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GREENING MONETARY POLICY

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Central banks have already started to look at climate-related risks in the context of financial stability. Should they also take the carbon intensity of assets into account in the context of monetary policy? The guiding principle in the implementation of monetary policy has been 'market neutrality', whereby the central bank buys a proportion of the market portfolio of available corporate and bank bonds (in addition to government bonds). But this implies a carbon bias, because capital-intensive companies tend to be more carbon intensive.

We first review the legal mandate of the Eurosystem. While the primary objective is price stability, the Treaty on European Union allows the greening of monetary policy as a secondary objective. We propose a tilting approach to steer or tilt the allocation of the Eurosystem's assets and collateral towards low-carbon sectors, which would reduce the cost of capital for these sectors relative to high-carbon sectors. This allocation policy must be designed so it does not affect the effective implementation of monetary policy.

The working of the tilting approach is calibrated with data on European corporate and bank bonds. We find that a modest tilting approach could reduce carbon emissions in the corporate and bank bond portfolio by 44 per cent and lower the cost of capital of low carbon companies by 4 basis points. Our findings also suggest that such a low carbon allocation can be done without undue interference with the transmission mechanism of monetary policy. Price stability, the primary objective, is, and should remain, the priority of the Eurosystem.

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1. Introduction

Central banks traditionally take a long-term view of economic and financial developments and play an important role in the economy through monetary policy and in the financial system by providing financial stability. In the second role, central banks have started to examine the impact of climate-related risks on the stability of the financial system (Carney, 2015). Consistent climate-related financial disclosures for financial reporting by companies and financial institutions have been developed by the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD, 2017). The Task Force also recommended that companies report on financial outcomes in a scenario of two degrees of global warming above pre-industrial levels. In that way the financial sector can assess the risks and opportunities for its investment and lending portfolio of the transition to a low-carbon economy. Central banks and supervisors have also established the Network for Greening the Financial System (NGFS)[1].

However, in the first role of monetary policy, central banks have a long-standing policy of market neutrality. However, there is evidence that the market has a bias towards carbon-intensive companies and monetary policy is thus not climate neutral (Matikainen *et al*, 2017). Doing nothing is a decision that undermines the general policy of the EU to achieve a low-carbon economy. What, therefore, should central banks do about their market-neutrality in this context? Is it time to change the stance? The appropriate stance of central banks in monetary policy operations is part of the wider debate on the role of appointed central bankers versus elected policymakers (Tucker, 2018).

Section 2 argues that central banks have a legal mandate for greening monetary policy. The primary responsibility of central banks is to maintain price stability, with a secondary responsibility to support economic growth. Interestingly, the European Union applies a broad definition of economic growth. Article 3(3) of Treaty on European Union states that *"The Union shall establish an internal market. It shall work for the sustainable development of Europe based on balanced economic growth and price stability … and a high level of protection and improvement of the quality of the environment."* This broad definition of sustainable economic growth could provide a legal basis for greening monetary policy.

Section 3 presents an approach central banks could take to green monetary policy operations, if they were to decide to do so. In this working paper, we use a broad definition of central bank core operations: i) conducting monetary policy operations; ii) managing foreign exchange reserves; and iii) operating (large value) payment systems[2]. These core operations, for which we use the shorthand of monetary policy operations, involve allocation decisions when purchasing assets and taking collateral (through the so-called 'eligibility criteria'). The basic idea of greening monetary policy is to steer or tilt the allocation of assets and collateral towards low-carbon sectors, which could lower the cost of capital for those sectors in comparison to high-carbon sectors. This allocation policy must be designed and executed so that it does not interfere with the effective implementation of monetary policy (ie the transmission mechanism of monetary policy should not be unduly affected). Price stability is and should remain the top priority for central banks.

Section 4 investigates which parts of the Eurosystem's asset and collateral base would be affected by our proposed greening of monetary policy. It also provides some numerical examples based on European corporate and bank bonds. We find that a modest tilting approach can reduce carbon emissions in the corporate and bank bond portfolio by 44 percent. We also estimate the impact on the

[1] See, for example, https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system and https://www.dnb.nl/en/news/news-and-archive/Nieuws2018/dnb374348.jsp.
[2] See Treaty on the Functioning of the European Union (TFEU), Article 127(2).

cost of capital, as the higher allocation to low-carbon companies would improve their liquidity. Our results suggest a spread difference between low and high-carbon companies of 4 basis points. Section 5 concludes with some policy reflections.

2. Central bank mandate

2.1 Legal mandate

Across the world, the core task of central banks is to maintain price stability. In addition, central banks are often asked to support economic growth. The precise division and wording of these functions is different in different countries. In the United States, the Federal Reserve has a dual mandate to stabilise prices and maximise employment. In the European Union, the Treaty on the Functioning of the European Union (Article 127(1)) 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 underlying trends in economic policy (Smits, 1997).

TEU Article 3(3), meanwhile, specifies that the EU internal market 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. 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 (see for example, Stiglitz, 2009, and High Level Expert Group on Sustainable Finance, 2018).

The European Central Bank's official line is that maintaining price stability is: *"the best contribution that monetary policy can make to an environment of economic stability conducive to the wider objectives of the European Community, such as economic growth and employment creation"* (ECB, 2001, p.7). Bini Smaghi (2007), a former member of the ECB's executive board, underlined the priority of price stability and referred to possible trade-offs between price and output stability. In these cases, Article 127(2) TFEU indeed prioritises price stability. But it is not clear whether there are such trade-offs between price stability and environmental policies.

Statements by ECB board members suggest they see leeway for greening monetary policy. ECB president Mario Draghi has acknowledged that the Eurosystem[3] should support the general policies of the EU, including *"the sustainable development of Europe based on balanced economic growth* […], *aiming at* […] *a high level of protection and improvement of the quality of the environment"* (Draghi, 2017). He added that while the ECB recognised it was of *"great importance to our societies"* for the EU to achieve its environmental goals, including in relation to the Paris Agreement on climate change, *"it falls to the political authorities to define and decide on the appropriate measures to achieve the objectives of the Paris Agreement."*

[3] The Lisbon Treaty changed the wording from the ESCB to the Eurosystem, which consists of the ECB and the central banks of the countries whose currency is the euro. See Article 282(1) TFEU of 2012.

Benoit Cœuré, a member of the ECB's Executive Board, has argued "the best the ECB can do is to concentrate its efforts on creating the right conditions for supporting the flow of capital into sustainable sectors." By doing this, the ECB would support the EU's environmental goals while staying true to its price stability goal (Cœuré, 2018). While he acknowledged the impact of climate change on the ECB's conduct of monetary policy, he stopped short of incorporating environmental criteria in its monetary policy implementation framework (Cœuré, 2018).

Summing up, the primary responsibility of the Eurosystem is maintaining price stability. The secondary responsibility is supporting general economic policies. The economic policies of the EU refer to sustainable development based on balanced economic growth, aimed at full employment, social progress and protecting and improving the quality of the environment. The legal mandate derived from the EU Treaties seems to allow the Eurosystem to green its monetary policy operations. It can even be argued that the Eurosystem is required to support the transition to a low-carbon economy, without prejudice to price stability.

2.2 Central bank reach

While a broad interpretation of the legal mandate is possible, the question is whether central banks should have such a wide remit. Tucker (2018) raises the valid point of delegation of economic policy powers from elected policymakers to unelected, albeit democratically-appointed, technocrat central bankers. He argues that a central bank can be seen as a co-manager of the government's consolidated balance sheet, as the profits and losses from central bank operations (seigniorage) largely fall to the government[4]. Allocation decisions on assets and collateral thus have a bearing on the riskiness of the government's consolidated balance sheet and on the seigniorage income for the government. At the same time, central banks are independent in the setting and implementation of monetary policy, which forbids them from taking government instructions on their monetary policy operations. So, how far should central banks go in their operations?

