

The climate impact of quantitative easing

Sini Matikainen, Emanuele Campiglio
and Dimitri Zenghelis

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About the authors and acknowledgements

Sini Matikainen is a policy analyst at the Grantham Research Institute. **Emanuele Campiglio** is assistant professor of climate economics and finance at the Vienna University of Economics and Business (WU). **Dimitri Zenghelis** is principal research fellow at the Grantham Research Institute.

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This policy paper is intended to inform decision-makers in the public, private and third sectors. It has been reviewed by at least two internal referees before publication. The views expressed in this paper represent those of the authors and do not necessarily represent those of the host institutions or funders.

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Executive summary

There is increasing awareness of the physical and transitional risks climate change poses to financial markets and financial stability.

Both climate change (in the form of climate-related damages to productive capital) and the low-carbon transition (in the form of mitigation policies imposing a strong reduction of greenhouse gas emissions or a market-driven structural shift to cleaner technologies) are likely to have deep implications for the functioning and stability of the macro financial system.

In response, financial regulators and central banks have largely focused the discussion on private sector disclosure and stress-testing to determine the magnitude of potential impacts of climate change.

When discussing the private sector, there is general agreement about the benefits of considering operational risks and opportunities related to climate change. For central banks, on the other hand, incorporating climate change into operational decisions is generally viewed as being outside their remit, and in contravention of their intention to remain market-neutral (avoiding distortionary effects on the market). However, even supposedly market-neutral interventions by central banks may show an unintended structural bias towards carbon-intensive industry incumbents.

Sectoral analysis of the quantitative easing (QE) corporate bond purchase programmes of the European Central Bank (ECB) and the Bank of England suggests a skew towards high-carbon sectors.

Calculations made using publicly available information indicate that 62.1 per cent of ECB corporate bond purchases take place in the sectors of manufacturing and electricity and gas production, which alone are responsible for 58.5 per cent of Eurozone area greenhouse gas emissions, but only 18 per cent of gross value added (GVA). For the Bank of England, manufacturing and electricity production – responsible for 52 per cent of UK emissions – make up 49.2 per cent of the eligible benchmark, but only 11.8 per cent of GVA.

Utilities, the most carbon-intensive sector by emissions, also make up the largest share of purchases for both the ECB and Bank of England.

Renewable energy companies, already a relatively small portion of the bond market to begin with, are not represented at all in ECB or Bank of England purchases, while oil and gas companies make up an estimated 8.4 per cent and 1.8 per cent of their portfolios, respectively. This partly reflects the makeup of the European bond market, and particularly the universe of bonds that meet the eligibility criteria of the programme. The purchases reflect the nature of financial markets, where externalities and future responses to them arguably are not adequately priced in and capital is sub-optimally allocated to large, carbon-intensive incumbents.

The carbon-intensive skew of these purchases raises concerns of disproportionately increasing prices and encouraging additional debt issuance in high-carbon relative to low-carbon sectors.

The academic literature suggests that the impacts of QE purchases pass through imperfectly to other asset classes and the larger economy; there is evidence of a disproportionate jump in the price of eligible assets after the introduction of these corporate bond purchase programmes.

The purchase of carbon-intensive assets is in direct contradiction with, and may undermine, the signals that financial regulators are making about the risks associated with high-carbon investments.

Consequently, the Bank of England and ECB should undertake additional research to better understand the impacts of their interventions and disclose how they are accounting for these risks.

Recommendations

- 1. The European Central Bank and Bank of England should increase transparency around the purchases and selection process**
 - Central banks should disclose how climate change risk is accounted for and incorporated into their decision-making, setting a good example for the private sector by mirroring the 2016 recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures on the topic. The ECB and Bank of England could offer additional detail on how they select assets for eligibility and whether or not they take into account climate-related risks, to include climate damages as well as transition risks.
- 2. Central banks should investigate the impact of their interventions on both high-carbon and low-carbon investment**
 - The ECB and Bank of England should initiate reviews on the material impact of monetary policy on high- and low-carbon investment. In addition to ongoing research on how monetary policy and financial stability are affected by climate change, this could look at what impact monetary policy is having on the transition itself.
- 3. The European Central Bank and Bank of England could consider options for changing their purchasing strategies, in parallel with the actions above**
 - The ECB and Bank of England could consider **revising eligibility criteria** in order to take a more proactive approach towards climate risk: for example, by deeming firms ineligible if credit ratings agencies disagree on investment grade status or have the issuers on credit downgrade watch, or by conducting their own internal risk analysis, to take into account that climate change risk is only beginning to be incorporated into credit ratings.
 - Monetary policy could be used more effectively **to support long-term sustainable growth**, for example by purchasing 'green' bonds issued by development banks (such as the European Investment Bank). However, there are currently constraints on the execution of such a strategy, for both the development banks that would be issuing the bonds and the central banks that would be purchasing them.
- 4. Central banks should communicate and coordinate with fiscal policy-makers and financial regulators**
 - Working in concert with other public institutions will enable central banks to harmonise the overall policy effort aimed at achieving a rapid and smooth transition to a low-carbon economy. The mandates of both the ECB and Bank of England state that the operation of monetary policy should support the general economic policies of their respective governments, including broad-based economic growth.
 - Bonds from renewable energy companies and other emerging technologies may face barriers to eligibility under the **collateral framework**. The intervention of other institutions may be necessary, for example the European Investment Bank could use targeted policy measures to increase the credit ratings of renewable energy bonds.
 - If current central bank interventions contribute to asset mispricing in high-carbon sectors, **financial regulators may want to focus on differentiating prudential regulations** across sectors and promoting disclosure as part of a wider effort to account for the potential financial stability risks associated with the transition to a low-carbon economy.

By **mainstreaming climate considerations** into their day-to-day operations and disclosing their approach to transitional risk, central banks would send a strong signal to financial markets and begin to address their own 'tragedy of the horizon'.

Glossary

Asset backed security (ABS): A debt security based on relatively illiquid underlying assets, such as mortgage or car/auto loans, that are pooled together.

Bloomberg Industrial Classification System (BICS): Used within Bloomberg Terminal for classifying financial assets by sector.

CBPS – Corporate Bond Purchase Scheme: Purchases of corporate bonds conducted by the Bank of England under its quantitative easing programme.

CSPP – Corporate Sector Purchase Programme: Purchases of corporate bonds conducted by the European Central Bank under its quantitative easing programme.

Covered bonds: Debt securities backed by underlying collateral, usually mortgages or public sector debt, that investors have recourse to in case of default.

European Central Bank (ECB): The central bank of the 19 European Union countries that have adopted the euro.

European Investment Bank (EIB): Bank owned by and representing the interests of the European Union member states.

Exchange traded fund (ETF): A tradable security linked to an index.

Green bonds: Bonds whose proceeds are used to fund environmental or climate-related projects, such as renewable energy, energy efficiency, clean transport, or pollution controls.

Gross value added (GVA): The value of goods and services produced in a region.

International Securities Identification Number (ISIN): Used to identify securities such as bonds and stocks.

Junk bonds: Bonds that are rated below investment grade; also known as high-yield bonds.

Macroprudential policy: Financial regulatory instruments put in place to improve the stability and resilience of the financial system.

NACE: Statistical classification of economic activities, used by Eurostat for national accounting purposes in the European Community. (Initials stand for *Nomenclature statistique des activités économiques dans la Communauté Européenne.*)

Nikkei 225: A stock market index based on the Tokyo Stock Exchange.

Quantitative easing (QE): A programme of asset purchases conducted by a central bank in order to stimulate inflation and, by extension, economic growth.

Task Force for Climate-Related Financial Disclosures (TCFD): Launched by the G20's Financial Stability Board in 2015 to develop a set of recommendations for climate-related disclosures by companies.

List of abbreviations

ABSPP	Asset Backed Securities Purchase Programme
APP	Asset Purchase Programme
CBPP	Covered Bond Purchase Programme
CSPP	Corporate Sector Purchase Programme
CBPP3	Covered Bond Purchase Programme 3
CISL	Cambridge Institute of Sustainability Leadership
ESCB	European System of Central Banks
ESRB	European Systemic Risk Board
ESG	environmental, social and governance [criteria/policies]
GFSG	Green Finance Study Group
IMF	International Monetary Fund
OECD	Organisation for Economic Cooperation and Development
PRA	Prudential Regulation Authority
PRI	Principles for Responsible Investment
PSPP	Public Sector Purchase Programme
SICS	Standard Industrial Classification System
SME	small and medium-sized enterprises
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme

1. Introduction

Climate change-related risks to financial stability have been increasingly acknowledged in recent years by central banks and financial regulators. Both climate change (in the form of climate-related damages to productive capital) and the low-carbon transition (in the form of mitigation policies imposing a strong reduction of greenhouse gas emissions or a market-driven structural shift to cleaner technologies) are likely to have deep implications for the functioning and stability of the macro financial system (Carney, 2015). For instance, transitioning to low-carbon forms of energy production would mean a structural shift away from fossil fuel companies, whose financial assets would likely drop in value, potentially leading to losses for the pension funds, insurance companies and other investors holding them.¹

As outlined in **Section 2**, financial regulation authorities have responded to climate-related financial risk by calling for more transparent information around companies' and investors' current and future emissions (see for instance Task Force for Climate-Related Financial Disclosures [TCFD], 2016), and by proposing the development of methods to run dedicated climate stress-tests on the stability of their banking and financial systems (European Systemic Risk Board [ESRB], 2016; UN Environment Programme [UNEP], 2015). However, until now they have declined to intervene more directly to support the low-carbon transition through, for instance, targeted monetary policy or financial regulation, as they consider it outside their mandate (see Box 1 below).

