will only be affected by a contemporaneous shock to itself. Following the disaster variable, the authors place industrial production, the unemployment rate, monthly changes in the US dollar nominal exchange rate, import prices, and oil prices next in the ordering. This implies that these domestic factors will be affected by contemporaneous shocks to natural disasters and themselves, but not by contemporaneous shocks to inflation. Importantly, inflation comes last in the ordering, which assumes that both natural disasters and domestic macroeconomic factors will affect inflation.



Shades of Green Monetary Policy: Would a green tilt help?

Daniel GROS

Farzaneh SHAMSFAKHR

Abstract

Any greening of monetary policy is likely to have at best a marginal effect on emissions given the very small spreads on the yields of green bonds and the cap on emissions inherent in the EU's emissions trading system.

Trying to limit the supply of capital to brown industries could backfire as these industries are those most in need of financing for capital-intensive decarbonisation.

These arguments apply both to the tilting of investments under the corporate sector purchase programme (CSPP) towards green industries/enterprises and to the potential greening of targeted long-term refinancing operations. Moreover, CSPP holdings will decline rapidly, so this prospective policy instrument will become irrelevant in a few years.

This document was provided by the Economic Governance and EMU Scrutiny Unit at the request of the Committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 27 November 2023.

CONTENTS

LIST OF ABBREVIATIONS

CSPP	Corporate sector purchase programme
ECB	European Central Bank
ETS	Emissions trading system
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
PSPP	Public sector purchase programme
PEPP	Pandemic emergency purchase programme
TLTRO	Targeted long-term refinancing operations

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EXECUTIVE SUMMARY

- **In an attempt to reduce the carbon emissions related to Eurosystem corporate securities holdings, the ECB has taken further steps to incorporate climate change considerations into its monetary policy framework, and to support green transition.**
- **The ECB is supposed to support the overall economic policy of the EU, subject of course to its primary goal of monetary policy**. But this does not constitute a valid argument to 'tilt' monetary policy towards green goals (within the monetary policy stance needed to achieve price stability).
- **It is difficult to justify why the ECB should prioritise the green transition over other EU policy goals.**
- **The choice of prioritising the green transition over other goals is a political one that puts the independence of the ECB at risk.**
- **Decarbonising the corporate sector purchase programme (CSPP) will have at best only a marginal influence on actual emissions, as the impact of CSPP purchases on individual bonds is negligible (a few percentage points).**
- **The EU emissions trading system implies a 'waterbed effect', as any attempt by the ECB to favour green sectors, given the overall cap, will only create more room for brown industry to expand.**
- **A small number of high-emitting brown sectors dominate the overall level of emissions. Yet, these are the sectors most in need of capital to finance costly investment to reduce emissions.** Making access to capital more difficult for brown sectors could thus harm mitigation efforts.

1. INTRODUCTION

Whether central banks should 'green' their monetary policy has been debated for some time. The head of the US Federal Reserve has taken the position that the Fed 'is not, and will not be, a climate policymaker'. [50]

The ECB seems to be following a different approach, as stated by Christine Lagarde: 'within our mandate, we are taking further concrete steps to incorporate climate change into our monetary policy operations'.[51] Accordingly, the ECB has announced, as part of its climate agenda, several measures to reduce financial risks associated with climate change and to support green finance. The ECB should of course carefully assess climate risk. As argued by the ESRB (2016), systemic risk can be expected mainly from a sudden change in policy after a too long period of complacency. This does not seem the case today. Climate change is a slow-moving process that is unlikely to generate risk in the sense of sudden changes in financial markets. There is thus a fine line between the necessary objective assessment of the financial risks deriving from climate change and the use of this risk assessment to force firms to change their investments. Moreover, the mandate to defend price and financial stability does not immediately imply a mandate to foster green finance in general. In these respects, the ECB has taken a different stance from that of the US Federal Reserve, whose President Jerome Powell has stated that it will not become a climate change agent.[52]

The argument for why the ECB should take climate change into account when setting its policy is simple. The Treaty states clearly that the overriding aim of monetary policy should be price stability, but that subject to this the ECB should support the economic policy of the Union. The EU has given itself ambitious targets for cutting greenhouse gas (GHG) emissions. It would thus seem that the ECB should support this policy by encouraging emission reductions. However, this argument that the ECB should support green objectives because they are part of the general economic policy of the EU must be qualified.

First of all, price stability is plainly not given as a reason at present. In a literal interpretation, this would seem to preclude any adjustment in the monetary policy stance for green objectives. The counterargument would be that it might be possible for the ECB to tilt its policy within a given monetary policy stance. One prominent example of this line of argument is that the ECB determines the path for the overall amount of corporate bonds to be held by the Eurosystem purely based on the objective of achieving price stability. But it could shift the composition of its holdings towards green industries.

Second, the EU has many other policy objectives, like fostering cohesion at the regional level, increasing the competitiveness of European industry, supporting SMEs or promoting gender equality. The ECB would be making an explicit political choice of prioritising the green transition over other EU policy goals. If supporting SMEs is important, the ECB should provide special financing to them. If regional cohesion is important, it could tilt its asset purchases towards lagging regions. But this is not on the agenda. Making such a political choice which worthy policy goal of the EU to support might endanger the independence of the ECB, which is based on the idea that it only has the task of maintaining price stability (see also Blanchard et al., 2023).

[50] https://greencentralbanking.com/2023/01/12/federal-reserve-jerome-powell-mandate/

[51] https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220704~4f48a72462.en.html

[52] https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220704_annex~cb39c2dcbb.en.pdf

A study by Nakov and Thomas (2023) recognises that there would be no need for the ECB to green its policy if governments imposed a carbon tax. However, the paper argues that if the carbon tax is suboptimal from a global welfare point of view, then a 'green tilting of purchases is optimal and accelerate the green transition'. Still, the optimality here refers to a particular model of the economy and neglects the fact that the 'optimal' carbon tax is a political decision that should be taken at the political level – not by a central bank. On what grounds would the ECB be better placed than the EU's co-legislators, the Council and Parliament, to decide on the appropriate level of carbon taxation and the speed of decarbonisation of the EU? This is the fundamental problem for any action towards greening monetary policy.

The purpose of this contribution is not to go deeper into these general arguments but to illustrate the issues that arise in practice if the ECB wants to pursue green objectives. It uses the case of corporate sector purchase programme (CSPP). The issues that arise in this particular case are of general relevance and will also arise if one considers the use of other instruments, such as the collateral framework, in the pursuit of green objectives.

The issues identified below are also relevant for other central banks that consider greening their monetary policy. But there is one consideration that applies solely to the EU. This stems from the fact that the EU has an emissions trading system (ETS) which puts a cap on total emissions. The existence of this cap has a profound implication. Given this cap, a green monetary policy will fail in its attempt to lower emissions. Any reduction in emissions achieved by the actions of the ECB will only lead to a lower emissions price, but not lower total emissions because these will remain at the level fixed by the ETS.

The remainder of this contribution is organised as follows. Section 2 looks at some issues facing any attempt to green monetary policy in general. Then, Section 3 turns to a more in-depth analysis, using the case of the CSPP. In Section 4, we discuss the concept of 'waterbed effect' in the context of green monetary policy. Section 5 briefly considers the potential for green targeted longer-term refinancing operations (TLTROs). The last section concludes.

2. MONETARY POLICY AND THE GREEN TRANSITION: WHAT LINK?

Against the backdrop of the Treaty, there should be no trade-offs between price stability and the green transition in the environment. Monetary policy should aim at price stability and by doing so provide the financial conditions for sound economic growth. The political authorities should then provide the appropriate regulatory framework to channel resources towards the green transition.

Many green investments are very capital intensive. One could thus argue that any tightening of monetary policy is likely to have an adverse impact on the green transition, for example by increasing the cost of capital for renewables. This is likely to be the case at present. Liebich et al. (2023) raise similar concerns, arguing that a tilting approach could withdraw support from companies that are transitioning to the use of low-carbon technologies.

However, one cannot just look at the monetary policy stance at any given moment. One must consider the average over a longer period and the impact of today's stance on future inflation and interest rates. Delaying a tightening of monetary policy in order to avoid negative effects on the green transition risks delaying price stability and thus requiring higher rates for longer in the future. This is actually what has happened over recent years. With hindsight, it is now apparent that the ECB was late in reacting to the inflationary pressures emerging in late 2021. This forced it to increase rates at a faster pace than might have been necessary if it had started earlier to tighten, possibly increasing the risk premium.

Moreover, the main instrument of monetary policy, the interest rate, is not targeted at just the green part of the economy. Tightening or loosening the policy stance affects the entire economy. It is likely that the impact of a monetary policy stance is stronger for capital-intensive sectors, like renewables. This applies to changes in both directions, tightening or loosening. In the parlance of financial markets, renewables have a high 'beta' with respect to the interest rate.

Renewables constitute only a very small part of the entire EU economy. Green investment in the EU, by the European Commission and the European Investment Bank, reached EUR 285 billion in 2022, representing around 2 % of EU GDP (Pons and Varin, 2023).

The monetary policy stance is thus a very inefficient instrument in relation to the green transition[53]. This is the reason why a central bank wishing to support the green transition will have to consider other instruments that can be targeted at specific sectors or enterprises. The unconventional monetary policy instruments that many central banks have resorted to over the last decade of stubbornly low inflation provide opportunities for doing just that.

For the ECB, this would be mainly the CSPP and the TLTROs. The collateral framework represents another instrument, but it is not considered separately here because the arguments pertaining to the CSPP and the TLTROs also apply, *mutatis mutandis*, to it. Using the collateral framework for green purposes, implies that the ECB is using an instrument meant to reduce its risk to discriminate between different types of enterprises or sectors – i.e. engaging in industrial policy.