A minimalist approach is to restrict monetary policy operations to open-market operations with short-term Treasury paper (Goodfriend, 2011). In that way, the central bank remains fully neutral towards the private sector. By contrast, in a maximalist approach, the central bank would be given free rein to manage the consolidated balance sheet, which would involve risks related to different group of companies and households. Tucker (2018) argues that the maximalist approach would *"take central banks close to being the fiscal authority and cannot be squared with any mainstream ideas of central banking competences in democracies"*.

A hybrid system

The Eurosystem's current policy of market neutrality (Wuermeling, 2018; Bindseil *et al*, 2017) is theoretically consistent with the minimalist conception of monetary policy operations. In practice, however, it seems to be a hybrid system, since the Eurosystem already accepted private sector paper (corporate bonds, bank bonds and bank loans) for asset purchases and collateral prior to the global financial crisis. This credit policy practice has been intensified under quantitative easing. The Eurosystem's asset purchase programme (APP) includes all programmes under which private sector securities and public sector securities are purchased in order to address the risks of too-prolonged a period of low inflation. The APP shows that the Eurosystem is not following the minimalist approach, but

[4] In most countries, the government holds the shares in the national central bank. The central bank is typically allowed to add a small fraction of profits (say 1 to 5 percent) to its reserves with the remainder paid-out as dividends to the [ultimate] shareholders (the government) – to reflect the Eurosystem situation where the national central banks own the ECB, not the governments directly.

already conducts credit operations with the private (and public) sector to foster economic growth[5] (although the stated aim is to address the risk of prolonged low inflation).

The issue at hand is whether or not the Eurosystem should remain market neutral with respect to the carbon intensity of its assets and collateral. A first question is whether the current approach towards private companies is carbon neutral. As carbon-intensive companies, such as fossil fuel companies, utilities, car manufacturers and airlines, are typically capital intensive (Doda, 2016), market indices for equities and corporate bonds are overweight in high-carbon assets. A market neutral approach thus leads to the Eurosystem's private sector asset and collateral base being relatively carbon-intensive (Matikainen *et al*, 2017). Investment in high-carbon companies reinforces the long-term lock-in of carbon in production processes and infrastructure. Doing nothing is therefore a decision that undermines the general policy of the EU to achieve a low-carbon economy.

While the carbon intensity of non-financial companies issuing corporate bonds can be assessed directly, it is more difficult for synthetic or financial institution securities. The look-through approach can be applied, whereby the underlying beneficiary instead of the intermediary is assessed. In the case of asset-backed securities, the carbon intensity of the assets in the vehicle (eg real estate underlying mortgage-backed securities) can be measured. In the case of bank loans, the carbon intensity of the borrower can be assessed. In the more general case of bank bonds, the carbon intensity of a bank's total loan portfolio should be evaluated. Using empirical euro–area data, Battiston *et al* (2017) show that while direct equity exposures to the fossil fuel sector are small (3-12 percent of banks' market capitalisation), the combined equity exposures to climate-policy relevant sectors are large (40-54 percent) and variable.

A second question is whether the price formation of carbon risk works smoothly. Andersson *et al* (2016) argued that there is little awareness of carbon risk among investors and the market thus does not price it. Hong *et al* (2019) investigated whether stock markets efficiently price risks brought on, or exacerbated, by climate change. Their findings support regulatory concerns that markets that are inexperienced with climate change underreact to such risks[6].

The first-best solution to these concerns would be to tax the climate change externality caused by carbon emissions. An appropriate carbon tax would provide an 'official' price for carbon risk and would spur the move from high to low-carbon investments. However in our second-best world which lacks a sufficiently high carbon tax, the question is what private companies, investors and semi-public government agencies can contribute to reducing carbon emissions.

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, the adoption of the monetary policy stance most appropriate for the euro area as a whole, taking into account the fiscal policy stance for 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 tighter the low-carbon allocation in monetary policy (and the higher the tax, the looser the low-carbon allocation).

A final question is whether the Eurosystem should actively support the EU's general policies of transitioning to a low-carbon economy. Following Smits (1997) and Tucker (2018), we argue that the

[5] ECB economists Ampudia *et al* (2018) analysed the effects of unconventional monetary policy. An important finding is that the Asset Purchase Programme has contributed to a reduction in unemployment.

[6] For greening monetary policy implementation, Cœuré (2018) suggested that the ECB should support international and European efforts towards sustainable investments but not change its own collateral framework in the face of climate risks. The ECB thus relies on markets and credit risk agencies to price climate risks properly.

Eurosystem should refrain from favouring assets of particular sustainable projects, agencies or companies, which would clearly imply it was assuming the role of elected policymakers. But should the Eurosystem adopt a general approach towards low-carbon assets in support of the EU's general policies on reducing carbon emissions?

As long as the Eurosystem followed a general approach, it would not assume an active policy role. It would only support (instead of hinder) the EU's policy decision to move to a low-carbon economy. In that way, the risk that appointed technocrats take policy decisions with distributional consequences (as highlighted by Tucker, 2018) would be minimised. Nevertheless, even a general approach towards low-carbon assets would have distributional consequences for the economy, because assets from low-carbon sectors would become 'more' eligible than those from high-carbon sectors. But these are exactly the kind of distributional consequences that are intended by the EU's policies on reducing carbon emissions.

Another possible obstacle is that once a central bank starts to support general government policies on the environment through its monetary policy operations, it might be subject to further requests to support other government goals (Cœuré, 2018). That is why it is important that the Eurosystem remains fully independent in the choice and design of its allocation policies (ie setting of eligibility criteria). Any secondary responsibilities should not interfere with price stability, which is the top priority on the monetary policy side. It should be noted that the ECB has already designed and adopted environmental standards for some of its activities. It has also recently become became a member of the Central Banks and Supervisors Network for Greening the Financial System.

There is a need for political space for the ECB to avoid central bankers making policy decisions countering official policies. As climate policy is a real concern and a top priority of European policy on a consistent basis, the ECB can contribute to this secondary objective in its asset and collateral framework for monetary policy operations. The European Commission and Council have repeatedly stated their aim to combat climate change by reducing carbon emissions[7]. This climate framework can be considered as the EU's general economic policies to protect the environment (in the context of TEU Article 3(3)). European Parliament members have repeatedly asked questions to the ECB president about the ECB's (lack of) carbon policies (see, for example, Draghi, 2018)[8].

3. Greening monetary policy operations

3.1 No interference with price stability

If central banks were to decide to green their monetary policy operations, how could they go about it? The Treaty is very clear. The Eurosystem shall support the general economic policies of the EU, without prejudice to price stability (see Article 127(1) TFEU). Maintaining price stability is thus the priority, and

[7] The EU's first package of climate and energy measures of 2008 set three key objectives for 2020 (relative to 1990 levels): a 20 percent reduction in carbon emissions; renewable energy to meet 20 percent of the EU's energy needs; and a 20 percent improvement in energy efficiency (the 20-20-20 targets). In 2014, the European Council reiterated and further tightened these targets in the 2030 climate and energy framework, committing to reduce carbon emissions by 40 percent, to increase the share of renewable energy to 27 percent, and to improve energy efficiency by 27 percent by 2030. In its latest update, the European Commission has increased these targets to carbon emissions reductions of 45 percent, a renewable energy share of 32 percent, and an energy efficiency target of 32.5 percent by 2030. See European Commission (2018), Commission welcomes European Parliament adoption of key files of the Clean Energy for All Europeans package', Press Release IP/18/6383, 13 November. http://europa.eu/rapid/press-release_IP-18-6383_en.htm.