This approach has been justified by the stated intention of central banks to remain neutral and to focus their actions on price and/or financial stability, leaving the choice of societal objectives and the means to achieve them to elected governments. However, as **Section 3** shows, central banks' supposedly 'neutral' actions may show a structural bias towards certain sectors and industries. Evidence suggests that the purchase of financial assets under quantitative easing (QE)² interventions, for instance, seems to have passed through imperfectly to the larger economy, leading some sectors to benefit relatively more from reduced funding costs than others. While monetary policy is likely to distort market efficiency in general (see, for example, Ganley and Salmon, 1997), this is particularly worrying when a central bank has already identified sectors where the risks have not been fully priced in, as it may exacerbate existing mispricing.

Section 4 focuses attention on the recently initiated programmes of purchase of corporate bonds by the European Central Bank (ECB) and the Bank of England. The purchases tend to be skewed towards high-carbon sectors, which partly reflects the makeup of the European bond market as a whole and especially the make-up of the universe of eligible bonds. These purchases could contribute to a mispricing of assets in carbon-intensive sectors and to additional and more convenient debt issuance from high-carbon companies. Despite the central banks' intent to be neutral and independent, in practice allocating corporate bond purchases according to relative market size may reflect the existing market distortions, disproportionately benefiting incumbents in high-carbon sectors over low-carbon industries, in terms of borrowing costs and asset valuations.³

This strategy is in direct contradiction with, and may undermine, the signals that financial regulators are making about the risks associated with high-carbon investments and the impact on market efficiency. While monetary policy cannot be a substitute for environmental policy, monetary

¹ The potential size of the losses is uncertain and depends greatly on the speed and timing of a transition, but is potentially significant (Baron and Discher, 2015; Carbon Tracker, 2013; ESRB, 2016; Griffin et al., 2015).

² This and other key terms are defined in the Glossary, p3 above.

³ Relative to the socially optimal distribution of capital, where negative externalities associated with greenhouse gas emissions were priced in fully; compare with the gap between the level of 'green' investment consistent with a 1.5–2°C pathway and the current level of high-carbon investment (World Economic Forum, 2013).

policy-makers should be mindful of the impacts on asset pricing, including risks to market efficiency and financial stability.

Section 5 presents recommendations for better understanding and communicating climate-related risks, as well as further policy options for incorporating climate considerations into asset purchasing strategies, which Section 6 concludes.

2. Central banks and climate financial risk

Climate-related risks to financial stability could arise from transitional, physical or liability risks (ESRB, 2016; Prudential Regulation Authority [PRA], 2015). On the transition side, meeting the objectives laid down under the Paris Agreement (UNFCCC, 2016) will leave a large proportion of existing fossil fuel reserves in the ground, hence becoming 'stranded' (Carbon Tracker, 2013; McGlade and Ekins, 2015) by technological or policy change. This could affect not only the asset prices of the firms involved in fossil fuel production, but also firms investing in physical and infrastructure capital based on fossil fuel resources (electricity production, transport, heat, industrial processes, and other sectors). Firms may also face litigation risk for climate change damages, which could have an impact on valuations (Covington et al., 2016). A rapid re-pricing of these financial assets⁴ could have significant implications for the investors holding the assets and for the financial system as a whole (Baron and Discher, 2015; Battiston et al., 2017; Carbon Tracker, 2013; ESRB, 2016; Griffin et al., 2015).

On top of this, there is the looming possibility of climate-related damages impacting the productive structure of the global economy, with potential deep impacts on the insurance system but also the economy more widely. Dietz et al. (2016), for instance, estimate the average global value at risk for global financial assets due to climate damages between 2015 and 2100 in a business-as-usual scenario to be 1.77 per cent, but reaching 16.86 per cent at the 99th percentile. The insurance sector has begun to incorporate the increased incidence of natural disasters into its planning but has highlighted that there is a large and increasing 'protection gap' as some events become too frequent and costly to be insured, meaning that the losses must be borne by the wider economy (Cambridge Institute for Sustainability Leadership [CISL] and PwC, 2016). The rest of the financial sector is also coming under increasing pressure to take these risks into account (Covington et al., 2016).

Reactions to climate risks by financial institutions

The scale of the potential systemic risk to the financial system attached to climate damages and the low-carbon transition, and the risk of a sudden adjustment to asset prices, have raised concern among the institutions responsible for ensuring financial stability. Mark Carney, governor of the Bank of England and chair of the G20's Financial Stability Board, gave a widely referenced speech in 2015 on the potential risks of climate change for the financial sector and financial stability, and the need for financial policy-makers to be aware of and to help mitigate these risks by encouraging an efficient transition to a low-carbon economy (Carney, 2015). The speech was concurrent with the release of an extensive report by the Bank of England's Prudential Regulation Authority (Prudential Regulation Authority [PRA], 2015) about the implications for the insurance sector, and was followed

⁴ In a forward-looking and efficient market, this raises the question of why asset repricing has not taken place already. This might reflect the fact that some asset repricing has already taken place but it is difficult to tell because the counterfactual is unobservable, that climate policies are not fully credible (which suggests that a first best response might be to increase the ambition and improve the credibility of global climate policies), or that a combination of cognitive biases, investment culture, regulation and misaligned incentives is leading financial actors to overlook and misprice climate transition risks (Silver, 2017; Weber, 2017).

by further comments from the governor of the Bank of England about the importance of green investment for an orderly transition to a low-carbon economy (Carney, 2016).

The Bank of England has also been working with the People's Bank of China and the United Nations Environment Programme (UNEP) on the G20 Green Finance Study Group (GFSG, 2016). The Bank of France (Villeroy de Galhau, 2015) and Bank of Italy (Signorini, 2017) have commented on the topic, and researchers at the Dutch Central Bank (Schotten et al., 2016), the Swedish Financial Supervisory Authority (Bowen and Dietz, 2016) and the European Systemic Risk Board (ESRB, 2016) have released papers on the financial stability implications of the transition to a low-carbon economy.

The main response of central banks and financial authorities in high-income countries to climate-related financial risk has been twofold.

First, they have stressed the importance of having **transparent information regarding companies' emissions and a standardised method to disclose them**. In 2015, the Financial Stability Board created the Task Force for Climate-Related Financial Disclosures. The Task Force published its initial report in December 2016, recommending that firms across sectors, both financial and non-financial, disclose risks and opportunities related to climate change in their public financial filings (TCFD, 2016). Such climate-related risk disclosure is already included as mandatory under France's Energy Transition Law (Principles for Responsible Investment [PRI], 2016), as part of a general trend of mainstreaming climate disclosure into ongoing financial filings. Second, central banks and financial authorities have raised the idea of **developing dedicated climate stress-tests**, to better assess the extent of the risk to the financial sector (ESRB, 2016; PRI, 2016; UNEP, 2015).

These central banks and financial authorities have, until now, declined to intervene more directly to support the low-carbon transition, for instance by adapting monetary policies and financial regulatory measures to support a reduction in carbon intensity of the economic system. In that context, it is often argued that environmental sustainability lies outside central banks' remits to

Box 1. European Central Bank and Bank of England mandates

Central bank mandates differ in their scope (see, for example, Barkawi and Monnin (2015) for an overview of the G20). The mandate of the European System of Central Banks (ESCB) is established by the Treaty of the Functioning of the European Union (2012). Article 127 of this treaty states that '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', which are defined in Article 3 as including 'social progress, and a **high level of protection and improvement of the quality of the environment**' [emphasis added].

Under the Bank of England Act (1998), the Bank of England operates as a politically independent entity, but the remit of the Monetary Policy Committee is given annually by the Treasury. As of 2017, the remit was to 'protect and enhance the stability of the financial system of the United Kingdom' and 'subject to that, to support the economic policy of Her Majesty's Government,' which is '**strong, sustainable and balanced growth in all regions and sectors of the economy**' (Hammond, 2017) [emphasis added].

Both mandates refer to the central banks supporting the economic objectives of their respective governments, which in the case of the ECB explicitly include environmental improvement. For the Bank of England, repricing of carbon-intensive assets and climate change damages could impact financial stability. This puts it under the Bank of England's remit, as noted by Governor Carney (Ahmed, 2015). A recent Bank of England staff paper also suggested that climate-related physical and transition risks could potentially lead to a reduction in the growth rate of the economy (Batten et al., 2016), which could have implications for the effectiveness of monetary policy.

focus on price stability. Indeed, it is widely accepted that the best tools for addressing the impact of emissions reductions are fiscal, ranging from carbon pricing to feed-in tariffs, market guarantees and standards and regulations. Thus while there has been discussion of how to deploy QE more strategically in order to promote sustainable economic growth (Ryan-Collins, 2013), or to specifically target low-carbon sectors (Anderson, 2015), the official positions of the Bank of England and ECB are to aim for sector neutrality and to avoid market distortions.⁵ However, as the next section shows, the available empirical and policy evidence seems to suggest that both current and past central bank interventions have had non-neutral⁶ effects on the economy and financial sector, which the mandates of both the ECB and Bank of England suggest that they should be considering (see Box 1 above).