[53] A recent study by Nakov and Thomas (2023) recognises this as 'the untargeted, inefficient nature of (conventional) monetary policy as a climate instrument'. https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2845~3b53c0a391.en.pdf?305579a38d3b38136e1338c6de5bbcd0

3. THE CASE OF THE CSPP

The Eurosystem now holds over EUR 300 billion or about 20 % of the outstanding eligible universe of corporate bonds, similar to the share of public sector bonds held under the public sector purchase programme (PSPP) and pandemic emergency purchase programme (PEPP). [54]

It is possible that the impact of the CSPP on the average yields of corporate bonds has been substantial. However, the few available studies suggest that it appears to have been limited. Bremus et al. (2021) find no effect of the CSPP announcement on yields. The ECB's own research credits the announcement effect of the CSPP with a reduction in corporate bond spreads for eligible securities of 25 basis points (De Santis et al., 2018).

Given that the average maturity of corporate bonds is only half that of the government bonds bought under the PSPP and PEPP (around 3 years for corporate bonds vs 7-8 years for government bonds) and given that the market for corporate bonds is much less liquid, one would expect less of an announcement effect from the CSPP, but maybe a stronger medium-term effect on spreads and issuance volumes. Although stimulating the issuance of corporate bonds might be a side effect of the CSPP, this is not an objective of monetary policy.

Studies focusing on the subsequent evolution of the market show somewhat mixed results for yields, but strong trend growth in overall issuance (Zaghini, 2019). Still, in the context of greening the CSPP the issue is slightly different. The ECB can expect a shift in holdings towards greener sectors or firms to have an impact only if this shift affects the yields of bonds whose holdings go up, leaving the average potentially unchanged.

Analyses of the impact of Eurosystem purchases on the yields of individual securities have mostly found very limited effects (around 1 percentage point) (Eser et al. 2023). This should not be surprising. It should be easier for investors to shift across individual company names within the class of corporate bonds than to adjust their holdings of the overall asset class. This is a first indication that tilting the CSPP portfolio might have only a limited effect. This effect will be further reduced because the ECB decided to stop the reinvestment of the CSPP as of July 2023.[55] In view of the rather short maturity of the CSPP portfolio, this implies that the holdings of the Eurosystem will decline quickly – twice as fast as those of the PSPP. Figure 1 below provides a rough illustration of the path of Eurosystem CSPP holdings based on observed redemptions over recent years.

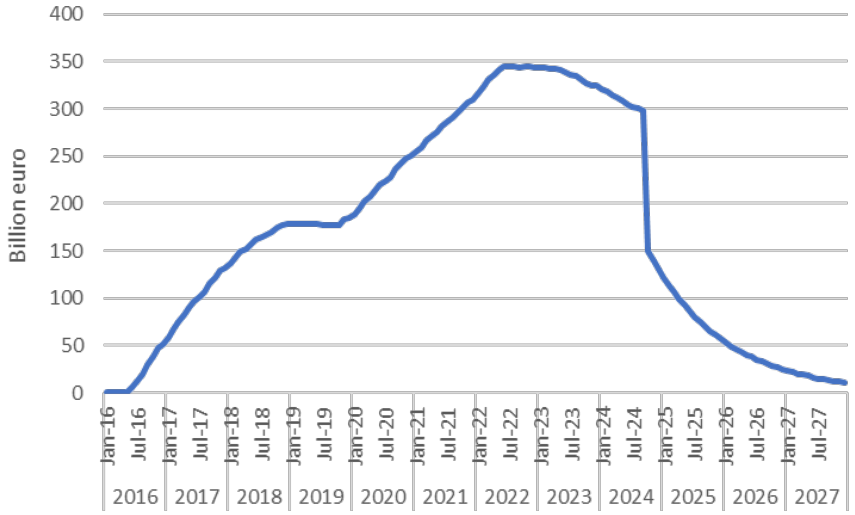
Eurosystem holdings of corporate bonds will thus become of marginal relevance within a couple of years. The only meaningful action that could be undertaken at this point would be to reshuffle the portfolio from brown to green industries/enterprises.

[54] ECB Economic Bulletin, Issue 5/2023.

https://www.ecb.europa.eu/pub/economic-bulletin/focus/2023/html/ecb.ebbox202305_06~3f689a7ab9.en.html

[55] https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html#:~:text=Between%20July%202022%20and%20February%202023%20the%20Eurosystem%20aimed%20to,reinvestments%20as%20of%20July%202023.

Figure 1: Simulation of CSPP holdings path



Source: Authors' elaboration based on data from the ECB.

Notes: Simulations include redemptions. For the period October 2023-October 2024, we use the redemption estimates from the ECB. For the period afterwards, we assume an annual redemption rate of 5%, based on the historical average, under the assumption of a similar structure as for holdings (in terms of weighted average maturity and distribution over maturities).

3.1 Emission intensity of the CSPP portfolio

The basic rule for CSPP purchases was that they should be market neutral. The CSPP holdings therefore reflect the distribution of bond issued across different economic sectors. Those sectors that one would consider *ex ante* as being the most emission intensive – like utilities, chemicals and construction – together account for less than a quarter of the total (of now somewhat above EUR 300 billion).[56] These shares have not changed noticeably since the start of the CSPP programme in 2017 because the market shares of the different sectors in the overall corporate bonds outstanding have not changed.

But the shares of different sectors in the CSPP portfolio say little about how brown or green it is because in reality there are great differences between sectors in terms of their carbon intensity. The measure of carbon intensity most often used in green finance is the ratio of emissions to revenues.[57] This ratio ranges from a high of over 1000 (tonnes of CO_2 per million euro in revenues) for construction (cement is cheap, but its production is very emission-intensive) and around 700 t/million euro for utilities (power generation) and chemicals to lows of less than 10 t/million euro for telecommunication and technology products. The range of emission intensity across sectors is thus around 100 to 1.

One first algebraic consequence of these huge differences is that percentage changes and absolute changes have very different meanings. A 10% reduction in the emission intensity of construction would mean 100 tonnes of CO_2 less (at unchanged revenues). A 50 % reduction in the emission intensity of telecommunications would mean only 5 tonnes less (again, at unchanged revenues).

Another implication for the CSPP is that a few high-emitting sectors dominate the total emissions embodied in the CSPP holdings of the Eurosystem even if their share in the portfolio is limited. If one multiplies the shares in the CSPP portfolio by the respective emission intensities one finds that the three

[56] https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html#cspp

[57] From an economic point of view, it would be preferable to use the ratio of emissions to value added instead of revenues. A firm that has a high rate of revenues to value added, for example in retail or wholesale services, would have a low ratio of emissions to revenues, but the emissions per value added would much be higher.

most emission-intensive sectors – utilities, chemicals and construction – together account for over 70 % of the CSPP holdings[58].

These three sectors all fall under the ETS[59] (utilities represent the ETS power-generation sector and construction comprises the cement plants that are also covered by the ETS, as are the large emitters in the chemical industry). The fact that these three sectors are already covered by the ETS means that their total emissions are already limited (capped). This suggests that providing green enterprises with easier financing conditions might have no effect on the aggregate amount of emissions. Section 4 analyses this 'waterbed' more in detail.

The 'waterbed effect' pertains to a situation where any government's intervention that reduces emissions in one particular part of a sector that is covered by the ETS will have no impact on total ETS emissions, as the total emissions cap remains unchanged.[60]Tilting the portfolio towards less carbon-intensive sectors, for example transport or services, are not subject to this 'waterbed effect'[61] because there is no price mechanism to limit emissions in these sectors.

The ECB does not use raw emission intensities. It is instead exploring a rather complex scoring system as a benchmark for tilting the Eurosystem's corporate bond purchases towards issuers with a better climate performance. Box 1 provides a simple illustration of the framework planned by the ECB for evaluating the climate performance of corporate bond issuers. On the ECB's scoring system, the average score is close to 4 out of 5 (the higher the score the better the climate performance), which is not surprising given that most quoted companies have reduced their emissions. [62]

The approach of the ECB to classify (then potentially decarbonise) the CSPP faces several challenges. For example, Liebich et al. (2023) highlight the data gaps in measuring sector-level and issuer-level carbon emission that are mostly backward-looking and sensitive to simplifying assumptions. As illustrated in the Box 1, forward-looking emission targets are one of the main aspects of issuers' climate score assessment underlying the ECB tilting approach. However, there is no systematic database on firms' future decarbonisation plans. Therefore, the ECB mostly relies on firms' self-reported emission reduction targets, 'disclosure'. Blanchard et al. (2023) argue that it is anyway difficult to ensure the better financing for green purposes result in additional emissions reductions. Liebich et al. (2023) argue that it is likely that high bureaucratic costs for disclosure disproportionately favour larger companies,

[58] The underlying hypothesis here is that the ratio of outstanding bonds to revenues is approximately the same across sectors and firms. Papoutsi et al. (2022) arrive at a similar result using a similar assumption, but they had also access to the detailed securities holdings of the ECB.

[59] The EU Emissions Trading System (EU ETS) is a carbon market that operates on a 'cap-and-trade' system of emission allowances. It aims to reduce GHG emissions by providing a financial incentive for regulated entities to reduce their pollution. Under the EU ETS, regulated entities, such as power plants and factories, are required to hold a permit for each tonne of CO_2 they emit. These permits, known as emissions allowances, can be freely traded. The more a power plant reduces its emissions, the fewer allowances it needs to buy. The key aspect of the ETS of interest in this context is the cap on total emissions. See https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

[60] There is the further complication in that the ETS covers the entire EU, but the ECB can only influence firms that issue bonds in euro. It is thus unlikely to have much impact on the financing conditions of firms outside the euro area. The free allowances available to industries exposed to carbon leakage constitute another complication not considered here.

[61] There is a large body of literature on the waterbed effect – see Perino et al. (2022) and Willner and Perino (2022). Perino finds that 'supply-side' policies that unilaterally raise the carbon price or directly limit emissions-intensive production have positive internal leakage – sometimes in excess of 100 % – as they raise emissions demand in other jurisdictions that 'fill the gap' due to lower domestic production. Reducing the access of brown firms to finance represents such a supply-side policy. The Market Stability Reserve that was recently adjusted might mitigate the waterbed effect, but it is meant to deal with situations of excess allowances, which should not arise in the first place.