[8] It could be argued that the ECB's carbon policy in the asset and collateral framework for its monetary policy operations should be discussed (and perhaps also approved) by the European Parliament.

should not be overridden by the possible greening of monetary policy operations. So, a monetary policy decision and its implementation should not be affected by low-carbon considerations in relation to assets and collateral. The ECB should make an independent assessment of whether the 'without prejudice' clause can be fulfilled, because the ECB is not allowed to take instructions from EU institutions in the exercise of its monetary policy mandate (Article 130 TFEU).

Monetary policy can be seen as a two-stage process. In the first stage, the relevant policy decision is taken. Taking a broad definition of central bank operations, policy decisions refer to monetary policy (for example, the interest rate), to reserve management (for example, the asset and currency composition of official reserves) and to large-value payment systems (for example, safe collateral for real-time gross settlement). In the second stage, policy decisions are implemented through market transactions following operational procedures. A common element of these procedures is that central banks aim to remain market neutral wherever possible in order not to impair the functioning of the markets and price formation (Wuermeling, 2018; Cœuré, 2018; Bindseil *et al*, 2017). Central banks have therefore a preference for a broad and liquid asset base in their transactions to avoid market distortions and ensure smooth conduct of monetary policy.

Eligibility criteria

As part of their operational procedures, central banks determine the eligibility criteria for assets and collateral. These criteria are important for the market because eligible securities become more liquid because of their possible use by banks in their operations with their central bank (see Nyborg, 2015, for an overview). The increased liquidity service translates into a higher security price and lower yield (Nagel, 2016). The cost of capital thus decreases for the issuer of the security. The same mechanism is at work for haircuts on collateral. A lower haircut increases the liquidity of the security and reduces the cost of capital for its issuer (Ashcraft *et al*, 2011).

The greening of monetary policy operations would involve steering the eligibility criteria towards low-carbon assets. The intended effect is that the cost of capital for low-carbon sectors/institutions would reduce relative to high-carbon sectors/institutions. Figure 1 shows major differences in terms of the carbon intensity of sectors. Section 3.2 discusses several pathways to incorporate environmental, social and governance (ESG) ratings into the eligibility criteria. How could this be done without affecting price stability? The current market-neutral approach contributes in general to a smooth transmission of monetary policy.

The effect on prices of a low-carbon bias could go either way (Cœuré, 2018). Climate-related shocks might lead to supply-side shocks, which are less easy to accommodate for central banks. A low-carbon bias would help to reduce the risk of climate-related shocks. By contrast, a low-carbon bias could lead to temporary or persistent price differences between high and low-carbon products, which can also complicate monetary policy. Central banks have experience of dealing with such price differentials.

In terms of central banks' ability to conduct monetary policy, we suggest three conditions to avoid disruption to the monetary transmission mechanism. The first is to not make major adjustments in the asset mix (ie the mix of government bonds, agency bonds, bank bonds, corporate bonds and bank loans), currency denomination and maturity, which are chosen to smooth the conduct of monetary policy and the management of reserves. Term spreads, and thereby the shape of the yield curve, would, for example, be affected, when maturities are varied (Aksoy and Basso, 2014).

The second is to keep the list of eligible assets within each asset class as broad as possible. A broad asset and collateral base contributes to minimising the impact on the functioning of markets and price formation (Bindseil *et al*, 2017). It is thus very important not to 'target' particular assets or even asset

prices of low-carbon sectors. That would impair the price stability objective of monetary policy and might erode support for central bank independence (Mishkin, 2001).

The third is to implement a possible low-carbon bias in steps, so central banks can learn about the possible impact of adjusted criteria on monetary policy transmission. A gradual implementation would allow for the carbon criteria to be optimised (see section 3.2) and the impact on the monetary transmission mechanism to be analysed. As maturities would remain more or less the same, the possible transmission consequences would be cross-sectional. Low-carbon companies would face a lower cost of capital, while high-carbon companies would face a higher cost of capital. The resulting transition dynamics in the economy might have an impact on the transmission channel. Central banks should analyse these dynamics and assess how monetary policy transmission would change.

3.2 Greening operations

The EU's general economic policies aim at achieving a transition to a low-carbon economy with a 40 percent carbon emissions cuts by 2030 (as explained in section 2.2). We take this general objective of EU climate policies as a guide for the possible greening of monetary policy operations.

Indicator

We use carbon emissions as shorthand for all greenhouse gas emissions, which include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Carbon emissions are the most widely used metric on the environmental side. Several companies now report their scope 1, scope 2 and scope 3 emissions. The Greenhouse Gas Protocol (WRI, 2015) distinguishes between direct emissions from sources that are owned or controlled by the reporting entity and indirect emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity. The GHG Protocol further categorises these direct and indirect greenhouse gas (GHG) emissions into three scopes:

- **Scope 1**: All direct GHG emissions of an organisation.
- **Scope 2**: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- **Scope 3**: Other indirect emissions: the full corporate value chain emissions from the products they buy, manufacture and sell (eg if a car manufacturer sells cars, this represents the emissions of the cars in use).

Not only do the emissions of a company across its value chain matter, the emissions of products and services that it produces for its customers are also relevant. Another relevant issue is whether companies are in transition to applying low-carbon technologies and creating low-carbon products and services, or are preparing for that transition (Schoenmaker and Schramade, 2019). So, it is important not only to assess current carbon emissions but also expected future carbon emissions (TCFD, 2017). In this forward-looking perspective, switching of investments from current high-carbon sectors into low-carbon technologies and products can be accommodated.

The carbon intensity of companies can be measured as follows:

$$CI_{i,t} = \frac{Emissions_{i,t+k}}{Sales_{i,t+k}} \quad (1)$$

where CI_i represents the carbon intensity of company i at time t in years. The carbon intensity is calculated as a company's scope 1 to 3 emissions divided by its sales at time $t + k$. Emissions are

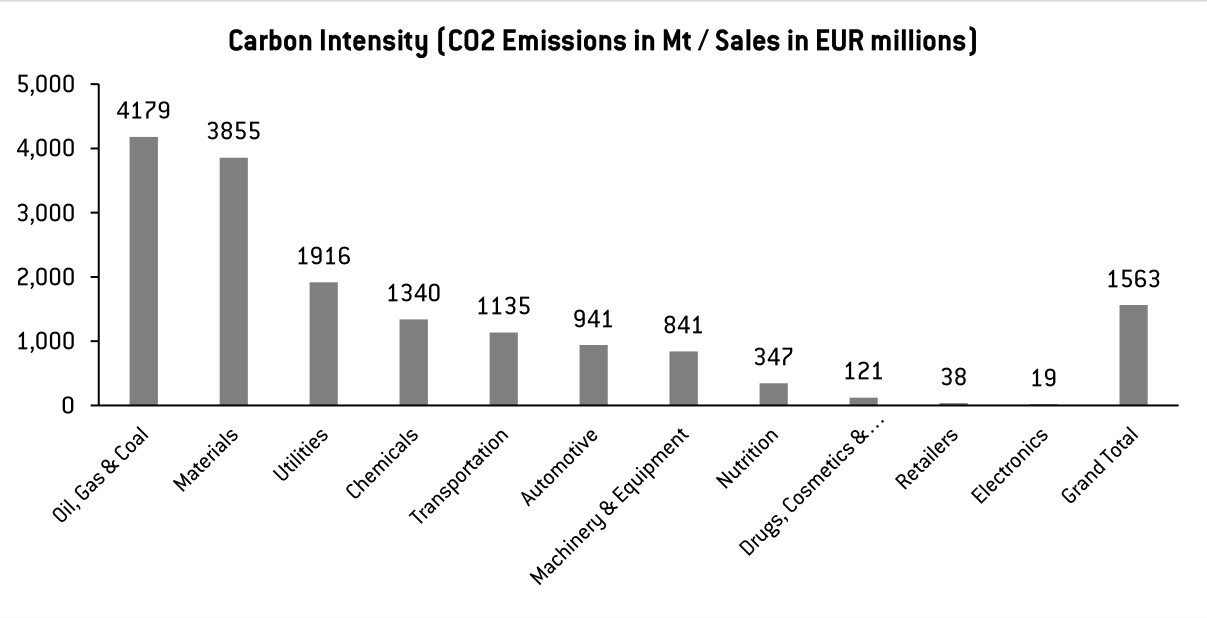
measured with some delay, so k would typically be -1. We propose to start with historical carbon emissions ($k = -1$). When companies have more experience of reporting expected future carbon emissions following the TFCD principles and auditors are able to provide assurance on these reported emissions, the indicator could be based on a mix of current and future emissions.