3. Is quantitative easing neutral?

As a reaction to the 2007 financial crisis, the subsequent economic stagnation and the apparent inability of national governments to implement large fiscal recovery programmes, a large number of central banking institutions have adopted unconventional policy measures. After cutting reference interest rates to levels close to or lower than zero, they launched substantial QE programmes to purchase financial assets that, depending on the country, may include public sector (sovereign or supranational) bonds, asset-backed securities, covered bonds, corporate bonds, or equities.

Broadly speaking, QE operations consist of the concurrent purchase of financial assets and creation of a proportional amount of central bank reserves, where reserves are accounts that commercial banks hold at the central bank and use to settle inter-bank transactions. In other words, the central bank autonomously expands its own balance sheet, purchasing assets on secondary markets, employing newly created money, while putting new reserves at the disposal of private banks. Such QE programmes aim to reduce financing costs, encourage bank lending, stimulate private spending, achieve a stable rate of inflation around a pre-announced target and revive economic growth.

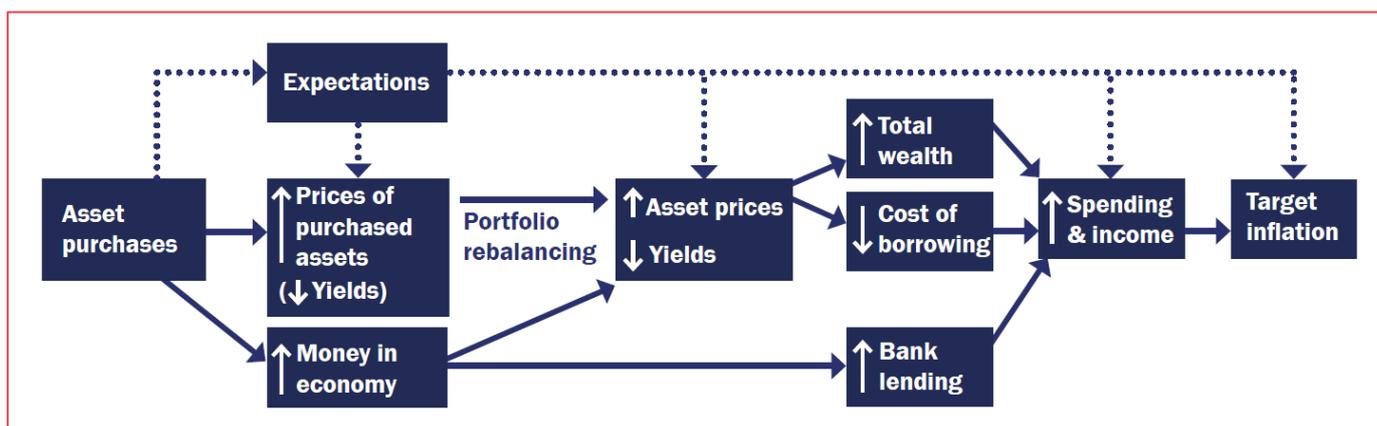
The sectoral effects of quantitative easing

In theory, QE is meant to act as a lever operating on the economy as a whole (see Figure 1 below). In a liquid and efficient market, the purchase of assets by a central bank should result in investors rebalancing their portfolios by selling the assets that are in high demand, and buying other assets that are relatively cheaper, leading to asset price increases across the board. This would decrease the cost of borrowing and encourage additional debt issuance, thus increasing investment and the rate of inflation and contributing to overall economic growth.

⁵ See, for example, the ECB's response to a freedom of information request regarding corporate bond purchases under the Corporate Sector Purchase Programme (CSPP), which references the intended neutrality of that intervention (Ask the EU, 2016).

⁶ Neutral meaning avoiding distortionary effects on the market.

Figure 1. Stylised transmission mechanism for asset purchases



Source: Authors, based on Benford (2009)

In practice, QE may have unintended effects due to frictions in the market and a lack of substitutability between assets (Haldane et al., 2016). For example, institutional investors may strongly prefer government bonds or investment-grade corporate bonds because they are looking for a low-risk, liquid and stable investment for a long-term time horizon. In the EU, the corporate bond market is relatively shallow, such that a large purchaser like the ECB can absorb quite a lot of the market. Rather than taking on more risk by buying junk bonds, or entering into a bidding war with the central bank, investors might choose to, for example, look abroad to US investment-grade corporate bonds to rebalance their portfolio (Bowman, 2016). In that case, while asset prices in some areas (e.g. investment-grade corporate bonds) would increase, the pass-through to other assets, asset classes and the domestic economy would be more diffuse.

Looking at the quantitative evidence, the most direct and easily demonstrable effect of QE is on the assets – usually government bonds – being purchased, while the impact on other assets is more difficult to separate from other influences (Joyce et al., 2010). The available evidence suggests, however, that QE benefits the asset being purchased, and assets with a similar risk profile, relatively more than other asset classes. In the US, purchases of Treasury bonds lowered the yields of those bonds and of low-risk bonds relatively more than higher-risk bonds (Krishnamurthy and Vissing-Jorgensen, 2011, 2012; Rogers, 2014). In the UK, micro-analysis of institutional investors shows that the purchase of Gilts resulted in some portfolio rebalancing effects towards corporate bonds, but not towards equities (Joyce et al., 2015). As noted above, some investors might have such a strong preference for government bonds that investment-grade corporate bonds are an imperfect substitute (being also relatively safe and liquid), while other assets (like junk bonds or equities) are an even more imperfect substitute because they carry higher risk. In a global economy, investors also have the option of shifting their investments abroad, such that not all the effects would be observable domestically.

Accordingly, the pass-through to productive investment is unclear (Ryan-Collins, 2013), and the overall effectiveness in terms of macroeconomic growth difficult to measure (Gros et al., 2015). Researchers from the International Monetary Fund, Bank for International Settlements and the Organisation for Economic Cooperation and Development have highlighted concerns that QE and loose monetary policy have increased asset prices in the financial markets to a level that is out of step with underlying economic fundamentals (Jones, 2015; Nassr et al., 2016; Vinals et al., 2013).

In order to stimulate the larger economy more directly, central banks have sometimes directly targeted certain sectors with their QE interventions, particularly household lending. Far from aiming for neutrality, the US Federal Reserve deliberately targeted mortgage-backed securities in its first

round of QE from 2008 to 2010 in order to 'provide support to mortgage and housing markets' (Federal Reserve Bank of New York, 2010). By cleaning up banks' balance sheets from underperforming and illiquid assets, QE freed them to extend more credit to the larger economy and helped to lower mortgage rates (Khemraj and Yu, 2016). It has been considered a particular success, with a wider macroeconomic impact than the second round of QE in 2011, which focused on Treasury bonds only (Krishnamurthy and Vissing-Jorgensen, 2011).

The Federal Reserve is not alone in using measures targeted to certain sectors: long-term refinancing operations conducted by the ECB have had the explicit aim of increasing lending to the real economy (ECB, 2016a). The Bank of England's Funding for Lending Scheme has targeted household lending (until November 2013) and lending to small and medium-sized enterprises (SMEs) (Bank of England, 2016a). Ryan-Collins (2013) describes how the bonds issued by the Canadian Industrial Development Bank were purchased by the Bank of Canada to support loans to SMEs.

The latest rounds of QE from the ECB and the Bank of England, which have both expanded their reach to include corporate bonds, seems to support these findings of a variable effect for the assets being purchased under QE. For bonds eligible for ECB purchase, analysis made shortly after the purchases started showed that yield spreads had widened since the announcement in March 2016 and for those bought since June of that year, showing both a lower cost of borrowing for the entire class of eligible bonds and for the bonds that had been bought specifically (Keohane, 2016). Following the announcement of the Bank of England's Corporate Bond Purchase Programme, eligible bonds – that is, investment-grade sterling-denominated – significantly outperformed their high-yield counterparts, and yields dropped to record lows (Lewin, 2016). Corporate bond issuance by investment-grade non-financial firms also increased significantly (Haldane et al., 2016).

Environmental implications of the choice of asset class

While the intention is to use asset purchases as a lever to stimulate growth overall, the literature suggests that the transmission channels work imperfectly, with relatively more benefit for the assets being purchased relative to other assets. This suggests that the overall effect is not neutral, and the choice of asset and asset class has an impact. Both the ECB and the Bank of England seem to be aiming for what they consider to be 'neutrality' in the sense of avoiding market distortions, but the choice of instrument – bonds rather than equities, covered bonds, asset-backed securities – itself has an impact (explained in detail in the next section). Even within an asset class, the action of allocating purchases according to the makeup of the market, or the economy, is a decision to maintain the status quo – and arguably, therefore, is not truly neutral as it does have a selective effect on the larger economy, by supporting industry incumbents and reinforcing existing market distortions compared with the socially-optimal distribution of capital.