[62] Climate-related financial disclosures of the Eurosystem's corporate sector holdings for monetary policy purposes, March 2023 See https://www.ecb.europa.eu/pub/pdf/other/ecb.climate_related_financial_disclosures_eurosystem_corporate_sector_holdings_monetary_policy_purposes2023~9eae8df8d9.en.pdf

and, in turn, their corresponding scores. All this suggests that it would be difficult to use this classification to make operational decisions which bonds to buy.

Moreover, the shift towards a greener CSPP portfolio would have a fiscal cost, albeit most probably a very small one, at least relative to the total interest income of the Eurosystem. But this small loss of revenue might still acquire some importance given that most of the national central banks in the euro area are likely to make losses over the next few years (Gros and Shamsfakhr, 2022).

The purpose of greening the CSPP portfolio is to reduce the financing cost of greener sectors relative to their browner counterparts (at the same level of rating or risk). To the extent that this goal is achieved, the average interest rate on a green CSPP portfolio would decline (relative to the average market interest rate). This implies that greening the CSPP would lower the interest income of the Eurosystem.

As argued above, the impact of higher CSPP holdings on the yields of individual corporate bonds is very small, certainly less than 10 basis points[63] As such, the magnitude of the yield differential that greening the CSPP could achieve would be very limited. A yield differential on half the CSPP of below 10 basis points would lead to a loss of interest income of less than EUR 300 million per annum.

[63] See also Nakov and Thomas (2023), who recognise that any impact 'on CO_2 emissions and global temperatures is limited by the small size of eligible bonds' spreads'.

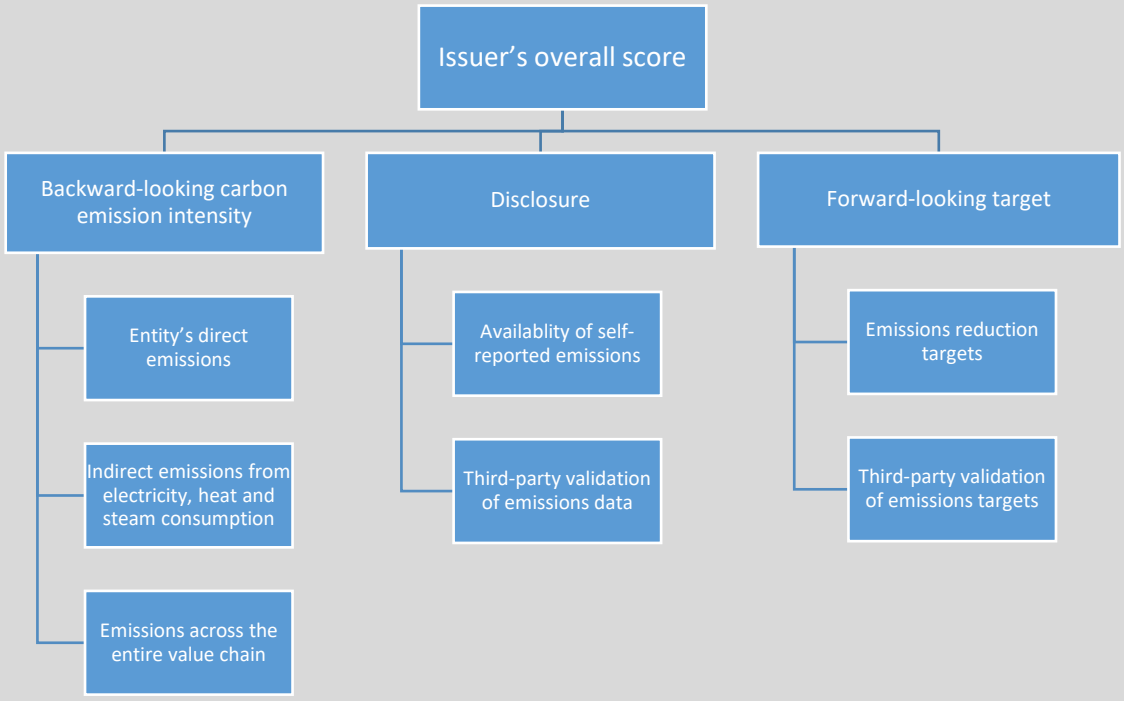
Box 1: Corporate issuers' scoring framework

According to the ECB, an issuer's overall score is a combination of three main dimensions: the backward-looking carbon emission intensity; the disclosure or the quality of the emissions data provided by issuers; and the forward-looking target reflecting the issuer's expected changes in future emissions. The sub-scores of the three aspects are aggregated, using certain weights, into issuer-specific climate scores. These in turn determine the tilting, such that future ECB corporate bond purchases and/or reinvestments are geared towards issuers with a better climate performance.

Backward-looking carbon emission intensity. This dimension reflects the past GHG emissions of an issuer. It encompasses an entity's direct emissions from output (scope 1), indirect emissions from input (scope 2) and emissions across the entire value chain (scope 3).

Disclosure. If issuers do not have self-reported emissions data, they are assigned a lower (backward-looking) emissions sub-score. The highest scores are assigned to issuers that have their climate-related financial disclosures verified by a third party. The lowest sub-scores are assigned to issuers that have no self-reported emissions data, and only estimates of their emissions from third-party data providers.

Forward-looking emissions target. A higher score is assigned to issuers that are on an ambitious decarbonisation path towards Paris Agreement targets, particularly if the target is science-based and has been validated by a third party. If issuers have no self-reported emissions data and emission reduction targets cannot be verified, they are assigned the lowest sub-score.



Source: Based on ECB (2023).

4. GREEN MONETARY POLICY UNDER THE ETS CAP: BEWARE OF THE WATERBED EFFECT

Separate from the question of the impact of CSPP purchases on the yield of individual corporate bonds, one needs to consider the impact of any reduction in the yields of 'greener' bonds on emissions. This is where a major conceptual problem arises as mentioned above.

Emission-intensive sectors like industry or power generation are covered by the ETS. This implies that the total allowable emissions of industry (and the power sector) are limited by binding ceilings, not only for today, but also for the next decade (and beyond).

This has a simple implication. If the Eurosystem tilts its corporate bond investments away from industry, capital will become marginally more expensive for industry. Yet, all this may do is reduce investment in industry somewhat. It does not imply that emissions in industry will fall below the ETS limit because the ex-ante lower investment in industry would also lead to a lower ETS price, which would then reduce efforts by firms to keep emissions down.[64]

The same argument applies to the idea that rebalancing the CSPP portfolio could just aim to provide finance to an individual firm within an industry or the power sector. The easier access to finance for some green industrial firms (i.e. those with lower emissions) and any market share they might gain relative to their browner competitors would just make room under the ETS ceiling for other firms to increase their production or to reduce their mitigation efforts.

To take an extreme example, providing a wind farm with (marginally) easier access to finance via a rebalancing of the CSPP portfolio might look like fostering green investment. The additional wind farm constructed through this policy would nonetheless reduce the emissions price, because there would subsequently be lower emissions at a given amount of electricity generated. The lower emissions price would in turn reduce the pressure on fossil fuel power stations to reduce emissions, leading either to a switch back to coal, or simply to older, amortised power plants with higher emission rates.

The end result of greening the ECB's portfolio might be a marginal reduction of the price of ETS allowances, but it will not change the overall emissions of the sectors covered by the ETS because that ceiling has been fixed. (The situation would be different if the EU had a fixed price for emissions. In that case, a greener ECB portfolio would make financing for low-emitting industries easier, leading to lower emissions at a given price for carbon.)

Greening the ECB's corporate bond portfolio in sectors not covered by the ETS, e.g. by switching bond holdings from brown service sector firms to greener ones, might have an impact on the total emissions of these sectors as they are not subject to a quantitative ceiling. However, the EU's legislators have clearly chosen not to limit the emissions of these sectors. The ECB would not be supporting EU policy but would actually be going against EU policy if it decided to provide some firms from these non-ETS sectors with easier financing conditions because they are less carbon intensive.

The makers of some green goods whose production is energy intensive, such as the production of batteries and wind turbines, represent a special case. To the extent that the production of these goods is emission intensive they should not be part of a green portfolio. Yet, these goods might deliver emissions reductions over their lifetime that far outweigh the emissions associated with their production.

[64] The waterbed effect is rarely considered in the literature on green monetary policy. Papoutsi et al. (2022) consider only carbon taxes although they describe specifically the case of the ECB's CSPP portfolio.

5. GREEN TLTRO?

One could imagine that the ECB provides a different target for its Targeted Longer Term Refinancing Operations (TLTROs). The purpose of the previous and existing TLTROs had been to foster overall investment by promising lower interest rate costs to banks that would increase their lending above a certain threshold.[65] With inflation rates considerably above 2% these targets were easy to reach because they had been set in nominal terms. The price level is now about 10% higher than it was when the last TLTROs were concluded. Even banks that reduced their lending in real terms could report an increase in the nominal amount of their loans. Under the TLTRO II some banks could qualify for the low (then negative) deposit rate if they kept their loan portfolio constant in nominal terms. Gros et al. (2016) describe how the rules for the TLTROs could result in this 'cash for loans'.

One could think about a new, green, TLTROs that would link lower refinancing costs to targets in terms of green lending. For example, the ECB could provide funds for less than the normal refinancing rate, e.g. at the deposit rate, for firms that increase green (or reduce brown) lending by a certain percentage. Given that the difference between deposit and refinancing rate is now 50 basis points (and has usually been of this size) this would provide a considerable incentive for green lending, more than any tilting of the CSPP that has resulted in only very small reductions in financing costs as argued above.