Banks lend not only to companies, but also to households mostly in the form of mortgages. The carbon intensity of a mortgage can be measured by the energy label of the house, which ranges from A (most efficient) to G (least efficient). In the EU, all properties when sold have to obtain an energy performance certificate that places the property on an A-G scale[9].

Data

Data on companies' carbon emissions is, for example, available at ASSET4 ESG Scores in Datastream (Thomson Reuters) and the Carbon Disclosure Project (CDP). When external emissions data or energy efficiency labels are not available, banks must provide an internal rating when supplying assets or collateral to the central bank. This is in line with the general ECB asset and collateral framework, under which banks are allowed to provide an internal credit rating for assets for which no external credit ratings exist.

Figure 1: Average carbon intensity by industry



Source: Bruegel based on ASSET4 ESG Scores in Datastream (Thomson Reuters) and company reports. Note: The graph depicts the average carbon intensity of sectors, measured as average of emissions in metric ton CO_2 divided by sales in millions euro. Scope 1, 2 and 3 emissions are included for the 60 largest corporates in the euro area. The Annex provides a detailed breakdown.

We take emissions and sales data from ASSET4 Datastream for the largest 60 companies. As we are interested in corporate bonds, we selected the largest companies by long-term debt. The Annex provides a list of companies and their carbon intensity. Figure 1 summarises the average carbon intensity for each sector. As expected, the oil, gas and coal sector has the highest carbon intensity at 4,179 (measured as metric tonnes of carbon emissions divided by sales in millions of euros) followed by the materials sector (metal producers and construction) at 3,855, utilities at 1,916, chemicals at

[9] See Energy Performance of Buildings Directive (2010/31/EU).

1,340, transportation (airlines) at 1,135 and automotive (carmakers) at 941, while the average is 1,563 (see the Annex for details).

Which method?

Which perspective should central banks adopt towards carbon emissions? Does climate change pose a risk or should it be seen as an opportunity to support the transition to a low-carbon economy (Schoenmaker, 2018)? It is often argued that central banks should manage the carbon risk in their operations, just like managing credit and market risks. While the risk perspective may be relevant for the financial stability side (ASC, 2016; Carney, 2015), both risk and an opportunity perspective are relevant for monetary policy. Monetary policy operations should avoid the risks of a high carbon bias and grasp the opportunity to support the shift to a low-carbon economy.

Amel-Zadeh and Serafeim (2018) distinguish several methods for considering ESG issues:

1. **Exclusionary/negative screening**: a method of deliberately not investing in companies that do not meet specific ESG criteria.

2. **Best in class**: an approach to sustainable investing that focuses on investing in companies that perform better on ESG issues than their peers do.

3. **Portfolio tilt:** the use of certain investment strategies or products to change specific aggregate ESG characteristics of a fund or investment portfolio to a desired level (eg tilting an investment portfolio toward a desired carbon footprint).

4. **Active ownership**: use of shareholder power to engage with companies to improve their ESG performance.

5. **Thematic investing**: focusing on those parts of the universe that benefit from and provide solutions for certain ESG trends.

6. **Impact investing**: an approach to investing that deliberately aims for both financial and societal value creation, as well as the measurement of societal value creation.

7. **Full ESG integration**: the explicit integration of E, S and G issues into the valuation and selection of securities.

While the first three methods are generally applicable, the last four methods are not. They require specific choices, valuations or actions. Full ESG integration, for example, would require that central bank officials investigate individual companies and come to a judgement on their ESG performance and transition preparedness (Schoenmaker and Schramade, 2019). In Section 2, we argued that appointed central bankers should avoid specific policies on the environment; such policies are in the remit of the government. It should be noted that the Eurosystem confines itself to corporate and bank bonds for its monetary policy portfolio, while national central banks also hold equities as part of their own reserves[10].

Amel-Zadeh and Serafeim (2018) report that negative screening is the most used method among investment professionals. At the same time, however, investment professionals perceive negative

[10] The Dutch central bank, for example, incorporates ESG criteria in its investment policy for its non-monetary policy portfolio and regularly checks the sustainability of its investments in equities and corporate bonds (De Nederlandsche Bank, Annual Report 2017, p.132). Some central banks with very large balance sheets, like the Swiss National Bank and the Bank of Japan, also hold equities in their main asset portfolio (Maechler, 2016).

screening as the least useful method, because it aims only to avoid the worst performers from a risk perspective. The best in class and portfolio tilt methods are risk and opportunity driven. These methods can be used to select relatively low-carbon assets or to tilt the asset and collateral portfolio towards less carbon-intensive assets. This in turn reduces the exposure to high-carbon assets.

The best in class method selects the X percent of best performers in a sector. That means the X percent companies with the lowest carbon emissions in this sector. To keep a broad asset and collateral base for central bank operations, X should be set relatively high, say 50 to 60 percent. Even with these high numbers, 40 to 50 percent of the companies in the market would be excluded. A tilting approach, which we explain below, is less distorting[11].

Tilting towards low carbon

To minimise distortions in the asset and collateral base, we propose a tilting approach for a central bank's direct asset holdings (eg related to official reserves or asset purchases under quantitative easing) and collateral holdings. The tilting method can be applied in different ways. A straightforward application would be to relate the relative share of a company's securities inversely to its carbon intensity. A central bank would then overweight low-carbon companies and underweight high-carbon companies in its portfolio.

$$S_{i,t}^{cb} = \left(1 + pt_{i,t}\right) S_{i,t}^{m} \quad (2)$$

where $S_{i,t}^{m}$ represents the share of asset i in the available market portfolio m; $S_{i,t}^{cb}$ the share of asset i in the central bank portfolio cb, and $pt_{i,t}$ the tilting factor of asset i. Note that $\sum_{i}^{n} pt_{i,t} = 0$.

For collateral, the additional haircut could be directly related to carbon intensity, just like credit risk. A central bank would then apply an additional haircut for medium and high-carbon assets. Following (Nyborg, 2015), the impact of an additional haircut on asset values works as follows.

$$V_{i,t}^{c} = \left(1 - (1 + a_{i,t})h_{i,t}\right) V_{i,t}^{m} \quad (3)$$

where $V_{i,t}^{c}$ represents the collateral value of asset i; $V_{i,t}^{m}$ the market value of asset i, $h_{i,t}$ the standard valuation haircut of asset i, and $a_{i,t}$ the additional haircut of asset i. Table 1 provides an overview of the standard valuation haircuts used by the ECB. While haircuts are often presented in absolute terms (eg 1 or 2 percent), we propose a multiplier approach for the additional haircut to ensure proportionality. An additional haircut of, for example, 2 percent would be very punitive for short-dated high quality liquid assets with a valuation haircut of 0.5 or 1 percent and not very effective for longer-dated illiquid assets of a lower quality with valuation haircuts of up to 44 percent. The aim is to tilt towards low-carbon assets within each category.