Of the available asset classes, public sector purchases leave the decision about the allocation of capital to fiscal authorities; equities tied to a benchmark would reflect the emissions intensity of the stock market as a whole; covered bonds and asset-backed securities may structurally disadvantage green loans; and corporate bonds may skew towards high-carbon sectors.

Public sector purchases

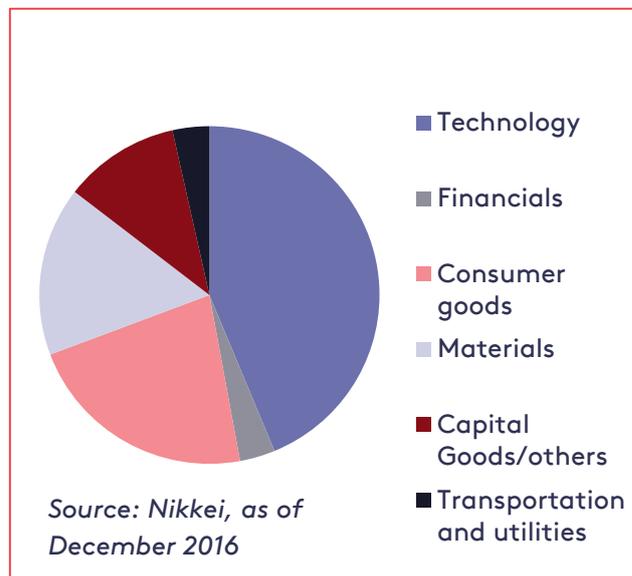
Central banks have generally focused on purchasing government bonds to implement their monetary policy decisions. Any environmental impact of these purchases of sovereign bonds would depend on government commitment to support low-carbon activities through direct spending – for example, both France and Poland have recently issued sovereign green bonds (Agence France Trésor, 2017; Kidney, 2016) – or preferential fiscal treatment.

In some cases, development bank bonds may also be eligible for purchase, in which case the environmental impact of the purchase of bonds will depend on the lending decisions adopted by the single development banks. The EU Green Party’s proposal for ‘green QE’ suggests purchasing an increasing number of European Investment Bank (EIB) bonds (Anderson, 2015), though there would be several obstacles to implementing such a proposal (see Section 5 for more details).

Equities

The Bank of Japan is unusual in that its QE programme has led and continues to lead to significant purchases of equities through exchange traded funds (ETFs) based on Japanese stock market indices. As a consequence, it is already one of the top shareholders in several companies, and is on track to be the number-one shareholder in 55 of those (Kitanaka et al., 2016). Industry analysts have expressed concern that the Bank of Japan is creating market distortions by implicitly guaranteeing the stock prices of the purchased firms, thus increasing the asset prices out of line with fundamentals and potentially undermining attempts at reforming corporate governance (Lewis and Colback, 2016; Witherell, 2016).⁷

Figure 2. Nikkei 225 sectoral weighting



While the Bank of Japan does not provide a company-level breakdown of its holdings, an ETF tracked to the Nikkei would skew towards technology and consumer goods (see Figure 2), suggesting that the choice of instrument itself can already alter the sectoral distribution. As in Europe, Japan’s manufacturing, transport and energy production sectors are the most carbon-intensive (Japanese Ministry of the Environment, 2016). Looking solely at the sectoral distribution implied by the asset class, this would suggest that relative to the ECB and the Bank of England, the Bank of Japan’s portfolio is rather less carbon-intensive (mainly due to the smaller weighting for utilities compared with their European counterparts), though it still focuses on industry incumbents and has a large share devoted to manufacturing. Equity-holders might, however, be more affected by a revaluation of assets related to climate-related risks.

The Bank of Japan has also asked the financial industry to develop customised ETFs focusing on ‘physical and human capital’ in order to stimulate growth (Lewis, 2016), which provides another illustration of intentional sectoral tilts in central bank asset purchases.

Asset-backed securities (ABS) and covered bonds

The Bank of England is not currently purchasing covered bonds or asset-backed securities (ABS), but the ECB purchases both in order to facilitate lending to the real economy (ECB, 2017a). After public sector purchases, covered bonds make up the second largest area of ECB purchases (see Table 2 below). There are legal restrictions on the issuance of covered bonds that exclude many types of loans, including to renewable energy companies (Damerow et al., 2012).

⁷ As another example, the Swiss National Bank (SNB) also holds an estimated US\$61.8 billion in equity holdings, including large American companies such as Apple and Exxon Mobil (Bosley, 2016). It retains voting rights and has exercised them in the past (Swiss National Bank, 2017), though the assets were not purchased as part of a QE operation.

Table 2. Asset purchase programme holdings of the European Central Bank, April 2017 (€m)

Changes of holdings	Asset Backed Securities Purchase Programme (ABSPP)	Covered Bond Purchase Programme 3 (CBPP3)	Corporate Sector Purchase Programme (CSPP)	Public Sector Purchase Programme (PSPP)	Asset Purchase Programme (APP) Total
Holdings March 2016*	24,190	214,446	75,455	1,457,652	1,771,743
Monthly net purchases	-408	1,928	6,807	54,311	62,638
Holdings April 2017*	23,782	216,374	82,262	1,511,963	1,834,381

**Note: At amortised cost, in million euros, at month end. Figures may not add up due to rounding. Figures are preliminary and subject to change.
Source: ECB (2017a)*

As for ABS, the ECB does not publish details of its purchases (ECB, 2016b), which makes it difficult to assess their carbon intensity. Notably, however, it has included ABS backed by loans for Volkswagen cars (Barker, 2015) and other automotive companies; ECB support has reportedly led to additional issuance of these ABS (Viita, 2014). The ECB collateral eligibility requirements suggest that green ABS might not currently be eligible (discussed in more detail in Section 5 below).

Additional information about how and which ABS are selected would be desirable, especially as the programme has been designed in order to encourage additional issuance of ABS, and the green ABS market has been particularly highlighted as an area of significant growth in the 2020s (Kidney et al., 2017; OECD, 2016a), which suggests that central bank support has the potential to help develop what is as yet a nascent sector. As noted above, the Federal Reserve purchased mortgage-backed securities in the first round of QE after the 2008 financial crisis with the explicit aim of encouraging increased lending to households (Khemraj and Yu, 2016; Krishnamurthy and Vissing-Jorgensen, 2011; Ryan-Collins, 2013).

Corporate bonds

By picking corporate bonds, the central bank has to make purchase decisions between sectors; even allocating purchases according to the existing makeup of the bond market is a decision to allocate capital to those companies that are particularly exposed to debt markets, potentially reproducing existing market distortions and inefficiencies (in the form of an over-allocation of capital to high-carbon sectors and an under-allocation to low-carbon sectors).

The ECB and Bank of England have recently expanded their QE programmes to include corporate bonds. The ECB started the Corporate Sector Purchase Programme (CSPP) in June 2016 to 'provide further monetary policy accommodation and contribute to a return of inflation rates to levels below, but close to, 2%' (ECB, 2016c). To be eligible for purchase, bonds need to be considered as 'investment-grade' by at least one major rating agency. As of April 2017, the ECB had already accumulated €75 billion-worth of corporate bonds (ECB, 2017a). The national central banks entrusted with carrying out the purchases regularly publish the list of individual securities they have bought, but not the purchase amounts by issuer.

The Bank of England first initiated an asset purchase programme of £50 billion targeting corporate bonds in 2009, which largely concluded in 2010 (Bank of England, 2009). In September 2016 the Bank launched its Corporate Bond Purchase Scheme (CBPS), with the aim of purchasing ‘a portfolio of up to £10bn of sterling bonds representative of issuance by firms making a material contribution to the UK economy, in order to impart broad economic stimulus’ (Bank of England, 2016b).

4. Analysis: ECB and Bank of England corporate bond purchases

The literature suggests that the choice of instrument has variable effects, as noted above. A closer sectoral analysis of the publicly available data (sources detailed in Appendix 1) on the ECB’s and Bank of England’s corporate bond purchases suggests that the purchases broadly reflect the non-financial corporate bond market, which is disproportionately skewed towards high-carbon sectors relative to the sector’s contribution to the European economy, as well as the socially optimal distribution of low-carbon investment. Utilities, the most carbon-intensive sector by emissions, also make up the largest share of purchases for both the ECB and the Bank of England. Renewable energy companies, already a relatively small portion of the bond market to begin with, are not represented at all in ECB or Bank of England purchases, while oil and gas companies make up an estimated 8.4 per cent and 1.8 per cent of their portfolios, respectively.

Carbon intensity of corporate bonds markets

The European bond market as a whole is dominated by bonds from the financial sector (see Table 3 below, column 2). ‘Green’ or ‘climate-aligned’ bonds make up a relatively small portion of the global bond market: Climate Bonds Initiative (2016) estimates that of the US\$90 trillion global bond market, approximately US\$694 billion-worth of bonds (less than 1%) are climate-aligned. For renewable energy specifically, finance from public markets currently makes up a small share of overall financing (McCrone et al., 2016). Green bonds are a nascent sector facing immediate challenges,⁸ though the OECD projects strong growth in the next few years and in the 2020s in particular (OECD, 2015, 2016a). This means that, currently, there is a constraint on the assets available for purchase, but also suggests that, if and when the green bond market increases in size, it is worth examining if there will be institutional or structural factors such as credit rating that would constrain their future eligibility (see Section 5).