It would be difficult to justify the use of such GTLTRO as a monetary policy instrument at present. The ECB is currently engaged in an effort to combat inflation, which includes a gradual reduction of its balance sheet via quantitative tightening and the ECB has also undertaken measures to accelerate the repayment of outstanding TLTROs. Price stability considerations would preclude the use of such an instrument at present (given current inflation rates). But if inflation falls below 2% and remains there despite interest rates reaching again the lower bound, the ECB might again be justified to engage in TLTROs.

The practical difficulties facing such a green TLTRO (GTLTRO) would at any rate be immense.[66] The key practical issues would be similar to the ones for a green tilting of the CSPP. First of all, how would the ECB define desirable 'green' lending? The aim of any GTLTRO would be to contribute to a reduction in emissions. But this then leads to question how to measure the required emission reduction. It could be in percentage or in absolute terms (but calibrated relative to the overall amount of the emissions of the enterprise in the second case). As argued above, the first alternative would favour low carbon intensity and provides little incentive to decarbonise brown sectors. The second alternative would run into the additionality problem, i.e. whether the decarbonisation results would not have been achieved even in the absence of the GTLTRO.

As mentioned above, a small number of industries produce the bulk of emissions. To have an impact, the GTLTRO would thus necessarily have to go mainly to brown industries. This might be difficult to communicate and emission reductions difficult to monitor.

[65] https://www.ecb.europa.eu/ecb/educational/explainers/tell-me/html/tltro.en.html

[66] For a cautious conclusion see also Scouteris and Anastopoulou (2022).

6. CONCLUSION

The broad conclusion of this analysis is that greening the CSPP represents much ado about very little. The impact of the greening on actual emissions is likely to be extremely small, if any.

It is understandable that the ECB feels under pressure from the public and some NGOs to appear green. But the environmental benefits of caving in to this political pressure are likely to be negligible relative to the dangers to its independence. Moreover, providing cheaper access to finance for green enterprises or sectors represents a use of public resources that has little to do with monetary policy. These considerations also apply to the idea of green TLTROs.

Two more general considerations emerge from the analysis.

First, there are very large disparities in the emission intensities of different sectors. A small number of high-emitting sectors dominate emissions as a whole. These brown sectors are those that are most in need to capital to finance costly investment to reduce emissions. Making access to capital more difficult for brown sectors could thus harm mitigation efforts.

The key problem is that a central bank is not well placed to judge whether the financing of a brown enterprise (a corporate bond issue or a bank loan) would enable the continuation of high-emission activities or investment in emission reductions. Given the fungibility of money, this would require a detailed analysis of the overall financing structure and investment planning of the enterprise in question.

Second, one needs to consider that the existence of the cap on emissions fixed by the ETS creates a waterbed effect. Giving monetary policy a green tilt might spur some companies to reduce their emissions. But total emissions would remain at the same level as before, because a lower price on emissions would then lessen the incentives for other firms to reduce theirs.

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Climate Change and Monetary Policy in the Euro Area

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Abstract

Climate considerations have entered the agenda of the ECB in recent years. The ECB has intensified its analyses of the macroeconomic impact of climate change and started to evaluate and implement more active approaches and best practices to support the green transition. In this paper we discuss how climate change could affect monetary policy, other policies available to the ECB to support the green transition, and potential trade-offs with its primary objective of price stability.

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CONTENTS

LIST OF ABBREVIATIONS

APP	Asset purchase programme
ECB	European Central Bank
ESG	Environmental, Social, and Governance (ESG)
GDP	Gross domestic product
GTLRTO	Green targeted longer-term refinancing operations
PEPP	Pandemic emergency purchase programme
TLTRO	Targeted longer-term refinancing operations

LIST OF TABLES

EXECUTIVE SUMMARY

- **Climate change can have considerable economic effects that are relevant for central banks.** Physical risks (e.g. temperature increases or a higher frequency of extreme weather events) and transition risks of climate change (e.g. due to carbon pricing or regulatory measures of governments) can impact inflation or output, increase macroeconomic volatility, and affect financial markets. Some of these effects will have only a temporary impact on inflation and are, thus, less of a concern of central banks. However, they can lead to higher inflation volatility and increase overall uncertainty, making it more difficult to identify the appropriate stance of monetary policy. Other effects could lead to more persistent upward pressure on inflation, but central banks have effective tools to stabilise inflation so that these effects should mainly result in relative price adjustments.
- **Governments are responsible for reducing carbon emissions to address climate change.** Policies to mitigate climate change can have large distributional effects. Therefore, it is important that such policies are backed by the democratic legitimation of governments. The mandate of the ECB leaves room to support as a secondary objective the general economic policies of the European Union, which include protecting and improving the environment. However, secondary objectives shall be supported without prejudice to the primary objective of price stability. Against this backdrop, the ECB can only have a supportive role in mitigating climate change.
- **The ECB has taken several measures to account for climate considerations.** Some of these measures are general reactions to climate change, such as improving the analytical toolkit with regard to the macroeconomic impact of climate change or conducting climate stress tests to assess the impact of climate change on financial markets. But the ECB has also introduced monetary policy measures to support the green transition, in particular the tilting of its corporate bond holdings towards issuers with a better climate score. Moreover, the ECB plans to adjust eligibility criteria for its market operations with regard to better climate-related disclosures and climate scores of issuers.
- **Achieving price stability is the most important contribution of monetary policy to the green transition.** Price stability contributes to sustained growth and high employment and stimulates investment. Moreover, it helps to firmly anchor inflation expectations, which will support achieving price stability in the future when the impact of climate change on inflation may increase. The impact of other measures of the ECB on mitigating climate change is probably small. The extent to which the ECB will be supportive will vary over time, given that the ECB aligns policies, including the volume of bond holdings, to its primary objective.
- **The ECB has to consider unwarranted side effects when supporting the green transition.** The instruments of the ECB are efficient in targeting price stability, but may not be in targeting other objectives. Moreover, there is lack of market standards for green investments and forward-looking indicators with regard to the green transition. Therefore, it is difficult to assess the impact of the measures of the ECB and how they interact with other measures from governments. The more the ECB would try to support the green transition the stronger potential conflicts with its mandate and the higher the risks for its credibility with regard to its primary objective would be.

1. INTRODUCTION

Climate change has moved to the centre of the policy debate. Climate considerations did not play an important role for central banks for a long time. While it was widely acknowledged that weather fluctuations, and extreme weather events in particular, can have significant macroeconomic effects, these effects were perceived to be largely transitory and thus less of a concern for central banks that seek to maintain price stability in the medium term. However, by increasing the magnitude and the frequency of weather fluctuations and extreme weather events, climate change can also have more persistent macroeconomic effects due to physical risks associated with events, such as heat waves, prolonged draughts, or flooding, and transition risks that arise in the process of the transition towards a carbon-free economy. In the meantime, climate change is more in the focus of many governments. For example, the mitigation of climate change is an important political goal in the European Union.

Climate considerations have also entered the agenda of the ECB in recent years. The implications of climate change for the conduct of monetary policy in the euro area have been analysed in the context of the ECB's comprehensive monetary strategy review (ECB, 2021a). The ECB has not only intensified its analysis of the impact of climate change on inflation, financial stability and the related consequences for monetary policy. It has also started to evaluate and implement active approaches and best practices to support the green transition, for example by tilting its corporate bond holdings guided by climate considerations. When evaluating more active approaches, the ECB has to consider its mandate with the primary objective being to maintain price stability. In this regard, the instruments of monetary policy aim to efficiently achieve such primary objective but might not be efficient to support other goals. Therefore, the ECB has to carefully check which incentives it provides when it tries to support the green transition and how its actions interact with measures taken by governments. In an international perspective, the Federal Reserve Board in the United States, while also monitoring the potential impact of climate change on output and inflation, is reluctant at this stage to actively take into account climate considerations in its monetary policy operations (Powell, 2023). One reason might be concerns on whether central banks could efficiently and should try to support actively the green transition. Moreover, the general political agenda with regard to mitigate climate change deviates across countries (DiLeo et al., 2023).

In this paper, we discuss the role of climate considerations for central banks. We start by providing a selected overview of the rich literature on the potential impact of climate change on the economy (Section 2). Given the primary objective of the ECB, we focus on the potential impact on inflation, but also on other areas, such as financial stability or the natural rate of interest. Next, we review to what extent the institutional framework gives the ECB room to take climate considerations into account and discuss potential trade-offs (Section 3). Finally, we discuss policy instruments of the ECB to take climate considerations into account, including instruments the ECB has already implemented, instruments it plans to implement, and instruments it may consider in the future (Section 4).

2. MACROECONOMIC EFFECTS OF CLIMATE CHANGE

2.1 Overview and theoretical considerations

Climate change can affect macroeconomic outcomes via physical risks and transition risks. Physical risks stem from both gradual warming, which requires adjustment to challenges such as rising sea levels or changes in precipitation patterns, and an increase in the frequency of extreme weather events with potentially large effects on economic activity. Transition risks arise from policies to reduce CO_2 emissions in the transition towards a green economy. This includes carbon pricing, which can reinforce shifts in consumer preferences and technological change and result in higher energy prices, increased uncertainty, and stranded assets of firms, especially in carbon-intensive industries (ECB, 2021a,b).

Physical risks and transition risks affect inflation, output, and financial markets. Climate change can affect both the level of output and inflation and their volatility. Physical risks can have an impact on headline inflation through energy and food prices, expectations, or other supply and demand factors. Effects of transition risks on energy prices and inflation are difficult to assess since they also depend on future policies, which may be adopted to foster the energy transition. Moreover, climate change could impair financial stability if extreme weather events cause large damages, or the transition is not appropriately priced in capital markets. Finally, climate change could affect the natural rate of interest, which is a reference for central banks for a neutral monetary policy stance (ECB, 2021a,b).[67] All of these channels are relevant for central banks. For the ECB, the impact of climate change on inflation is particularly important given its primary objective to maintain price stability. This includes not only persistent but also transitory effects of climate change (e.g., due to stronger weather fluctuations or a higher frequency of extreme weather events) as an increase in volatility makes it more difficult to identify the main drivers of macroeconomic developments and to assess the appropriate monetary policy stance.