[11] Central banks can also follow a passive approach by using a low-carbon index as guide for asset purchases and collateral haircuts. Examples are the MSCI Low Carbon Index or the S&P 500 Carbon Efficient Index, which measures the performance of companies in its underlying index while overweighting companies with lower levels of carbon emissions and underweighting companies with higher levels of carbon emissions.

Table 1: Eurosystem haircut levels for marketable assets

		Category I: Central government debt		Category II: Other government and agencies debt		Category III: Covered bank bonds and corporate bonds		Category IV: Unsecured bank debt		Category V: Asset-backed securities
Credit quality (rating)	**Residual maturity (years)**	fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	
AAA to A-	0-1	0.5%	0.5%	1.0%	1.0%	1.0%	1.0%	6.5%	6.5%	10%
	1-3	1.0%	2.0%	1.5%	2.5%	2.0%	3.0%	8.5%	9.0%	
	3-5	1.5%	2.5%	2.5%	3.5%	3.0%	4.5%	11.0%	11.5%	
	5-7	2.0%	3.0%	3.5%	4.5%	4.5%	6.0%	12.5%	13.5%	
	7-9	3.0%	4.0%	4.5%	6.5%	6.0%	8.0%	14.0%	15.5%	
	>10	5.0%	7.0%	8.0%	10.5%	9.0%	13.0%	17.0%	22.5%	
B+ to BBB-	0-1	6.0%	6.0%	7.0%	7.0%	8.0%	8.0%	13.0%	13.0%	Not eligible
	1-3	7.0%	8.0%	10.0%	14.5%	15.0%	16.5%	24.5%	26.5%	
	3-5	9.0%	10.0%	15.5%	20.5%	22.5%	25.0%	32.5%	36.5%	
	5-7	10.0%	11.5%	16.0%	22.0%	26.0%	30.0%	36.0%	40.0%	
	7-9	11.5%	13.0%	18.5%	27.5%	27.0%	32.5%	37.0%	42.5%	
	>10	13.0%	16.0%	22.5%	33.0%	27.5%	35.0%	37.5%	44.0%	

Source: Bruegel based on Annex X of the Guideline (ECB/2015/510) on the implementation of the Eurosystem monetary policy framework (ECB/2014/60). Note: This table provides the levels of valuation haircuts for marketable assets applied by the Eurosystem. The top of the table presents five categories of issuers. The first column provides the credit ratings and the second column the residual maturity of assets.

Table 2 presents a simple structure for carbon factors in the ECB's asset and collateral framework. Three carbon categories C^j are introduced: low ($C^{low} = 1$), medium ($C^{medium} = 2$) and high ($C^{high} = 3$). Companies $i = 1, .., n$ are divided in tertiles according to increasing carbon intensity $CI_{i,t}$: the bottom tertile is $[1,\ \frac{1}{3}n]$, the middle tertile is $(\frac{1}{3}n,\ \frac{2}{3}n]$ and the top tertile $(\frac{2}{3}n,\ n]$. Houses (used as collateral in mortgages) are divided according to their energy efficiency label, ranging from A to G. For bonds of financials (eg (un)covered bank bonds) or special purpose vehicles (eg asset-backed securities), a weighted average of the carbon category of the underlying assets with weight w_i is taken, whereby a strict definition is applied: $C^j \geq C^{j,avg} = \sum_i w_i C_i^j$.

Moving to the carbon factors, the tilting factor pt_i can range from -1 to +2 in a structure with 3 categories. To avoid major distortions, we suggest a modest tilting factor of +0.75 for low-carbon assets, -0.25 for medium-carbon assets and -0.5 for high-carbon assets. The additional haircut is set at 0.1 for medium-carbon assets and 0.2 for high-carbon assets in Table 2. The Eurosystem can introduce the additional haircuts for collateral in a stepwise order until the desired changes of -25 and -50 percent for medium and high-carbon collateral assets are obtained.

Table 2: Carbon factors in the asset and collateral framework

Carbon category	**Portfolio tilt (*pt*)**	**Additional haircut (*a*)**	**Carbon intensity**	
			Companies (tertile)	**Houses** (eco-label)
Low	0.75	0	Bottom	A, B
Medium	-0.25	0.1	Middle	C, D, E
High	-0.50	0.2	Top	F, G

Source: Bruegel. Note: Assets are divided over three carbon categories according to their carbon intensity. The tilting factor (*pt*) is applicable to a central bank's asset purchases and the additional haircut (*a*) to its collateral.

4. The effects of greening monetary policy

4.1 Asset and collateral base

What would be the effects of a greening of central bank operations? Table 3 provides an overview of the consolidated balance sheet of the Eurosystem. The largest items on the Eurosystem balance sheet refer to securities holdings under the Asset Purchases Programme (item 7) and lending to EU credit institutions as part of monetary policy operations (item 5). The remaining items refer to gold (item 1), IMF drawing rights and other external claims (item 2), euro government securities (item 8) and other assets (item 9). The carbon factors are not relevant for these remaining assets.

Table 4 further breaks down the securities holdings under the Asset Purchases Programme. Government securities form the vast majority of these securities at more than 80 percent. The carbon factors are only relevant for the private securities, which amount to €513 billion. These comprise covered bank bonds (11.2 percent of total securities holdings), corporate bonds (7.4 percent) and other assets (1.0 percent). Section 4.2 provides some numerical examples of how the carbon factors would apply to these private securities. As the Eurosystem primarily holds public securities and other official assets, the application of low-carbon criteria would apply to about 11 percent of the Eurosystem's assets.

Table 3: Consolidated balance sheet of the Eurosystem, 21 September 2018

Assets	Amounts (in € billions)
1. Gold	373.2
2. Claims on non-EA residents in foreign currency	318.1
2.1 Receivables from the IMF (drawing rights)	*73.9*
2.2 Other external assets	*244.2*
3. Claims on EA residents in foreign currency	20.3
4. Claims on non-EA residents in euro	18.5
5. Lending to EU credit institutions in monetary policy operations	744.0
6. Other claims on EU credit institutions	33.7
7. Securities of EA residents	2,868.7
7.1 Securities held for monetary policy purposes (APP)	*2,613.6*
7.2 Other securities	*255.1*
8. General government debt in euro	24.5
9. Other assets	244.8
Total assets	**4,645.8**

Source: ECB.

On the collateral side, Table 5 shows that banks keep the most liquid and high-quality assets, like government bonds, on their own balance sheets, and pledge covered bonds, asset-backed securities and bank loans as collateral at the Eurosystem. The carbon factors can be applied to slightly over 80 percent of the Eurosystem's collateral holdings.

Table 4: Outstanding holdings under Asset Purchases Programme, 21 September 2018

Securities	1. Eligible market securities (in € billions)	2. Holdings (in € billions)	3. Holdings as share of market (2. as % of 1.)	4. Carbon factors applicable (2. as % of total)
Government securities	7,699.0	2,100.7	27.3%	n.a.
Covered bank bonds	1,405.9	292.1	20.8%	11.2%
Corporate bonds	1,670.0	193.9	11.6%	7.4%
Asset-backed securities	613.4	27.0	4.4%	1.0%
Total	**11,388.3**	**2,613.6**	**22.9%**	**19.6%**

Source: Bruegel based on ECB. Note: The second column presents marketable securities that are eligible under the APP. The third column presents the holdings under the APP. The fourth column presents APP holdings as share of eligible market securities. The fifth column indicates whether the carbon factor would be applicable to the respective collateral category.