Carbon intensity of eligibility criteria

ECB eligibility criteria

In order to be eligible for purchase under the Corporate Sector Purchase Programme, a corporate bond must meet specific criteria: it must be denominated in euros, eligible as collateral for Eurosystem credit operations, rated investment-grade by at least one credit rating agency, and have a maturity of between six months and 30 years (ECB, 2016c, 2017b). The issuer must be established in the euro area and cannot be a credit institution or asset management vehicle (in other words, it must be a non-financial corporation).

Each of these criteria narrows the range of eligible bonds, from a universe of about 80,000 euro-denominated corporate bonds (Table 3, column 2) to 1,156 that meet the ECB eligibility criteria

⁸ For example, a lack of commonly accepted certification standards, a pipeline of bankable projects, and underdeveloped domestic bond markets (OECD, 2015).

(column 6). Out of these bonds eligible for purchase, the list of current holdings published by the Eurosystem central banks implementing the CSPP (column 7) contains 846 unique securities.

Table 3. Sectoral distribution (%) of EU corporate bond market, Corporate Sector Purchase Programme-eligible bonds, and estimated purchases, by share of total amount outstanding, according to BICS* sector

1: BICS sector classification name	2: All Euro corporate bonds (%)	3: All corporate bonds except finance (%)	4: Corporate bonds of eligible maturity (%)	5: Investment-grade corporate bonds of eligible maturity (%)	6: CSPP-eligible (%)	7: Estimated purchases (%)
Communications	4.38	13.10	12.81	10.78	11.54	11.11
Consumer discretionary	5.08	15.20	15.34	12.52	14.37	11.07
Car/automobile manufacturing	2.16	6.47	6.19	7.98	9.85	6.84
Consumer staples	2.35	7.02	7.43	8.43	7.71	8.57
Food & beverage	1.52	4.55	4.94	5.97	7.00	6.97
Energy	2.55	7.64	7.29	8.25	8.63	9.54
Integrated oils	1.71	5.11	4.68	6.03	7.58	8.40
Renewable energy	0.18	0.55	0.54	0.26	0.02	0.00
Financials**	70.72	12.35	11.13	12.30	8.64	8.36
Government***	0.00	0.00	0.00	0.00	0.00	2.62
Health care	1.76	5.26	5.29	5.98	4.31	4.26
Industrials	3.99	11.93	12.72	11.10	11.16	10.63
Materials	3.57	10.69	11.16	8.55	7.62	7.39
Technology	0.64	1.92	1.96	1.64	1.58	1.78
Utilities	4.97	14.89	14.87	20.45	24.45	24.67

*Notes: *BICS = Bloomberg Industrial Classification System. **Financial institutions under supervision are excluded from purchase; however, other financial actors such as real estate and financial services are eligible. *** As detailed in Appendix 1, Columns 1–6 are based on a search of ECB-eligible bonds from Bloomberg Terminal, which excludes 'government' bonds as ineligible (using BICS sector classification). Column 7 is based on the list of international securities identification numbers (ISINs) provided by the ECB, in which four government-backed entities appear: Deutsche Bahn, SNCF, Sagess and RATP group.*

Sources: Bloomberg (2017); ECB (2017), authors' own calculations. See Appendix 1 for further details.

Table 3 shows that the estimated purchases seem to match up with the sectoral distribution of the universe of eligible bonds, though the eligible universe does not match the bond market as a whole, due in large part to the exclusion of bonds from financial institutions. The restrictions on maturity and investment grade status also eliminated a number of the renewable energy issuers from the list of ECB-eligible bonds. Notably, there were four euro-domiciled renewable energy issuers – Innogy SE, Vela Energy, WindMW, and Breeze Finance SA – that meet the maturity and credit rating criteria but are not among the assets purchased. Three of these were ineligible under the ECB's collateral eligibility framework, namely Vela Energy, WindMW, and Breeze Finance SA, which suggests it could be a useful exercise to consider how emerging technologies may be (in)eligible under the collateral framework (see Section 5).

The corporate bond market itself is only a subsection of the financial market (excluding, for example, equities and sovereign bonds as well as bank loans), which does not reflect the distribution of the economy and which is itself already sub-optimally tilted towards high-carbon industry. In other words, the CSPP-eligible universe does not reflect the entire bond market, which does not reflect the real economy, which does not reflect the socially optimal state of low-carbon capital distribution.

Bank of England eligibility criteria

Table 4. Sectoral distribution of UK corporate bond market, Corporate Bond Purchase Programme-eligible bonds, and estimated purchases, by share of total amount outstanding, by BICS* sector

1: BICS sector classification name	2: All sterling corporate bonds (%)	3: All corporate bonds except finance (%)	4: All corporate bonds of eligible maturity (%)	5: Investment grade corporate bonds of eligible maturity (%)	5: CBPP-eligible (%)	7: Bank of England benchmark list of eligible bonds (%)
Communications	8.64	14.29	13.15	12.48	12.89	12.23
Consumer discretionary	11.31	18.71	18.49	13.10	13.32	10.83
Car/automobile manufacturing	2.55	4.22	3.44	3.37	3.46	3.42
Consumer staples	5.42	8.96	8.88	7.98	8.09	10.50
Food & beverage	1.67	2.76	2.62	2.38	2.30	1.72
Energy	2.23	3.70	3.59	3.68	3.81	2.95
Integrated oils	1.35	2.24	2.28	2.33	2.42	1.83
Renewable energy	0.02	0.03	0.03	0.00	0.00	0.00
Financials**	46.89	12.11	12.55	11.13	11.06	6.60
Government***	0.00	0.00	0.00	0.00	0.00	2.80
Health care	2.48	4.10	4.30	4.48	4.54	5.85
Industrials	5.02	8.31	8.58	9.71	9.71	6.15
Materials	1.26	2.08	1.86	2.31	2.40	1.20
Technology	0.51	0.85	0.87	1.14	1.18	1.46
Utilities	16.25	26.89	27.73	33.99	33.00	39.44

Notes: This table is based on the BICS industrial classification system, while the Bank of England provides the breakdown of purchases according to a different sectoral classification system – see Appendix 1 for details. * BICS = Bloomberg Industrial Classification System. **Financial institutions under supervision are excluded from purchase; however, other financial actors such as real estate and financial services are eligible **Financial entities under their supervision are not eligible for purchase, but this category also includes real estate and financial services. ***As detailed in Appendix 1, Columns 1–6 are based on a search of bonds from Bloomberg Terminal that meet the Bank of England’s eligibility criteria, which excludes ‘government’ bonds (using BICS sector classification). Column 7 is based on the list of eligible ISINs provided by the Bank of England, includes government-backed entities such as Transport for London.

Sources: Bloomberg (2017); Bank of England (2017); authors’ calculations. See Appendix 1 for further details.

The Bank of England’s Corporate Bond Purchase Programme targets sterling-denominated investment-grade bonds ‘representative of issuance by firms making a material contribution to the UK economy’ and ‘designed to purchase a balanced portfolio of bonds across eligible issuers and sectors, so that we purchase a representative portion of the market and do not influence the allocation of credit to particular companies or sectors of the economy’ (Bank of England, 2016b). Similarly to the ECB, the Bank appears to be targeting a benchmark that reflects the makeup of the eligible bond universe and excludes financial firms under its supervision. While the sectoral distribution of the benchmark is similar to the universe of investment-grade bonds, excepting financial services, it does not reflect the economy as a whole or the socially optimal state (see above). Notably, the oil and gas industry makes up a much smaller percentage of the Bank of England’s benchmark compared with the ECB’s, though utilities make up a larger share.

Carbon intensity of purchases

The sectoral distribution of purchases also appears to be inconsistent with the sectoral distribution of the euro-area economy in terms of contribution to gross value added (GVA), and skewed towards sectors characterised by high greenhouse gas emissions.