Extreme weather events and increasing temperatures tend to increase food prices. The main transmission channels are negative effects on supply via a reduction of production capacities and natural resources as well as disruptions in supply chains (Kotz et al., 2023; Faccia et al., 2021). Extreme weather events, such as droughts, can lead to a decline in food supply (Ciccarelli et al., 2023). Effects on demand are not clear. After hot summers, lower economic activity might result in lower food demand, especially in less developed countries. Such negative demand effects could even lead to a decline in food prices in the medium run (Faccia et al., 2021). However, the consensus in the literature is that extreme weather events and higher temperatures tend to increase food prices in the short run, and potentially in the medium term, and increase volatility (Kotz et al., 2023; Faccia et al., 2021; Mukherjee and Ouattara, 2021).

Physical risks can affect energy supply and demand, thus inflation. Physical risks can directly affect headline inflation via energy prices and indirectly as energy is an input factor for the production of other goods (Lucidi et al., 2022) or due to a disruption of supply chains (Ciccarelli et al., 2023). Temperature increases have two opposing effects on energy demand: Warmer winters reduce energy demand for heating while warmer summers raise demand for cooling. Overall, the evidence suggests that the negative effect of warmer winters is stronger, resulting in lower energy demand if global temperatures are increasing (Lucidi et al., 2022). Negative effects of temperature increases on energy

[67] The natural rate of interest reflects the equilibrium real interest rate that would prevail in an economy without nominal rigidities in wages and prices under full employment (Mongelli et al., 2021).

consumption have been documented in various studies for the United States and the euro area (Considine, 2000; Dowling, 2013; Spinoni et al., 2018). A negative effect on energy demand can also result from the negative impact of higher temperature and extreme events on economic activity. Similar to food prices, extreme weather events tend to increase energy price volatility and uncertainty (Wen et al., 2021).

Also, the transition towards a carbon free economy can affect energy prices. This implies the need to reduce the consumption of carbon-intensive energy, such as fossil fuels. Given that a full substitution of such energy forms with green energy is not possible in the short run, one important instrument to lower carbon emissions is to increase carbon prices, which could lead to persistent upward pressure on energy prices. The resulting impact on headline inflation also depends on the roll-out of the energy transition. Scenario-based projections of transition risks on inflation usually consider two different scenarios related to energy prices: An orderly transition to carbon neutrality characterised by immediate but gradual increases in energy prices, which are anticipated, and an unorderly transition, in which energy price increases are higher, occur later and are not anticipated. An unorderly transition leads to higher upward pressure on inflation (ECB, 2021a; Allen, 2020).

Climate risks may also affect inflation expectations. Persistent inflation rates above the 2% level increase the risk that long-run expectations are de-anchoring from the inflation target of the ECB. This risk is particularly high when prices of goods that are frequently purchased, such as energy and food, are increasing (Carvallo et al., 2017). A recent ECB survey among 90 large and mostly multinational companies shows that two thirds of respondents expect physical climate risks and the energy transition to have no net effect on their business activity (Kuik et al., 2022). However, half of them pointed towards risks stemming from climate change and more than 75% expect to increase their prices, mentioning higher prices of raw materials, energy inputs, and carbon prices as major reasons. However, given that inflation expectations have been fairly stable after the recent period of prolonged inflation, a de-anchoring would probably require substantial price increases, including significant second-round effects. Inflation expectations are also unlikely to increase solely as a result of higher inflation volatility. Overall, climate change can affect inflation expectations, but such effects reflect a propagation mechanism rather than an original source and they will be probably small if the credibility of central banks to maintain price stability is high.

Climate change can also affect headline inflation via changes in productivity and output. Physical risks can reduce total productivity due to lower labour productivity as a result of heatwaves or due to lower capital productivity as a result of capital and infrastructure destruction (ECB, 2021a,b). Lower productivity would lead to upward pressure on inflation. Empirical analyses find such effects, for example in international trade and in the tourism industry (Deryugina and Hsiang 2014; Ciccarelli et al., 2023). The effects of transition risks on productivity are unclear given that they depend on technological and structural changes (ECB, 2021a).

2.2 Quantitative impact of climate change on the economy and implications for monetary policy

Different approaches have been applied to assess the impact of transition risks and physical risks on the economy. The impact of weather fluctuations or extreme weather events, which could provide information about the physical risks, is usually analysed via empirical models based on historical data. In some cases, such estimates rely on climate projections to forecast future effects on inflation. The macroeconomic impact of climate change in the future, including transition risks, depends on several factors, such as the impact of climate change on weather, climate policy measures, or technological change, which are only partially covered by historical data. Therefore, the economic

impact of transition risks is usually gauged via climate models, which account for different scenarios and can also be adopted to analyse the impact of extreme events. A workhorse model in this regard is provided by the Network for Greening the Financial System (NGFS).[68] Table 1 in the Annex provides a selective overview of the literature on the effects of climate change on inflation.

Scenario-based analysis of transition and physical risks indicate that climate change can have persistent effects on inflation, but that such effects are unlikely to raise inflation above the 2% target in the medium term. The ability of the central bank to affect output and inflation in these scenarios depends on the natural rate of interest, which can restrict the monetary policy space due to the zero lower bound (ECB, 2021a). Results for transition risks suggest that in an orderly transition scenario (with an immediate expected rise of energy prices by around 3.5% per annum) effects on headline inflation are negligible, while in the case of an unorderly transition (with an unexpected and later increase in energy prices by 13.5% per annum) headline inflation increases by 0.5 percentage points (p.p.) after four years (ECB, 2021a). Further simulations analyse different frequencies of disasters as physical risks which are modelled via a combination of both demand and supply shocks. In a baseline scenario, in which the current distribution of such shocks is used and the natural rate of interest is 2%, consumer price inflation (CPI) averages at 2%. In a second scenario, in which more frequent major disasters occur, average CPI drops to 0.9% for a natural rate of interest of 2%. In case of more frequent disasters, inflation increases only in the short-run while negative effects on output reduce inflation in the medium term. (ECB, 2021a).

Several studies have identified a positive effect of both extreme weather events and higher temperature on food price inflation, but estimated medium-term effects for advanced economies on headline inflation tend to be small. The empirical evidence suggests that positive short-run effects on food price inflation are not propagated into headline inflation in advanced economies over the medium term (Faccia et al. 2021; Mukherjee and Ouattara, 2021). For both natural disasters (including droughts and storms) and temperature increases, a cross-country analysis finds substantial effects on food and headline inflation in emerging and developing countries and a rather limited effect in advanced economies (Parker, 2016; Faccia et al., 2021). Kotz et al. (2023) estimate the effects of global warming on inflation for 121 countries based on both historical estimates and climate projections. According to their findings, future warming will increase annual food and headline inflation by a range of 0.9-3.2 and 0.3-1.2 percentage points per year, respectively, depending on the scenario and the empirical specification. They find that the impact of a one degree Celsius increase in temperature on inflation in one month persists for one year. Moreover, climate effects on food prices increase the volatility of headline inflation. Peersman (2023) finds that shocks to food prices contribute up to 30% to euro area inflation volatility in the medium term. Empirical evidence of physical climate risks on energy prices is scarce. Lucidi et al. (2022) analyse the impact of temperature shocks on inflation for six euro area countries (Belgium, France, Germany, Italy, Greece, Spain) from 2000 to 2019. They find that warm spells lead to a moderate downward pressure on headline inflation, which can be attributed to a decline in energy prices.

Further evidence points to nonlinear effects of physical risks on inflation. Several studies find that temperature increases have larger inflationary impacts in hotter months and regions and that hot summers have particularly strong effects on inflation. (Kotz et al., 2023; Ciccarelli et al., 2023; Faccia et al., 2021; Mukherjee and Ouattara, 2021). Such nonlinearities increase uncertainty surrounding future inflation since the effects on inflation and its volatility are more difficult to predict.

[68] The NGFS is a group of central banks and supervisors with the aim to analyse and enhance the role of the financial system to manage risks and stimulate low-carbon investments for environmentally sustainable development.

Climate change can also affect economic growth and trade. Both temperature changes and extreme weather events reduce output as they impair production and lower productivity. The effects of transition risks on output depend on a variety of factors, such as policies implemented to mitigate climate change and resulting uncertainty. Table 2 in the Annex presents selected empirical evidence on the effects of physical risks on economic growth and international trade. The negative effect on economic growth has been confirmed for many countries and across various samples by several studies (Dell et. al., 2012; Felbermayr and Gröschel, 2014).

Climate change can result in higher volatility in financial markets and increased systematic risks. Both physical and transition risks could materialise in financial distress due to stranded assets or sudden adjustments in financial markets (ECB, 2021a; Carney, 2015; Lane, 2019). Firms with high carbon emissions are for example particularly exposed to future carbon prices and regulatory measures while countries in hot regions are more exposed to temperature increases. There is also the risk that the transition towards a green economy leads to boom and bust cycles of green assets. Whether climate risks of firms are correctly priced by financial markets is an open question. One reason why climate risks might not be correctly reflected in asset prices could be that carbon prices do not fully reflect the external effects of CO_2 emissions. There is some evidence that financial markets already take climate risks into account. Banks in the euro area already charge higher (lower) interest rates to companies with higher (lower) carbon emissions (Altavilla et al, 2023). Moreover, there is evidence that financial markets demand a risk premium for firms with high carbon emissions (Bolton and Kacperczyk, 2021). However, there is also evidence that stock prices of food companies do not completely reflect the risks of climate change (Hong et al. 2019). Financial distress can have large effects on output and inflation and is therefore relevant for central banks, also because it can hamper the monetary policy transmission. Central banks have instruments to mitigate financial distress, as has been shown during the global financial crisis or the sovereign debt crisis in the euro area. The ECB tries to assess financial risks by climate stress tests (ECB, 2021a,b; ECB, 2023c). The latest results show that a faster transition, despite higher energy and investments costs, significantly reduces financial risks in the medium term (ECB, 2023c). This aligns with previous scenario-based estimates by the ECB, which showed that an orderly transition would reduce the probability of asset and capital losses for financial institutions and investors (ECB, 2021a).