Table 5: Collateral data of the Eurosystem, 21 September 2018

Collateral categories	1. Eligible market assets (in € billions)	2. Use of collateral (in € billions)	3. Collateral as share of market (2. as % of 1.)	4. Carbon factors applicable (2. as % of total)
Central government securities	7,260.1	241.6	3.3%	n.a.
Regional government securities	438.9	56.1	12.8%	n.a.
Uncovered bank bonds	2,008.6	93.5	4.7%	5.9%
Covered bank bonds	1,405.9	339.5	24.1%	21.3%
Corporate bonds	1,670.0	59.9	3.6%	3.8%
Asset-backed securities	613.4	367.4	59.9%	23.0%
Other marketable assets	888.7	43.1	4.8%	2.7%
Bank loans		394.9		24.7%
Total	**14,285.6**	**1,596.0**	**8.4%**	**81.3%**
Central bank operations				
Monetary policy operations		744.0		
Other operations		852.0		

Source: ECB. Note: 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 (see Table 1). The fourth column presents collateral as share of eligible market assets. The fifth column indicates whether the additional carbon haircut would be applicable to the respective collateral category. The bottom rows specify for which central bank operations collateral is used. Other operations include large-value payment system operations.

4.2 Numerical examples

The way central banks could put the tilting method into operation can be illustrated with some numerical examples. We take corporate bonds, unsecured and covered bank bonds, which are large asset classes in the ECB's asset and collateral framework alongside government bonds. Starting with corporate bonds, we examine the impact of the tilting factor on the carbon footprint of a portfolio with corporate bonds. For the calibration of the corporate bond portfolio, we assume that the market portfolio of eligible corporate bonds contains 60 corporate bonds in equal size, which means that $n = 60$ and $S_{i,t}^{m} = 0.0167$. We take the corporate bonds of the 60 largest companies, measured by long-term debt (see the Annex).

Table 6 reports the results. The fraction of low-carbon corporate bonds increases from 0.33 to 0.58 and the fraction of medium and high-carbon corporate bonds decreases from 0.33 to 0.25 and 0.17 respectively. The carbon footprint of the central bank's corporate bond portfolio is reduced by 44 percent compared to the original market portfolio. The lopsided distribution of carbon emissions with

very high carbon intensity in some sectors (ie the fossil fuel, materials and utilities sectors in Figure 1) explains this strong reduction of 44 percent, with a modest tilting factor of +0.75 for low carbon and -0.25 and -0.5 for medium and high-carbon companies.

Table 6: Tilting of corporate bond portfolio

Carbon category	Carbon intensity	Fraction in market portfolio	Carbon intensity market portfolio	Fraction in central bank portfolio	Carbon intensity central bank portfolio
Low	79.5	0.33	26.5	0.58	46.4
Medium	692.3	0.33	230.8	0.25	173.1
High	3,916.6	0.33	1,305.5	0.17	652.8
Portfolio		1.00	1,562.8	1.00	872.3
Reduction					44.2%

Source: Bruegel. Note: Corporate bonds are divided over three carbon categories according to their carbon intensity (measured as metric ton CO_2 divided by sales in million euros; see Figure 1); the average carbon intensity for each tertile is presented. The tilting factors of Table 2 are applied. The carbon footprint of the central bank portfolio is reduced with 44 percent.

The second numerical example concerns the unsecured bonds of two single-A rated banks. The bonds have a residual maturity of four years and a fixed coupon, which gives a valuation haircut of 11 percent (see Table 1). The carbon category of unsecured bank bonds is derived from the carbon factors of the underlying loan portfolio. Table 7 reports that Bank A has 40 percent of its loans to companies and 60 percent to households (in the form of mortgages) spread across the three carbon categories. The weighted average carbon factor is 2.32, which leads to an additional haircut of 0.2. The total haircut thus increases from 11 to 13.2 percent. Bank B has slightly lower carbon intensity in its loan portfolio with an average carbon factor of 1.92. The additional haircut of 0.1 increases the total haircut from 11 to 12.1 percent.

Table 7: Additional haircut for uncovered bank bonds

Carbon category	Carbon factor	Bank A		Bank B	
		Companies 40%	Mortgages 60%	Companies 60%	Mortgages 40%
Low	1	0.04	0.12	0.18	0.16
Medium	2	0.12	0.24	0.24	0.16
High	3	0.24	0.24	0.18	0.08
		0.40	0.60	0.60	0.40
Average carbon factor		2.32		1.92	
Valuation haircut		11.0%		11.0%	
Additional haircut		0.2		0.1	
Total haircut		13.2%		12.1%	
Increase of total haircut		20%		10%	

Source: Bruegel. Note: The single A rated banks have a loan portfolio of corporate loans and mortgages. The average carbon factor is calculated as a weighted average of a bank's asset carbon factors. The valuation haircut is based on a residual maturity of 4 years and a fixed coupon (Table 1). The additional haircut (Table 2) is based on the upward rounded carbon factor.

The third and final numerical example concerns a covered bank bond. Again the bank is single-A rated and the bond has a remaining maturity of four years with a fixed coupon. The valuation haircut is 3 percent. In the case of a covered bond, the average carbon factor of the underlying houses has to be calculated. The bank has a portfolio with relatively energy efficient houses: 60 percent with label A or B, 30 percent with label C to E, and 10 percent with label F or G. The average carbon factor is 1.5, which

gives rise to an additional haircut of 0.1. The total haircut for this covered bond increases from 3 to 3.3 percent. Only when all houses have an A or B label, there would be no additional haircut.

These numerical examples show a substantial reduction in the carbon footprint or increase of the haircut for corporate and bank bonds. Nevertheless, a broad asset base is maintained, minimising the scope for distortions in the monetary transmission mechanism.

4.3 Impact on cost of capital

Would an allocation bias towards low-carbon assets support the general environmental policies of the EU? To put it more directly, would a low-carbon allocation support the transition to a low-carbon economy? In Section 3.1, we already discussed that increased eligibility for low-carbon assets would generate a liquidity premium that would reduce the cost of capital. The cost of capital for high-carbon companies would then become higher than that for low-carbon companies. This primary effect would already give low-carbon companies a funding advantage and thus contribute to the transition. Moreover, central bank efforts to green monetary policy operations would also give a powerful signalling effect to other financial market participants (Braun, 2018), boosting the case for greening the financial system.

Equilibrium effects

Heinkel *et al* (2001) examined the equilibrium effect of transition. If the higher cost of capital more than overcomes the cost of reform (ie a polluting company cleaning up its activities), then high-carbon companies will transition their production technologies and products to low carbon. A key determinant of the incentive for high-carbon companies to reform is the fraction of funds controlled by green investors, who boycott these high-carbon companies. In an empirically calibrated model, Heinkel *et al* (2001) showed that more than 20 percent of green investors are required to induce any polluting companies to reform. By greening their monetary policy operations, central banks would become a greener investor and thus increase the fraction of green investors speeding up the transition.

The proposed tilting approach would change the current fractions of asset and collateral holdings, which is by design one third in low, medium and high-carbon companies respectively. We assume the changing fractions of collateral are similar to those of assets: +75 percent for low carbon, -25 percent for medium carbon and -50 percent for high-carbon companies. Table 8 reports the changes in fractions after tilting. In the case of covered bank bonds, the fraction of collateral in high-carbon covered bonds would reduce by 4 percent. The calculation works as follows: the Eurosystem holds 24 percent of covered bonds as collateral (Table 5), of which 8 percent is in high-carbon covered bonds; the additional haircut of 0.2 leads to a 50 percent reduction from 8 to 4 percent in high-carbon covered bonds.