Figure 3. ECB Corporate Sector Purchase Programme purchases, contributions to euro-area gross value added (GVA) and to greenhouse gas emissions (carbon dioxide equivalent), by NACE sector

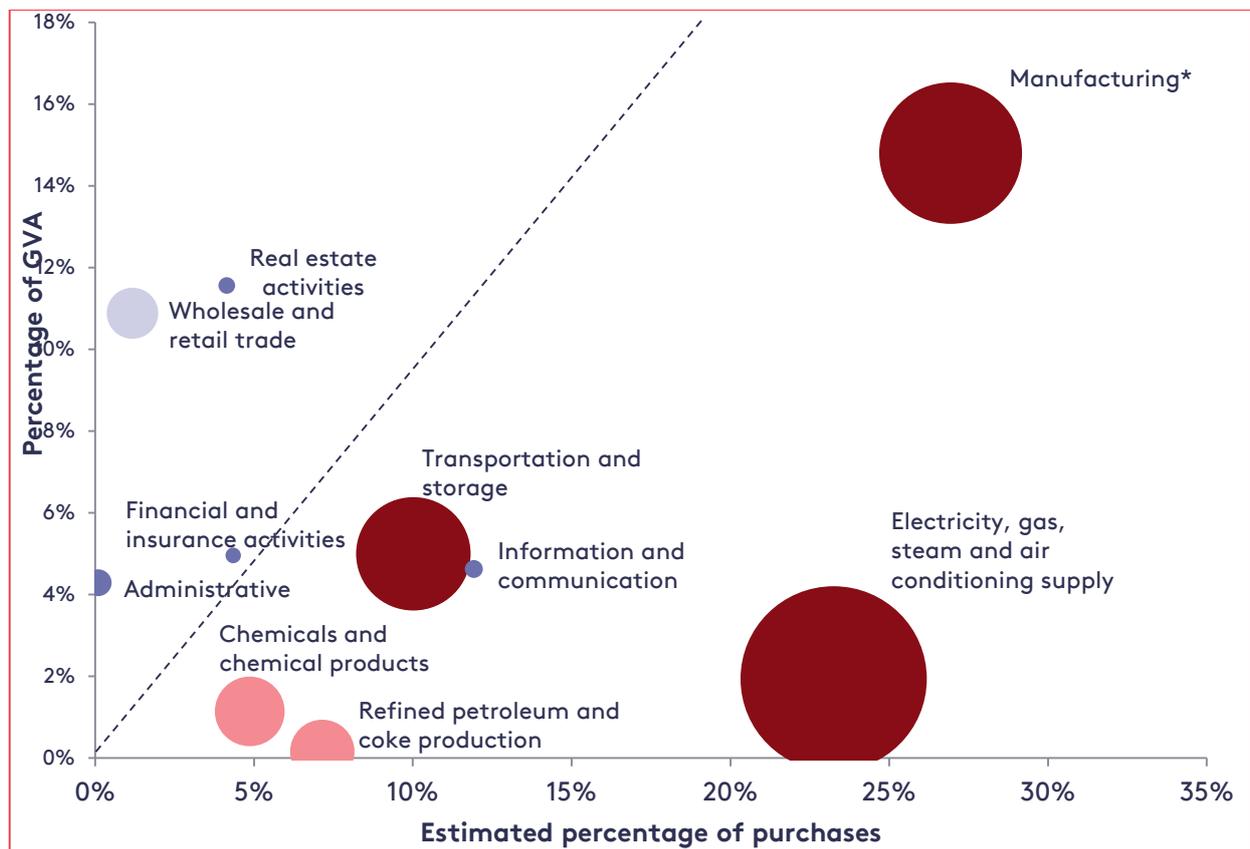


Figure notes: Size of the bubble indicates relative contribution to emissions in euro-area countries. Colours are indicative of the more (red) and less (blue) carbon-intensive sectors. NB: This graph uses a different sector classification system from Tables 2 and 3 – see Appendix 2 for details. *The manufacturing category excludes petroleum and chemical production, which are listed separately. For ease of viewing, only the sectors with more than 1% of estimated purchases are shown and the names of some sector categories have been appended; see Appendix 2 for full list. **Sources:** ECB (ISINs, as of February 2017), Bloomberg (NACE categories, 2017), Eurostat (emissions and GVA data, as of 2013), and authors’ calculations.

All of the sectors beneath the 45 degree line in Figure 3 – meaning a larger proportion of purchases than their proportional contribution to GVA – are emissions-intensive, with the exception of information and communication. The two largest sectors by purchases, manufacturing and utilities, are also the two largest in terms of contribution to emissions (although there is considerable variation between utility firms in their emissions levels, depending on their energy portfolio). Both, but utilities in particular, account for a share of ECB corporate bond purchases that lies significantly above their contribution to GVA.

Moreover, chemical and petroleum products make up a significant portion of purchases, despite contributing less than 1 per cent of the Eurozone area’s GVA. They are also fairly emissions-intensive, even more so when taking into account that the emissions data from Eurostat does not include end-use emissions, e.g. the combustion of petroleum products: the sectoral emissions would be even larger if downstream activities were included.

In contrast, sectors such as wholesale and retail trade and real estate make up a relatively small percentage of purchases, though they contribute a relatively large amount to GVA and relatively little to emissions. To a certain extent, this could be attributable to the high capital intensity of sectors such as manufacturing and utilities. However, as discussed above and shown in Table 3, the structure of the eligibility criteria has meant that while utilities only make up 5 per cent of the EU bond market as a whole, they make up 25 per cent of the purchases, while other industries that started out at a similar level (such as communications) ended up making up a much smaller proportional share of the purchases. The NACE sectors of manufacturing and electricity production alone constitute an estimated 62.1 per cent of CSPP purchases, 58.5 per cent of Eurozone area emissions, but only 18 per cent of GVA.

Figure 4. Bank of England corporate bond purchase programme benchmark, gross value added (GVA) and greenhouse gas emissions (carbon dioxide equivalent), by NACE sector

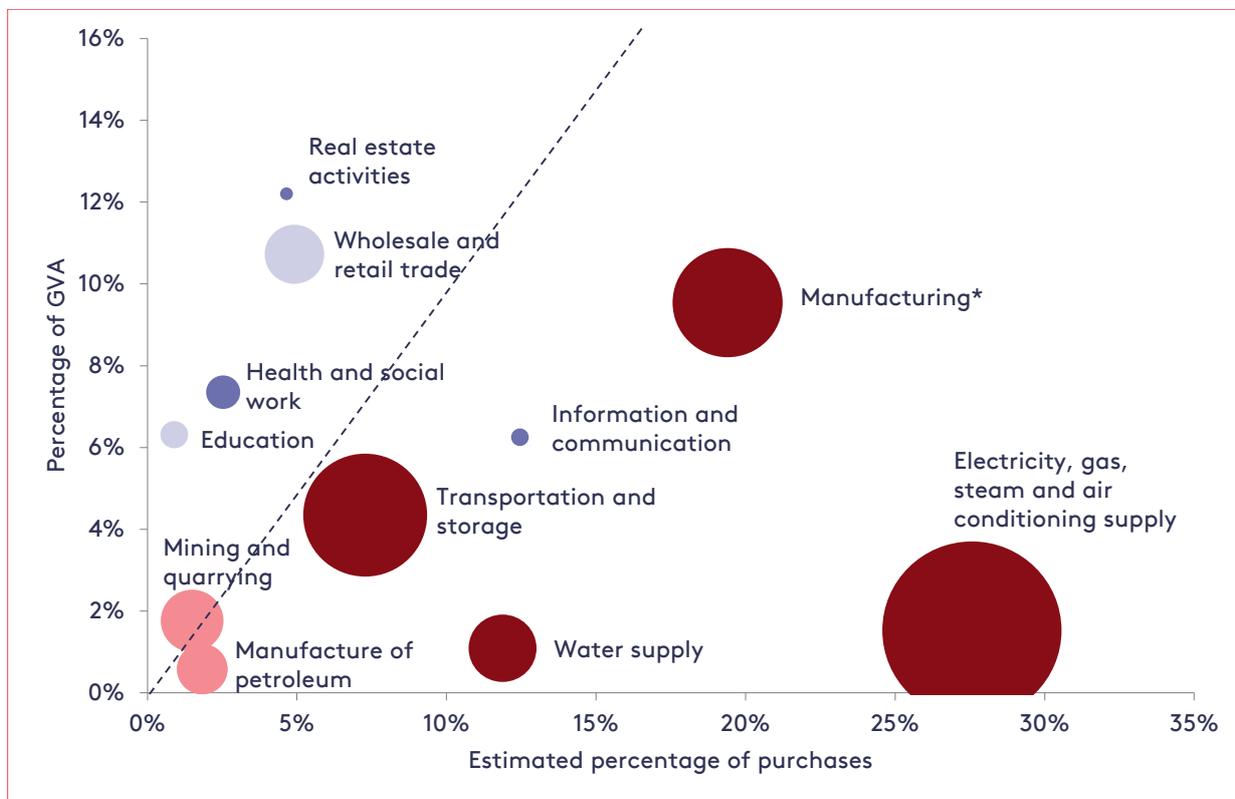


Figure notes: Size of bubble indicates relative contribution to emissions in the UK. Colours are indicative of the more (red) and less (blue) carbon-intensive sectors. *The manufacturing category excludes petroleum and chemical

production, which are listed separately. For ease of viewing, only the sectors with more than 1% of estimated purchases are shown and the names of some sector categories have been appended. NB: This graph uses a different sector classification system from the Bank of England and Tables 2 and 3 – see Appendix 2 for details of this and full list of sector categories. Sources: Bank of England (ISINs, as of February 2017), Bloomberg (NACE categories, as of 2017), Eurostat (emissions and GVA data, 2013), and authors' calculations.

As Figure 4 shows, the sectoral distribution of the Bank of England's benchmark is similar, with the two largest contributors to industrial emissions – manufacturing and utilities – also making up the largest share of purchases, though there is slightly more diversity in its holdings overall. In addition, oil and gas make up a much smaller percentage of the Bank of England's estimated purchases compared with the ECB. The NACE sectors of manufacturing and electricity production alone make up 49.21 per cent of the eligible benchmark, 52 per cent of emissions, but only 11.8 per cent of GVA.