Climate change could also affect the natural interest rate. The natural rate of interest is a reference to assess whether monetary policy is tight or loose and is therefore relevant for central banks. A recent survey by Mongelli et al. (2021) suggests that the natural rate of interest is likely to decrease due to climate change. Several transmission mechanisms could lead to a decline in the natural rate, such as precautionary savings in response to uncertainty with regard to physical and transition risks, or negative effects on potential output growth. The impacts of other effects stemming from demographic trends and labour productivity are not clear. A negative impact on the natural rate could be dampened if the green transitions leads to a higher demand for investment. A lower natural rate would imply that monetary policy will hit the zero lower bound more frequently so that central banks will more often have to rely on non-standard policy tools, such as asset purchase. However, estimates of the natural rate of interest come with a high degree of uncertainty, which is likely to increase when the impact of climate change is considered.[69]

All in all, climate change can have a considerable impact on inflation. Most directly, climate change will have effects on food prices mainly via physical risks and on energy prices mainly via transition risks**.** Of course, climate change can also have effects on a variety of prices, for example, because it can also

[69] For a review on the estimation of natural rate of interest and its role for monetary policy, see Fiedler et al. (2018).

affect output, productivity, or trade and thereby in turn influence inflation, or because of second-round effects of energy price fluctuations. Against this backdrop, climate change will probably lead to more transitory increases in inflation, to a higher volatility in inflation and other macroeconomic variables, and higher uncertainty. Climate change could also lead to persistent upward pressure on inflation, for example, if energy prices are increasing strongly in the transition period towards a carbon-free economy. However, the available evidence suggests that persistent upward price pressure will likely be moderate in magnitude.

Climate change can be challenging for central banks, but does not necessarily compromise price stability. For central banks, it is important to distinguish between transitory and persistent effects of climate change. Transitory effects, e.g. due to weather fluctuations or extreme weather events, on inflation would be less of a concern of central banks because they will fade out anyway and monetary policy measures usually need some time to realise its full effect on inflation. However, in practice it is often difficult to differentiate between transitory and persistent drivers of inflation. Consequently, an increase in volatility and uncertainty will make it more difficult for central banks to identify the main drivers of inflation and, in turn, the appropriate stance of monetary policy. If climate change leads to more persistent upward pressure on inflation, central banks can maintain price stability in the medium term with existing instruments so that the impact of climate change will materialise in relative price changes. High credibility will help central banks anchor inflation expectations and stabilise inflation over the medium term at the desired level. Climate change can also lead to challenges for central banks in other areas. There is the risk that the zero lower bound will be hit more often amid a lower natural interest rate with implications for monetary policy. Moreover, climate change can increase financial market volatility and systemic risks making it more challenging for the ECB to assess financial stability. Finally, climate change could also influence monetary policy transmission although conclusive evidence concerning the effects of climate change on monetary policy transmission is still missing (ECB, 2021a).

3. INSTITUTIONAL FRAMEWORK AND TRADE-OFFS

The primary objective of the ECB is to maintain price stability. The Treaty on the Functioning of the European Union states that the primary objective of the European System of Central Banks is to maintain price stability in the euro area. Secondary objectives shall be only supported without prejudice to the primary objective. The ECB defines this mandate to keep inflation low, stable, and predictable and more concretely by keeping inflation at 2% over the medium term. The mandate of the ECB is in line with the Tinbergen rule that states that one policy instrument is needed to achieve one policy goal because otherwise trade-offs could emerge (Tinbergen, 1952).

Climate change can affect inflation, but measures to foster the green transition are hardly in the scope of the primary objective. To the extent that the consequences of climate change will impact inflation or the effectiveness of monetary policy to maintain price stability, measures that contribute to mitigate climate change could help the ECB to meet its primary objective of price stability in the future (ECB, 2021a). However, while monetary policy tries to maintain stability in the short to medium-run, climate change is a long-run phenomenon and measures to mitigate climate change likely unfold their effects largely beyond the medium term. If trade-offs between stabilising current prices and implementing measures to foster the green transition exist, it is mandatory for central banks to prioritise price stability. If the ECB would tolerate larger deviations from its inflation target this could undermine credibility with respect to its primary objective and in turn de-anchor inflation expectations. However, well-anchored inflation expectations are an important precondition for effective monetary policy and thereby will help the ECB to maintain price stability in the future (Beckmann et al., 2022), in particular if the impact of climate change on inflation will increase. Moreover, it is uncertain to what extent the ECB could contribute to mitigate climate change and how large the impact of climate change on inflation in the future will be. Reasons include that inflation is driven by a variety of factors, which are difficult to disentangle, and that the impact of climate change on inflation depends on different factors, such as technological change. In this regard, successfully mitigating climate change depends crucially on whether governments make efficiently use of their policy tools and how quickly international coordination can be improved.

The secondary objective of the ECB gives some room to consider climate change in monetary policy. According to the Treaty on the Functioning of the European Union, the secondary objective of the ECB is to support the general economic policies of the European Union. These general economic policy aims include balanced economic growth, full employment, and protecting and improving the environment (ECB et al., 2021b). The second objective of the ECB does not comprise a hierarchy between policies of the European Union. Therefore, the ECB has some discretion to prioritise between the policies it supports (ECB, 2021c). In doing so, however, the ECB has to meet several general provisions and principles, such as proportionality, institutional balance, the principles of an open market economy, and equal treatment (ECB, 2021a). This implies that the ECB supports institutions that are responsible to mitigate climate change but does not autonomously addresses climate change or other policy goals of the European Union and that its prioritisation of policies is not in conflict with the prioritisation of the European Union. These provisions, therefore, limit the extent to which the ECB can engage in the green transition or other policies.

Governments are responsible for reducing carbon emissions to address climate change, leaving only a limited role for monetary policy. Policies to mitigate climate change can have large distributional effects on private households, firms, or regions, for example by increasing the price for or by supporting technologies to reduce carbon emissions (Eurofound, 2021). For social acceptance, it is important that such policies are backed by the democratic legitimation of governments. The more

the ECB engages in such policies, for which it has no explicit mandate, the more its independence might be called into question. Given that mitigating climate change by a green transition is an important objective, governments have effective tools at hand to reach this goal, including carbon pricing and regulatory measures. Governments have to implement these tools in a way that ensures that the goals with regard to the green transition can be reached largely independently of monetary policy given that central banks follow their main objective of price stability. One reason is, that the contribution of monetary policy is hardly plannable. The ECB stabilises output and prices usually at business cycles frequency around a long-run trend (Woodford, 2003). This implies that the stance of monetary policy on average will be neutral, with expansionary and restrictive stances varying largely symmetrically over time according to the macroeconomic circumstances. This also implies that the ECB will unwind bond holdings after some time when it is warranted to maintain price stability. Against this backdrop, monetary policy can contribute to mitigate climate change within its mandate but will probably only have a limited role.

Monetary policy can make an important contribution to the green transition by efficiently achieving its primary objective. It is widely acknowledged that price stability contributes to sustained growth and to high employment (Bernanke, 2006). For example, price stability helps to allocate resources to the most productive use, as large fluctuation in prices could distort price signals. Price stability also makes future costs of firms better plannable and reduces uncertainty. Therefore, it helps to stimulate investment, including those to facilitate the green transition, which usually have a long investment horizon. By maintaining price stability, the ECB could also contribute to increase its credibility with regard to its primary objective and to anchor inflation expectations at its inflation target, thereby mitigating the impact of climate-related economic shocks on inflation. Moreover, credible monetary policy also supports well-functioning financial markets, which are an important condition for effective monetary policy transmission and, at the same time, will support the green transition.

When supporting the green transition, the ECB has to carefully check for unwanted side-effects. The market for green bonds (bonds that are used to finance green investments) is — while increasing — still relatively small. In 2022, the share of green bonds in total bond issuance in the European Union was below 10% (European Environment Agency, 2023). Therefore, large asset purchase programmes of the ECB tilted towards green bonds could have a disproportionally large impact on this market and potentially distortionary effects (ECB et al., 2021b). If the ECB conducts asset purchases to maintain price stability, at some point it has to unwind its assets holdings when the macroeconomic conditions have changed. As a result, volatility of green assets could increase. Higher volatility could in turn increase uncertainty, which is usually a drag on investment (Bloom, 2009). In "low for long" interest rate environments, the ECB can conduct asset purchase programmes as an additional tool to ease financing conditions. If inflation undershoots persistently the target of the ECB, such as in the euro area in the period between the sovereign debt crisis and the pandemic, there might be room to further increase asset purchases focused on green assets, as inflation is too low anyway and the optimal amount of asset holdings is uncertain.[70] However, expansionary monetary policy can have negative side-effects. For example, there is evidence that low interest rates can foster a misallocation of resources that in turn dampens productivity (Acharya et al., 2023; Cette et al., 2016; Monacelli et al., 2023). Moreover, prolonged expansionary monetary policy can result in financial imbalances and increase the risk of financial crises (Grimm et al., 2023). Such side effects would counteract objectives of economic policies of the European Union, such as sustained growth and high employment, that are a secondary objective

[70] Of course, there are several additional relevant aspects with regard to the appropriate size of asset purchase programmes. For a detailed discussion of quantitative easing programmes see e.g., Fiedler et al. (2016).

of the ECB similarly to the protection of the environment. In turn, such side effects could lower the fiscal space and thereby make it for governments potentially more difficult to foster the green transition.