On the securities holdings under APP, the biggest changes are for covered bonds (-1.7 percent for medium carbon and -3.5 percent for high carbon) and corporate bonds (-1.0 percent and -1.9 percent). On the collateral side, the biggest changes are for covered bonds (-2 percent and -4 percent) and asset-backed securities (-5 and -10 percent). The final column of Table 8 gives the combined effect. As the Eurosystem is only a temporary investor in assets under the Asset Purchase Programme, the changes in the collateral holdings have more lasting impact. The results indicate that the Eurosystem could considerably add to the fraction of green investors in some asset classes and thus speed up the adjustment of high and medium-carbon companies or houses (in the case of covered bonds) in these asset classes.

Table 8: Changes in fractions after tilting

Asset type	Carbon category	Holdings under APP	Collateral	Total
Uncovered bank bonds	Low	0.0%	1.2%	1.2%
	Medium	0.0%	-0.4%	-0.4%
	High	0.0%	-0.8%	-0.8%
Covered bank bonds	Low	5.2%	6.0%	11.2%
	Medium	-1.7%	-2.0%	-3.7%
	High	-3.5%	-4.0%	-7.5%
Corporate bonds	Low	2.9%	0.9%	3.8%
	Medium	-1.0%	-0.3%	-1.3%
	High	-1.9%	-0.6%	-2.5%
Asset-backed securities	Low	1.1%	15.0%	16.1%
	Medium	-0.4%	-5.0%	-5.4%
	High	-0.7%	-10.0%	-10.7%

Source: Bruegel (Tables 4 and 5). Note: The starting point is that the Eurosystem's assets are divided equally over low, medium and high carbon assets (holdings under APP in Table 4 and collateral in Table 5). The fraction of low carbon assets increases with 75 per cent and the fraction of medium and high carbon assets decreases with 25 and 50 per cent respectively. This table reports the changes in the fractions after tilting.

Empirical evidence

The introduction of the Additional Credit Claims framework in late 2011, as part of unconventional monetary measures, provided a major expansion in the availability of collateralised lending to banks by the ECB. As this expansion was unexpected at the time, the impact on the credit growth and spread of newly-eligible companies can be assessed. Cahn *et al* (2017) found 8 percent higher credit growth for newly-eligible companies compared to ineligible companies, while Mésonnier *et al* (2017) estimated a 7 basis points reduction in credit spread for newly eligible companies.

These figures are found in the case of a 100 percent increase in the eligibility of an asset class. The tilting approach aims at a 25 percent reduction for medium-carbon assets and a 50 percent reduction for high-carbon assets. Assuming that the results are linear and comparable, tilting would lead to a 2 and 4 percent reduction of credit growth for medium and high-carbon companies, and a 1.75 and 3.5 bp increase in the credit spread.

5. Concluding policy reflections

Central banks have a long-term perspective (often making reference to sustainable economic growth) and are therefore mindful of the impact of climate change on stability. They have already started to examine the impact of climate change on the stability of the financial system from a risk management perspective. On the monetary side, there is no comparable direct impact on price stability, which has a medium-term horizon. Nevertheless, the Eurosystem's legal mandate states that it *"shall support the general policies in the EU, without prejudice to price stability"*. The transition to a low-carbon economy is a cornerstone of the EU's general economic policies.

The Eurosystem could support the EU's climate policy by greening monetary policy operations. The basic idea would be to tilt the asset and collateral base for these operations towards low-carbon assets. A modest tilting approach could reduce carbon emissions in the central bank's corporate bond portfolio by 44 percent and lower the cost of capital for low-carbon companies (compared to high-carbon companies) by 4 basis points. This working paper shows how this could be done without unduly interfering in the smooth conduct of monetary policy. That is all technical.

The real question is whether central bankers are prepared to cross the Rubicon in support of EU climate policies. Similar deliberations have taken place in other sectors. Should auditors examine a company's integrated report with social and environmental indicators? Or should they stick with the financial part, which is within their professional realm? Should institutional investors include sustainability considerations in their investment policies? The High Level Expert Group on Sustainable Finance (2018) has recommended incorporating sustainability in the fiduciary duty of investors, which is now put into proposed legislation by the European Commission. More generally, the required political space for the ECB to adopt low-carbon criteria seems to be present. The European Council, the European Commission and the European Parliament are all committed to the transition to a low-carbon economy.

If the Eurosystem were to pick up the challenge of greening its monetary policy operations, it would be of utmost importance to do that in full independence. The Eurosystem could adjust the eligibility criteria for assets and collateral in a general way, using a transparent and objective indicator, such as current and future carbon emissions (TCFD, 2017). It should refrain from favouring specific projects or setting sectoral targets, which is an issue for government policy. The EU and the member states can use their multilateral development bank (the European Investment Bank) and their national development banks to steer financing towards specific green projects, if they wish to do so.

References

Advisory Scientific Committee (ASC) (2016) 'Too Late, Too Sudden: Transition to a Low-Carbon Economy and Systemic Risk', Report No. 6 of the Advisory Scientific Committee of the European Systemic Risk Board, Frankfurt

Aksoy, Y. and H. Basso (2014) 'Liquidity, Term Spreads and Monetary Policy', *Economic Journal*, 124(581): 1234-1278

Amel-Zadeh, A. and G. Serafeim (2018) 'Why and How Investors Use ESG Information: Evidence from a Global Survey', *Financial Analysts Journal* 74(3)

Ampudia, M., D. Georgarakos, J. Slacalek, Or. Tristiani, P. Vermeulen and G. Violante (2018) 'Monetary policy and household inequality', *ECB Working Paper Series* No. 2170, European Central Bank

Andersson, M., P. Bolton and F. Samama (2016) 'Hedging Climate Risk', *Financial Analysts Journal*, 72(3): 13-32

Ashcraft, A., N. Gârleanu and L. Pedersen (2011) 'Two Monetary Tools: Interest Rates and Haircuts', in D. Acemoglu and M. Woodford (eds) *NBER Macroeconomics Annual 2010*, 25: 143-180

Battiston, S., A. Mandel, I. Monasterolo, F. Schütze and G. Visentin (2017) 'A climate stress-test of the financial system', *Nature Climate Change,* 7(4): 283-288

Bindseil, U., M. Corsi, B. Sahel and A. Visser (2017) 'The Eurosystem collateral framework explained', *ECB Occasional Paper Series* No. 189, European Central Bank

Bini Smaghi, L. (2007) 'With or Without Prejudice to Price Stability?' speech to the Barclays Capital Annual Conference London, 24 May

Braun, B. (2018) 'Central banking and the infrastructural power of finance: the case of ECB support for repo and securitization markets', *Socio-Economic Review* 16

Cahn, C., A. Duquerroy and W. Mullins (2017) 'Unconventional Monetary Policy and Bank Lending Relationships', *Working Paper* No. 659, Banque de France

Carney, M. (2015) 'Breaking the tragedy of the horizon: climate change and financial stability', speech at Lloyd's of London, 29 September

Cœuré, B. (2018) 'Monetary Policy and Climate Change', speech to the NGFS Conference 'Scaling up Green Finance: The Role of Central Banks' at the Deutsche Bundesbank, Berlin, 8 November

Doda, B. (2016) 'Sector-level carbon intensity distribution', *Working Paper* No. 281, Centre for Climate Change Economics and Policy

Draghi, M. (2017) 'Letter to the European Parliament', L/MD/17/383, Frankfurt, 10 October

Draghi, M. (2018) 'Letter to the European Parliament', L/MD/18/207, Frankfurt, 12 June