Effects of corporate bond purchase programmes

The aim of the ECB's Corporate Sector Purchase Programme is to encourage additional debt issuance and lower borrowing costs, which, according to the Bank's own assessment, has been working (Buell, 2016). Two of the issuers whose bonds the ECB has purchased, Henkel and Sanofi, were the first public companies to issue negative-yielding euro bonds (Jackson, 2016), and the programme has reportedly led to a record level of corporate debt issuance (Yap, 2016). Market analysis (Keohane, 2016) suggests that these benefits have accrued selectively, however, with the issuers of CSPP-eligible bonds benefiting from lower yields relative to unpurchased or ineligible bonds, as indeed the literature on differential effects for different asset purchases suggests.

On a more granular level, for both the ECB and the Bank of England, their purchases in the energy sector have been restricted to oil and gas companies exclusively: Apetra, ENI, OMV, Petrol, Shell, Repsol, Sagess, Schlumberger, Total, Transport ET and Vier Gas for the ECB; and BG Energy, BP, Rio Tinto, Shell and Total for the Bank of England. Shell in particular was one of the issuers specifically highlighted by the press as having benefited from the announcement of the ECB programme, as its bond yields dropped below zero (Bakewell, 2016).

As a response to a cyclical economic downturn, QE is itself a temporary phenomenon. However, the effects of QE can lead to long-term implications. Additional debt issuance for investment in long-dated infrastructure could contribute to carbon lock-in, in which path dependency reinforces energy systems constructed around fossil fuels (Unruh, 2000). As it is, the oil and gas sector has been increasing its levels of debt even while on downgrade watch (Blas, 2016; Crooks, 2016), leading to concern about default risk and unsustainable levels of indebtedness (Loder et al., 2016). By encouraging additional debt issuance from carbon-intensive sectors, this could be exposing the financial system to higher transition-related risks in the future and could undermine the signal that central banks are trying to send about how seriously they take climate risk.

On the other side, low-carbon assets and sectors seem to be relatively under-represented, with neither the ECB nor the Bank of England purchasing any bonds from renewable energy issuers. The dearth of green assets in the ECB's and Bank of England's corporate bond purchase programmes suggests not a deliberate attempt to exclude them but rather that much of green investment is taking place through funding structures other than corporate bonds. However, low-carbon bond issuance⁹ is expected to increase over the next 10 years in particular (OECD, 2016a), and the lack of representation of renewable energy bonds in the purchase programmes raises questions of how the eligibility or decision-making criteria favour large, incumbent industries. As shown in the literature, since the pass-through effect from purchased bonds to high-yield bonds is already indirect, it

⁹ The OECD does not speculate on whether these bonds will be labelled 'green' as such; currently bonds that are labelled 'green' make up a relatively small proportion of the overall 'climate-aligned' bond universe (Climate Bonds Initiative, 2016).

appears that green sectors benefit under-proportionately from QE. If this is the case, the current allocation of newly created purchasing power would stand in direct contradiction with the concerns among central banks about climate financial risk. QE could be utilised differently to address the risk of a structural bias towards high-carbon sectors and potentially to help address the green investment gap.

5. Recommendations and policy options

The sub-optimal allocation of capital to low-carbon industries is an economy-wide, structural problem. The best solution is to price externalities adequately and durably, and provide a credible and stable decarbonisation policy environment so that market prices fully reflect climate transition risk when capital is allocated.

In a second-best world, policy efforts should be aligned as much as possible across institutions in order to increase their effectiveness. Echoing the language of the ECB and Bank of England mandates, monetary policy should seek to support these general economic objectives without conflicting with their primary objective of price stability. The central bank response should focus on increasing transparency around the selection process for these bonds, additional research on the impacts of these asset purchase programs and policy options to address them, and coordination with the appropriate fiscal and regulatory authorities to address possible institutional barriers to scaling up low-carbon finance and investment.

Recommendation 1:

The European Central Bank and Bank of England should increase transparency around the purchases and selection process

- In the case of the ECB, the lack of underlying data on covered bonds and asset-backed securities in particular makes it difficult to assess the carbon-intensity of the assets purchased, for example the purchase of asset-backed securities backed by automotive loans. The eligibility criteria note that the ECB carries out due diligence on the loans but do not mention whether this includes an assessment of climate-related or environmental risk, though the collateral eligibility criteria suggest that asset-backed securities based on renewable energy and energy efficiency loans may not currently be eligible.
- The Bank of England specifies that the bonds should come from issuers that make a 'material' contribution to the UK economy. It should clarify how it makes this judgement, and whether or not climate change risk is taken into account.
- Disclosing how climate change risks are being incorporated into decision-making would not only facilitate analysis, it would also mirror the recommendations that have been put forward in 2016 for the private sector by the Task Force on Climate-Related Financial Disclosure. While the recommendations of the Task Force are aimed at the private sector, the principle of encouraging voluntary disclosure could apply more widely. Central banks also help set discussion in the larger financial community – see, for example, the influence of Bank of England governor Carney's speeches on climate change – so intervention by central banks could lead by example. This could also highlight if the central bank balance sheets are vulnerable to transition risk.

Recommendation 2:

Central banks should investigate the impact of their interventions on both high-carbon and low-carbon investment

- The ECB and Bank of England should consider not only how their operations are affected by climate change and the transition to a low-carbon economy but also how their operations could affect the transition itself.
- In particular, central banks should study the implications of a structural carbon bias in their asset purchases, and whether this meaningfully affects asset prices and debt issuance, such that it contributes to asset mispricing and carbon lock-in.
- As part of this analysis, the ECB and Bank of England might consider the sectoral distribution of the asset class they are using (for example, covered bonds, corporate bonds, asset-backed securities) and a more granular analysis of the individual issuers purchased.
- The process of investigating and publicly commenting on the issue would in itself send a clear signal to financial markets that central banks and financial supervisors are taking climate change risks seriously.
- Research of this nature could go beyond asset purchases to consider the operation of monetary policy instruments more generally, including, for example, collateral eligibility frameworks.¹⁰

Recommendation 3: The European Central Bank and Bank of England could consider options for changing their purchasing strategy

- In parallel with researching the magnitude and nature of the impacts of monetary policy operations, central banks should consider their role in aligning policy with the larger effort to support the transition to a low-carbon economy.
- Central banks could take a more proactive approach to incorporating climate considerations into their purchase strategies, though there are benefits and drawbacks that would require further consideration.

Two options are outlined below.

Option A: Revise risk criteria for eligible assets

Central banks could address some of the risk associated with high-carbon assets by incorporating climate considerations into the eligibility criteria. According to the current criteria, bonds are eligible for purchase if they are rated as investment-grade by at least one ratings agency (ECB, 2016c). A more proactive approach to credit risk could, for example, require two or more of the agencies to agree on the investment-grade status, or could screen bonds from issuers that are being monitored for potential credit ratings downgrades. Of the big three ratings agencies, S&P and Moody's are beginning to incorporate climate risk into their assessments, while Fitch Ratings has not commented on the issue (to the best of the authors' knowledge).

With the methodology still under development, however, it may not fully and adequately account for climate risks (Center for International Environmental Law, 2015). Taking the 'best' credit rating, then, might favour an unreasonably optimistic methodology, or one that lags behind the others in assessing climate risk.

¹⁰ Recent research suggests that collateral eligibility frameworks can have a distortionary effect on the market (Nyborg, 2017). Further research could examine, for example, the impacts of collateral frameworks on low-carbon investment. This is also relevant for asset purchases, since the ECB has stated that assets purchased under the CSPP must be eligible under the collateral framework (ECB, 2016c).

The fact that credit ratings agencies in the past collectively missed systemic credit risk events may serve as a further reason for caution in this context (for example, see the 2008 mortgage crisis: Bolton et al., 2012; Hilscher and Wilson, 2015). Against this background, central banks may want to explore options to incorporate environmental, social and governance criteria into their purchase decisions. While independent analysis arguably would be beneficial not only for climate risk but for credit risk more generally, one of the major criticisms of credit ratings agencies is that the issuer pays for the assessment, which compromises the integrity of the ratings (Bolton et al., 2012; Xia and Strobl, 2012). This might be a time- and resource-intensive task for the central bank to undertake. Doing so would require deciding which ESG ratings, or which elements of these ratings, would be most relevant to consider and to what end. For example, would the target be to reduce default risk only, or would there be some consideration of other social objectives? And if so, which ones?

Option B: Revise the purchasing strategy

Another proposed option has been for QE to prioritise purchases of low-carbon assets in order to promote sustainable growth – either in isolation or in conjunction with other policies to address risks to financial stability. This ‘green QE’ would provide a large and stable demand for green bonds issued by companies or public development banks (Murphy and Hines, 2010; Anderson, 2015). The OECD (2015, 2016a) has highlighted that green bonds will be a large and growing market in the 2020s globally, with corporate bonds and asset-backed securities playing a potentially large part in Europe, and it emphasises the need for policy support in developing the market.

Investing in renewable energy and sustainable infrastructure could be a more effective way to promote long-term growth, in that investment in infrastructure and technology will have to be low-carbon in order to be future-proofed and consistent with the long-term emission reduction targets legislated by the EU and the UK government (Zenghelis, 2016). This could also address the ECB’s and Bank of England’s mandate to support the respective general economic policies of their governments, namely protection of the environment (ECB) and broad-based sustainable growth (Bank of England).