4. MONETARY POLICY INSTRUMENTS TO ADDRESS CLIMATE CHANGE

The ECB has different measures available to take climate considerations into account. The ECB has already implemented several of these measures or has concrete plans to implement them (ECB, 2021d; ECB, 2022). Some of them are general reactions to the consequences of climate change and are not directly related to market operations. For example, the ECB is expanding its analytical toolkit to better understand the impact of climate change and of policies to mitigate climate change on inflation or financial stability. The ECB also tries to improve statistical data useful for such analyses and has started to tilt its non-monetary holdings (e.g., holdings in the pension fund), which are not subject to the policy mandate, towards lower carbon emissions (ECB, 2023a).

Some of the implemented measures aim to directly support the green transition. The main instrument of monetary policy — adjusting interest rates — leaves little room to take other considerations than price stability into account. However, other instruments of the ECB are somewhat more flexible with regard to secondary objectives. For example, the ECB has implemented asset purchase programmes, which have become an additional tool when interest rates hit the zero lower bound. Moreover, the ECB can adjust regulatory measures, such as eligibility criteria for collateral in their market operations. For example, the ECB will introduce compliance with disclosures for corporate assets under the Corporate Sustainability Reporting Directive (CSRD) as a requirement for eligibility as collateral in their market operations beginning in 2026. As a large part of assets that are generally eligible are not covered by the CSDR (e.g., asset-backed securities), the ECB wants to foster better climate-related disclosures for such assets. In doing so, the ECB will improve information available for markets to reduce and prevent a systematic mispricing of climate-related risks. The ECB has implemented or is preparing measures that have a more direct impact on financial markets. First, it has started to tilt its corporate bond holdings towards green assets. Second, it will adjust the collateral framework with the aim to limit the share of assets from issuers with a high carbon footprint beginning during the year 2024.

The ECB has started to deviate from the market neutrality principle in its corporate bond holdings to take the climate performance of issuers into account. When the ECB is implementing its monetary policy, it usually only aims to affect general market conditions but not relative prices of assets, which could have unintended consequences and may conflict with the mandate of the ECB (Cœuré, 2015). Therefore, the ECB used to purchase corporate bonds in proportion to their market capitalisation relative to all eligible bonds. With regard to the institutional requirements, this concept of market neutrality complies with the provision of the Treaty on the Functioning of the European Union to "act in accordance with the principle of an open market economy with free competition, favouring an efficient allocation of resources". From a general perspective, monetary policy interventions will never be completely neutral, for example because firms or industries are differently affected by changes in the interest rate or because only firms active in the capital market are directly affected by asset purchase programmes. However, these effects are accepted because price stability is seen as an overarching objective and because monetary policy is expected to be conducted largely symmetrically around a neutral stance so that its long-run impact might be small. With regard to carbon emissions it turns out that the corporate bond purchases of the ECB were biased towards firms with relatively high carbon emissions (Liebich et al., 2021). One important reason is that firms with high carbon emissions are usually relatively capital-intensive and therefore are issuing more bonds than other firms. In 2022, the ECB started to tilt its corporate bond holdings from the corporate sector purchase programme (CSPP) and the corporate bonds bought in the pandemic emergency purchase

programme (PEPP) towards issuers with a better climate performance. To do so, the ECB redirected its reinvestments within the purchase programmes based on a climate score.

It is not easy to be green.[71] When taking climate considerations into account in its market operations, the ECB has to consider several aspects. For example, simply underweighting bonds of high carbon emitters could distort incentives to lower carbon emissions for firms that have the highest emissions. Therefore, the ECB uses several indicators — in addition to past carbon emissions also plans to reduce emissions and the quality of disclosures with regard to emissions — to build a score that guides the weight within their bond holdings (ECB, 2023b). However, there is lack of market standards for green investments and forward-looking indicators with regard to the green transition of firms complying with climate goals. Also, there is no general consensus concerning the techniques and industries to be qualified as green, for instance in the case of nuclear power generation or natural gas plants. Therefore, it is difficult to assess the impact and the efficiency of the criteria applied by the ECB (ECB, 2021a). In this regard, it is also uncertain how the tilting of bond holdings of the ECB interacts with other measures to foster the green transition implemented by governments. By tilting its bond holdings towards issuers with a better climate performance, the ECB sets its priority on one specific secondary goal as it is difficult to assess whether its bond holdings are biased with regard to other secondary objectives, such as sustainable growth, full employment or, more recently, defence.

Financial market considerations may also play a role for the ECB. The ECB may also improve capital allocation on financial markets (Schnabel, 2021) and reduce risks in their bond holding related to climate change (ECB, 2023b). The efficient allocation of capital might be hampered to the extent that externalities of carbon emissions are not correctly priced on capital markets, for example if current carbon prices do not fully reflect externalities. If externalities are fully priced in, there is the risk that assets of firms with high carbon emissions suffer severely. However, it is difficult to assess to what extent risks related to carbon emission are appropriately priced on capital markets — respective evidence is mixed — and whether the ECB can contribute to a more appropriate pricing. Moreover, also green assets could be subject to boom-and-bust cycles, for example due to technological change, regulatory risks or herding, and thereby create risks for portfolios.

The impact of the ECB's measures on the green transition is difficult to assess, but probably small. Corporate bond holdings account only for a small share in the asset purchase programmes of the ECB. Since the beginning of 2022, the share of corporate bond holdings in total bond holdings of the Asset Purchase Programme (APP) is relatively stable at about 10% with a volume of about 300 billion euros. The share of corporate bond holdings in the Pandemic Emergency Purchase Programme (PEPP), which overall size is roughly half of that of the APP, is below 10%. The share of corporate bond holdings in the total volume of eligible bonds is about 20%. However, the impact on total corporate finance conditions is lower than this relatively large share suggests. First, not all corporate bonds are eligible for the asset purchase programmes, because several eligibility criteria apply. In particular, only bonds of non-financial corporations are eligible for these programmes, while a large share of bonds are issued by financial corporations. Second, corporations finance themselves also by means of equity capital and bank loans. In particular, bank loans are relatively important for the financing of corporations compared to bonds in euro area. In 2022, the liabilities of non-financial corporations in bank loans was about three time as large as liabilities in bonds. Empirical evidence suggests that the corporate bond purchases have improved financing conditions for non-financial corporations. However, yields of non-eligible bonds have declined due to portfolio rebalancing of investors (Mäkinen et al., 2020; Todorov, 2020; Zaghini, 2019). The adjustment of asset purchases based on climate scores

[71] Hauser (2021).

implies that the relative effect on financing conditions of corporations with a good climate score will be reduced to the extent that portfolio rebalancing effects will also lower yields for bonds of corporations with a bad climate score. The ECB implemented its tilting approach to its bond holdings in a period when it did not increase its bond holdings anymore, but only reinvested redemptions. Available data indicate that the reinvestments made in the fourth quarter — the ECB started titling its bond holdings towards issuers with a better climate score in October 2022 — were considerably less carbon-intensive than the reinvestments made before (Elderson and Schnabel, 2023). However, in its efforts to tighten monetary policy in accordance with its primary objective, the ECB stopped to reinvest redemptions within the APP in July 2023 and thereby slowed the tilting. As the ECB apparently has no plans to actively rebalance its portfolio towards bonds issuers with a better climate score, the strategy of the ECB to guide its corporate bond purchases by climate considerations, therefore, will only become fully visible in its bond holdings when the ECB at some point will loosen its monetary policy again and considers purchases of corporate bonds necessary to maintain price stability. Finally, it is not obvious whether a lack of finance is a major impediment for the green transition compared to earnings prospects, regulatory burdens, or pricing of external effects.

The collateral framework of the ECB is another instrument to address climate change considerations. Commercial banks pledge assets as a collateral for the refinancing operations of the ECB. Depending on the rating, a different discount/haircut is applied to these assets. From a historical perspective, the collateral framework is closely related to the lender of last resort function of a central bank. Today it is also known as the "Bagehot rule", which argues that in a financial panic a central bank should lend fast and forcefully against good collateral (Bagehot, 1873). The refinancing operations of the ECB fulfilled this crisis character during the Great Financial Crisis, the Euro Crisis and the early stages of the pandemic (Schnabl and Sonnenberg 2020). The collateral framework was changed several times during these crisis periods. For example, one of the first measures during the early stages of the pandemic was the easing of the risk tolerance of the Eurosystem and hence the reduction of haircuts applied to bonds of a lower rating and the inclusion of Greek sovereign bonds (ECB 2020). Another variant of refinancing operations are targeted longer term refinancing operations (TLTROs), which were instrumental in the pursuit of the ECB to easing the monetary stance at the zero lower bound (Sonnenberg 2023). These refinancing operations are targeted to increase the credit supply of commercial banks. During the early phase of the pandemic these operations were remunerated negatively, thus commercial banks could earn extra interest income, when they engaged in the issuance of new loans or at least held their credit supply constant. Also, for these operations commercial banks have to pledge a collateral.

In principle the universe of eligible collateral could be tilted towards "green" assets by the ECB in order to consider climate change risks. This tilting would, however, be facing several caveats. In response to the crisis the ECB enlarged the universe of eligible collateral in order to prevent a financial panic from developing. During the pandemic, the collateral framework was also eased to "fallen angles", i.e. bonds which were downgraded during the pandemic. It is doubtful how credible an exclusion of "non-green" assets would be in a crisis period, when a financial panic is looming. Therefore, the impact in the first place could be limited if the announcement is not credible. Another caveat is that a non-controversial rating for green and non-green assets is required, otherwise window dressing and green washing activities could undermine the approach.

Financing conditions of low-emission firms could benefit, from tilting the collateral framework towards green assets, but the overall effect on green investments will be small. Giovanardi et al. (2023) find that financing conditions of greener (lower emissions) companies would improve as banks would prefer lending towards these sectors in an adjusted collateral framework. The authors report

that a possible wedge between the yields of green and non-green sectors might emerge, while the yields on green bonds fall and the yields of conventional bonds rise. This per se could create incentives for more green investments. However, the authors report that the effects on green investments are low. Additionally, the change in the collateral framework has an impact on the leverage ratio of green companies, which increase their debt financing. The authors conclude that the effect on green investments would probably be small and that this policy is an inferior substitute for an explicit carbon taxation.