ECB (2001) *The Monetary Policy of the ECB*', European Central Bank

Goodfriend, M. (2011) 'Central Banking in the Credit Turmoil: An Assessment of Federal Reserve Practice', *Journal of Monetary Economics*, 58(1): 1-12

Heinkel, R., A. Kraus and J. Zechner (2001) 'The Effect of Green Investment on Corporate Behavior', *Journal of Financial and Quantitative Analysis*, 36(4): 431-449

High Level Expert Group on Sustainable Finance (2018) *Financing a Sustainable European Economy*, Final Report, European Union, Brussels

Hong, H, F. Li and J. Xu (2019) 'Climate Risks and Market Efficiency', *Journal of Econometrics* 208(1): 265-281

Maechler, A. (2016) 'Investment policy in times of high foreign exchange reserves', speech at SNB Money Market Event, Zurich, 31 March

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

Mésonnier, J., C. O'Donnell and O. Toutain (2017) 'The Interest of Being Eligible', *Working Paper* No. 636, Banque de France

Mishkin, F. (2001) 'The Transmission Mechanism and the Role of Asset Prices in Monetary Policy', *NBER Working Paper* No. 8617

Nagel, S. (2016) 'The Liquidity Premium of Near-Money Assets', *Quarterly Journal of Economics*, 131(4): 1927-1971

Nyborg, K. (2015) 'Central bank collateral frameworks', *CEPR Discussion Paper* No. 10663

Orphanides, A. (2017) 'The Fiscal-Monetary Policy Mix in the Euro Area: Challenges at the Zero Lower Bound', *CEPR Discussion Paper* No. 12039

Schoenmaker, D. (2018) 'A Framework for Sustainable Finance', *CEPR Discussion Paper* No. 12603

Schoenmaker, D. and W. Schramade (2019) *Principles of Sustainable Finance*, Oxford University Press, Oxford

Smits, R. (1997) *The European Central Bank: Institutional Aspects*, Kluwer Law International, The Hague

Stiglitz Report (2009) *Report by the Commission on the Measurement of Economic Performance and Social Progress*, Paris

Task Force on Climate-related Financial Disclosures (2017) *Recommendations of the Task Force on Climate-related Financial Disclosures: Final Report (Bloomberg Report)*, Financial Stability Board, Basel

Tucker, P. (2018) 'Pristine and parsimonious policy: Can central banks ever get back to it and why they should try', in P. Hartmann, H. Huang and D. Schoenmaker (eds) *The Changing Fortunes of Central Banking,* Cambridge University Press, 48-64

World Resources Institute (WRI) (2015) *Greenhouse Gas Protocol*, Washington DC

Wuermeling, J. (2018) 'Prospects for monetary policy implementation', speech at the 2018 Banking Evening at the Deutsche Bundesbank's Regional Office in Baden-Württemberg, Stuttgart, 6 February

Annex: Corporate bond portfolio

This annex contains the carbon intensity (based on scope 1, 2 and 3 emissions) of the top 60 companies in the euro area, selected by long-term debt. Two firms (Heineken Holding and Airbus) were removed from the top 60 due to lack of data and replaced by Deutsche Lufthansa (rank 61) and Linde (rank 62). The data are taken from ASSET4 EGS Scores in Datastream and cross-checked with company reports. For some companies, scope 3 emissions data are missing in Datastream and company reports. These scope 3 emissions are estimated based on the industry average.

Table A1: Carbon intensity of top 60 companies (CO_2 emissions in Mt/sales in EUR million)

Company	Country	Industry sector	Carbon intensity
AENA	ES	Miscellaneous	642.0
AIR FRANCE KLM	FR	Transportation	2,015.4
AIR LIQUIDE	FR	Chemicals	1,295.1
ALD	FR	Miscellaneous	9.5
ALTICE EUROPE	NL	Utilities: Energy	116.3
ANHEUSER BUSCH INBEV	BE	Nutrition: Beverages	296.6
ARCELORMITTAL	NL	Materials: Metal Producers	3,450.0
ATLANTIA	IT	Miscellaneous	151.1
BASF	DE	Chemicals	2,372.6
BAYER	DE	Chemicals	351.6
BMW	DE	Automotive	738.0
BOLLORE	FR	Transportation	269.7
CARREFOUR	FR	Retailers	37.5
CASINO	FR	Retailers	37.6
CHRISTIAN DIOR	FR	Diversified	19.6
CNH INDUSTRIAL	IT	Machinery & Equipment	19.8
COMPAGNIE DE SAINT GOBAIN	FR	Diversified	504.6
DAIMLER	DE	Automotive	454.8
DANONE	FR	Nutrition: Food	880.8
DEUTSCHE LUFTHANSA	DE	Transportation	1,121.0
DEUTSCHE TELEKOM	DE	Utilities: Telecom	262.9
E.ON	DE	Utilities: Energy	2,091.4
EDP	PT	Utilities: Energy	2,349.8
EIFFAGE	FR	Materials: Construction	116.4
ELECTRICITE DE FRANCE	FR	Utilities: Energy	1,426.1
ENEL	IT	Utilities: Energy	1,555.4
ENGIE	FR	Utilities: Energy	4,329.0
ENI	IT	Oil, Gas, Coal	4,366.9
EXOR	IT	Automotive	560.3
FERROVIAL	ES	Materials: Construction	306.9
FIAT CHRYSLER AUTOMOBILES	IT	Automotive	1,439.4
FRESENIUS SE & CO	DE	Drugs, Cosmetics & Healthcare	59.0
HEIDELBERGCEMENT	DE	Materials: Construction	14,996.8
HEINEKEN	NL	Nutrition: Beverages	164.8
IBERDROLA	ES	Utilities: Energy	1,626.6
INNOGY	DE	Utilities: Energy	5,231.8
KONINKLIJKE KPN	NL	Utilities: Telecom	137.7
LINDE	DE	Machinery & Equipment	1,662.7
LVMH	FR	Diversified	7.2
MERCK KGAA	DE	Drugs, Cosmetics & Healthcare	70.7
NATURGY ENERGY GROUP	ES	Utilities: Energy	7,021.8

OMV	AT	Oil, Gas, Coal	5,904.5
ORANGE	FR	Utilities: Telecom	33.5
PERNOD RICARD	FR	Nutrition: Beverages	97.5
REPSOL	ES	Oil, Gas, Coal	4,351.7
ROYAL DUTCH SHELL	NL	Oil, Gas, Coal	2,801.7
RWE	DE	Utilities: Energy	5,198.7
SANOFI	FR	Drugs, Cosmetics & Healthcare	232.0
SIEMENS	DE	Electronics	19.5
SNAM	IT	Utilities: Energy	690.4
SUEZ	FR	Utilities: Water	1,864.5
TELECOM ITALIA	IT	Utilities: Telecom	392.7
TELEFONICA	ES	Utilities: Telecom	87.0
TERNA RETE ELETTRICA NAZIONALE	IT	Utilities: Energy	69.1
TOTAL	FR	Oil, Gas, Coal	3,468.6
UNILEVER	NL	Nutrition: Food	293.0
VEOLIA ENVIRONNEMENT	FR	Miscellaneous	1,672.1
VINCI	FR	Materials: Construction	406.2
VOLKSWAGEN	DE	Automotive	1,514.2
WENDEL	FR	Diversified	105.1
Grand Total			**1,562.8**

Source: Bruegel based on ASSET4 ESG Scores in Datastream (Thomson Reuters) and company reports. Note: The last column provides the carbon intensity, measured as average of emissions in metric ton CO_2 divided by sales in millions euro. Scope 1, 2 and 3 emissions are included.

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