In the spirit of TLTROs, green targeted longer-term refinancing operations (GTLTROs) have been suggested as an additional policy tool. GTLROs are based on the idea to adopt the objective and modalities of standard TLTROs, while including incentives for banks to issue credits towards companies investing in green activities (ECB, 2021a).

It has been argued that common TLTROs support unsustainable lending practices via cheap refinancing options. The correction of such market failures and improving financial stability via a reduction of environmental and climate-related financial risk are arguments brought forward for green TLTROs (van 't Klooster and van Tilburg, 2020). There are two different ways of green longer-term refinancing operations, which have been proposed (van 't Klooster and van Tilburg, 2020). Either the interest rates banks pay would be adjusted according to the volume of green loans issued by the bank or the volume of GTLTRO credits depends on the percentage of new green loans issued by the bank. The potential implementation of GTLTROs raises several key questions and the resulting challenges make an implementation in the near future unlikely.

The concrete implementation of GTLTROs would further increase the reporting effort and require an uncontroversial classification of green and non-green projects. While the ECB is sympathetic to the idea of GTLRTOs, it has been pointed out that acquiring the adequate information, ensuring banks are able to collect relevant data and defining a verification process represent serious challenges which need to be overcome first (ECB, 2021a). The distinction between green and non-green companies raises several questions. The ongoing discussion regarding Environmental, Social, and Governance (ESG) ratings reflects these issues. Such ratings are designed to grade companies and countries based on the idea that ESG investments are of key relevance for meeting emission targets (Wang et al., 2023). As a result, such ratings have been considered as an important instrument for green finance policies (Zhang, 2023). However, ratings can differ significantly depending on the provider, possibly reflecting ambivalent or different methodologies. Different ESG ratings can display correlation below 50%(Billio et al., 2021). Divergent ESG ratings make it therefore difficult for banking supervision or lenders to achieve relevant information (Zhang, 2023). Given these shortcomings, the implementation of green targeted longer-term refinancing operations is not straightforward and the benefits with regard to financial stability or a green transition are not obvious. In June 2023, the European Commission has published, as part of its sustainable finance package, a legislative proposal to introduce rules for ESG ratings providers to improve transparency and reliability.

5. CONCLUSION

Climate change can have considerable macroeconomic effects that are relevant for central banks. Physical risks include implications of gradually rising temperatures and a higher incidence of extreme weather events. Transition risks arise from initiatives of governments to decarbonise the economy such as carbon pricing or regulatory measures. Both can directly impact inflation, in particular by leading to upward pressure on food or energy prices and higher volatility. They can also affect output, productivity, or trade and thereby indirectly affect inflation. Climate change tends to increase macroeconomic volatility and can lead to financial market instabilities, for example because some firms are particularly exposed to the impact of climate change. Some of the effects of climate change will have only a temporary impact on inflation and are, thus, less of a concern of central banks. However, they lead to a higher inflation volatility and increase overall uncertainty, making it more difficult to identify the main drivers of inflation and the appropriate stance of monetary policy. Increasing carbon prices could lead to more persistent upward pressure on inflation. However, central banks have effective tools to stabilise inflation so that these effects should mainly result in relative price adjustments. Overall, climate change could make it more challenging for central banks to achieve their primary objective, but they have the instruments to maintain price stability amid climate change.

Governments are responsible for addressing climate change, leaving only a limited role for the ECB. Policies to mitigate climate change can have large distributional effects. Therefore, it is important that such policies are backed by the democratic legitimation of governments. Governments have effective instruments to achieve this goal, including carbon pricing and regulatory measures. Governments have to implement these tools in a way that ensures that a green transition can be achieved independently of monetary policy support. The mandate of the ECB leaves some room to take climate considerations into account as part of its secondary objective, which is to support the general economic policies of the European Union, includes protecting and improving the environment. However, secondary objectives shall be supported without prejudice to the primary objective of price stability. Against this backdrop, the ECB will only have a supportive role in mitigating climate change.

The ECB has taken several measures to account for climate considerations. Some of these measures are general reactions to the potential consequences of climate change, such as improving the analytical toolkit with regard to the macroeconomic impact of climate change or conducting climate stress tests to assess the impact of climate change on financial markets. Yet, the ECB has also adjusted its monetary policy operations to support the green transition, in particular the tilting of its corporate bond holdings towards issuers with a better climate score. Moreover, the ECB plans to adjust eligibility criteria for its market operations with regard to better climate-related disclosures and climate scores of issuers. Achieving price stability is the most important contribution of monetary policy to the green transition. Price stability contributes to sustained growth and high employment and stimulates investment. Moreover, it helps to firmly anchor inflation expectations which will support achieving price stability in the future when the impact of climate change on inflation may increase. The impact of other measures of the ECB on mitigating climate change is probably small. The extent to which the ECB will be supportive will vary over time, given that the ECB aligns policies, including the volume of bond holdings, to its primary objective.

There could be unwarranted side effects the ECB has to consider when supporting the green transition. The ECB has instruments that allow to efficiently achieve price stability, however, they might be not efficient in supporting other objectives. Moreover, there is a lack of market standards for green investments and forward-looking indicators with regard to the green transition. Therefore, it is difficult to assess the impact of the measures of the ECB with regard to supporting the green transition

and how they interact with other measures implemented by governments. The more the ECB would try to support the green transition the stronger potential conflicts with its mandate and the higher the risks for a loss of its credibility with regard to its primary objective and a de-anchoring of inflation expectations. There is even the risk that in a tightening phase monetary policy could to some extent discriminate against green investment if in order to achieve its primary target it should find it necessary to unwind bond holdings, which have been accumulated with a disproportionate share of green assets. Against this backdrop, the ECB has also to carefully evaluate potential additional measures to support the green transition, such as green targeted longer-term refinancing operations.

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ANNEX

Table 1: Overview of literature on inflation and climate

Study	Sample period	Country	Variable explained	Measure of climate risk	Estimated effect
Allen et al. (2023)		France	GDP, consumer price inflation	Transition shocks (e.g., disorderly carbon taxation)	Transition might induce inflation deviations ranging between -0.8 and +2 p.p. , depending on the scenario
Ciccarelli et al. (2023)	01/1991-12/2019	Germany, France, Italy and Spain	Consumer price inflation and several components	Temperature anomalies	Heterogenous effects of temperature mean and variability shocks; in summer, increases mean temperatures increase inflation
Heinen et al. (2019)	2001-2012	15 Caribbean countries	Consumer price inflation	Natural disasters (hurricanes and floods)	Hurricanes and floods lead to inflation, especially in the case of food prices;
ECB (2021a)		Euro area	Headline and core inflation	Transition scenarios: orderly and unorderly transition to carbon-neutral economy	Orderly transition: negligible effects on inflation; unorderly transition: 0.5 p.p. increase of headline inflation above the baseline after four years
Faccia et al. (2021)	1990-2018	48 countries	Consumer, food and producer price inflation	Temperature anomalies	Hot summers increase food prices by 0.38% in the short run; the effect is stronger for emerging economies; in the medium term, negative effects on inflation occur
Kotz et al. (2023)	1991-2020	121 countries	Consumer and food price inflation	Temperature (global warming)	Future warming could increase annual headline inflation by 0.32-1.18 p.p. per year until 2035; even stronger effects on food inflation
Lucidi et al. (2022)	01/2000-12/2019	Belgium, France, Germany, Italy, Greece and Spain	Consumer and energy price inflation	Temperature anomalies (warm and cold spells)	Warm spells incur (small) downward pressure on headline and energy prices; cold spells show mixed results; annual headline inflation was 0.05% in 2015-2021 due to temperature anomalies
Mukherjee and Ouattara (2021)	1961-2014	107 countries	Consumer price inflation	Temperature anomalies	Temperature shocks induce inflationary pressures, potentially persisting several years; 1% increase in temperature induces inflation increase of 2.6%
Parker (2016)	1980-2021	212 countries	Consumer, food, housing and energy price inflation	Natural disasters (droughts, storms, earthquakes)	Heterogenous effects: results differ between rich and poor countries and between types of disasters; disasters can have large and persisting effects on inflation in emerging and developing countries

Table 2: Overview of literature on economic activity and climate change

Study	Sample period	Country	Variable explained	Measure of climate risk	Estimated effect
Dell et al. (2012)	1950-2003	125 countries	Aggregate output, GDP components, Political instability	Temperature and precipitation	Increase by 1 degree Celsius reduces economic growth on average by 1.3 p.p. in a poor country
Deschênes and Greenstone (2007)	1978 - 2002	USA	Agricultural profits	Temperature and precipitation	Overall, climate change leads to 4% increase in annual agricultural profits
Felbermayr and Gröschel (2014)	1979-2010	108 countries	Growth rate of real GDP per capita	Natural disasters	Natural disasters negatively affect real GDP per capita; low- and middle-income countries experience stronger effects; weakest 95% of disaster years cause a GDP loss of up to 0.46%
Felbermayr et al. (2022)	1992-2013	24,000 grid cells, covering area of 197 countries	Night-light emission as a proxy for economic activity	Local weather anomalies (storms, precipitation, droughts, cold spells)	Weather anomalies tend to reduce night-light growth, on average between 0.1 and 0.3 p.p.
Jones and Olken (2010)		USA and "World"	Exports	Temperature	Increase by 1 degree Celsius reduces a poor country's export growth rate by 2.0- to 5.7 p.p.

Climate change and monetary policy are becoming increasingly intertwined. The relationship between climate risk and inflation is non-trivial, presenting the ECB with a number of trade-offs in its monetary policy operations. Lately, the ECB has stepped up its efforts to embed climate change considerations at the heart of its monetary policy framework, yet recent inflationary pressures threaten to water down the effectiveness of its actions, including the tilting of its bond portfolio towards green issuers.

Four papers were prepared by the ECON Committee's Monetary Expert Panel on the integration of climate change considerations in the conduct of monetary policy by the ECB.

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