However, there are several open questions over the feasibility of this strategy. Given the current size of the green bond market in Europe, would it be deep enough for the Bank of England or ECB to wade into? If not, how could a green QE programme help expand it and what standardisation, e.g. of asset-backed securities based on renewable energy loans, would be needed to move in this direction? Also, given the time horizons of QE interventions, the Bank of England and ECB might not hold the assets to maturity – that is, they could unwind their position by selling the bonds once inflation picks up – leading to questions of whether or not this would be a stable long-term source of demand for green assets that could help the nascent market develop. Focusing on one sector also raises the question of whether this could be ‘too much of a good thing’, in that it could also contribute to mispricing – of low-carbon rather than high-carbon assets.

A possible approach in this context is to purchase public bonds from development banks. In the case of the ECB, this could be structured, for example, by purchasing European Investment Bank (EIB) bonds in order to support their green financing and lending programmes (Anderson, 2015). A close look at current constraints of such bond purchases and possible solutions would be an important first step in this context. First, the ECB cannot buy EIB bonds on the primary market due to the prohibition against monetary financing in Article 123 of the Treaty on the Functioning of the European Union. Accordingly, such purchases would need to be (and have been) carried out on the secondary market, which suggests that – by design – the impact on the cost and availability of funding would be indirect. Second, EIB loans are limited to 50 per cent of a project’s financing, meaning that an increase in lending by the EIB would need to be matched by additional funding from private banks or EU grants (EIB, 2017). Third, many development banks in general, and the EIB

in particular, are constrained in their lending by predetermined leverage ratios. In the case of the EIB, its total lending cannot exceed 250 per cent of subscribed capital, reserves and retained earnings, implying a leverage ratio of 2.5:1 (EIB, 2013; IDS, 2016). In practice, however, EIB lending remains well below this ratio, in part because of the conservative capital management style common to multilateral development banks and because of the difficulties involved in raising further capital (Humphrey, 2015).

Similarly, the Bank of England could, for example, favour investment-grade bonds issued by national development banks such as the Green Investment Bank and the British Business Bank. These institutions are constrained by their lack of banking licences, such that they cannot leverage their capital and do not currently issue bonds (Ryan-Collins, 2013), though the Green Investment Bank's recent privatisation may change its funding structure in the future.

The Bank of England and others have long recognised the need to fund sovereign bonds in order to achieve this coordination between fiscal and monetary policy (OECD, 2016b; Zenghelis, 2016). Catherine Mann, chief economist of the OECD, has argued that the world is 'overloaded on monetary policy' (Chan, 2016). Andrew Haldane, chief economist of the Bank of England, notes that historically low interest rates 'give insufficient room above the effective lower bound to accommodate a typical loosening cycle' (Haldane, 2015). The scarcity of sovereign bonds is already a problem for both the ECB (ETF Securities Research, 2017) and the Bank of England (Moore, 2016).

Recommendation 4:

Central banks should communicate and coordinate with fiscal policy-makers and financial regulators

- The incorporation of climate risks into financial markets and the stimulation of additional investment in renewable energy and sustainable infrastructure requires a coordinated policy response, including:
 - **Fiscal and energy policy:** support for renewable energy, carbon taxes or cap-and-trade.
 - **Financial disclosure:** the incorporation of climate-related risks into disclosure requirements.
 - **Prudential regulation:** possible use of macro- or microprudential regulation to mitigate risks associated with carbon-intensive assets.
 - **Sustainable investment:** Public policies to encourage additional investment, such as green bond issuance. (OECD, 2015)
- While most of these policy efforts are outside the purview of central banks, central bank operations should be designed to interact with them in a coordinated way, in order to align the policy efforts coming from distinct public institutions to the pursuit of the same set of objectives and avoid costly policy and institutional conflicts. Collateral frameworks and the activation of macroprudential policy provide two illustrative examples, described below.

Collateral frameworks

The ECB's collateral framework requires that corporate bonds have an investment-grade rating from at least one ratings agency. Restricting higher-risk assets is sensible – and perhaps could even be applied more proactively in order to account for climate change risk – though it may disadvantage emerging technologies and smaller companies. For example, the Danish company Vestas Wind Systems A/S is the largest manufacturer of wind turbines in the world by installed capacity, but it does not have a rating from any of the big three credit ratings agencies (Wienberg, 2015). The credit rating matters not only for eligibility, but also because it determines the haircut applied under collateral requirements, which could impact banks' purchase decisions (Nyborg, 2017). Rather than changing the collateral eligibility criteria, the more appropriate intervention

might be to help raise the credit rating of low-carbon bonds. For example, the EIB's Project Bond Credit Enhancement facility guarantees the subordinated debt of infrastructure projects in order to improve the overall credit rating (Rossi and Stepic, 2015).

In order for asset-backed securities to be eligible under the ECB's collateral framework, the underlying loans must come from a homogenous pool based on: (a) residential mortgages; (b) commercial real estate mortgages; (c) loans to small and medium-sized enterprises (SMEs); (d) car/auto loans; (e) consumer finance loans; (f) leasing receivables; or (g) credit card receivables. While sustainable infrastructure and renewable energy could fit under these categories – for example, loans to SMEs for energy efficiency or consumer finance loans for small-scale solar installation – there is not currently a sufficient volume of homogenous loans for these to be bundled and securitised (Kidney et al., 2017). Again, the appropriate action might not be a change to the collateral eligibility framework in itself, but rather policy efforts to encourage the bundling of homogenised green loans – though if such a process were undertaken, it should be with due awareness of the potential risks involved in securitisation.

Macprudential regulation

Low interest rates and QE could contribute to asset mispricing and the formation of bubbles (Vinals et al., 2013; Allen, 2015). As discussed in Section 3, the apparent high-carbon bias of ECB and Bank of England corporate bond purchases could contribute to mispricing of carbon-intensive assets. But the same could potentially happen for low-carbon assets: in case fiscal policy and QE were to be reoriented towards the purchase of green bonds or similar financial assets without safeguards to promote financially sustainable growth and appropriate pricing, a 'low-carbon financial bubble' could develop. In both instances, macroprudential policy – that is, financial regulatory instruments put in place to improve the stability and resilience of the financial system (Galati and Moessner, 2011) – might need to be activated. Financial regulation can be aligned to climate-related objectives through, for instance, differentiating reserve and capital ratio requirements depending on the carbon intensity of the activity being financed, or by incorporating environmental, social and governance (ESG) criteria into asset risk assessment for risk-weighted capital requirements (Campiglio et al., 2017).

6. Conclusions

With the expansion of the Bank of England's and ECB's asset purchase programmes into corporate bonds, both institutions have stated their intention to remain market-neutral. The choice of instrument, however, combined with the eligibility criteria, necessarily constrains sectors and issuers that are purchased under the programme.

A closer examination of the assets purchased, analysed according to publicly available information, indeed shows that **emission-intensive sectors such as manufacturing and utilities make up a disproportionate share of estimated purchases** relative to their contribution to GVA, and the European bond market as a whole. Combined with the evidence suggesting that the choice of asset has differential effects, this implies a potential distributional impact on the cost of capital for different sectors.

This raises concerns that **high-carbon sectors might benefit relatively more than low-carbon from lowered financing costs**, and that the purchases might contribute to **asset mispricing** in high-carbon sectors such as oil and gas that are at risk of becoming stranded assets. More generally, central banks undertaking asset purchase programmes that reflect the existing state of the market

may be unintentionally reinforcing the status quo, in which **low-carbon investments suffer from a 'green investment gap'** relative to the socially optimal scenario consistent with limiting warming to 1.5–2°C above pre-industrial levels. Delaying the transition to a low-carbon economy risks the worst of both worlds: what the ESRB terms a 'hard landing' involving both heavy transition costs and physical costs.

Economy-wide, structural problems such as a skew towards high-carbon sectors and a green investment gap require high-level policy coordination, and **monetary policy should work in concert with fiscal policy and financial regulation**. Central banks play an important role in financial markets, as supervisory authorities, market players, and discursive leaders in identifying risks and shaping conversation. Even though the ECB and Bank of England may begin slowing or halting their purchase of corporate bonds soon, this is worth further consideration for future QE programmes and in light of other issues such as collateral eligibility requirements, which will continue to have an impact. **Research, disclosure and coordination** will be important for aligning policy efforts across financial institutions and other public bodies.

With the 'long horizon' of climate change quickly becoming shorter as policy is changed and disruptive technologies become competitive, central banks should consider how their day-to-day operations affect and are affected by climate change transition risk. By **mainstreaming climate considerations**, they would send a clear signal that this is not a niche environmental issue but a feature of a world undergoing a large-scale structural transition: that the risk associated with not managing this transition is significant enough to merit serious consideration.

Appendix 1: Data sources

The analysis in this report is based on publicly available information.

The Bank of England has published the list of the international security identification numbers (ISINs) of eligible bonds. The Bank uses this list as a benchmark for the purchases, such that 'aggregate holdings are representative of each sector's share – in terms of the face value of bonds outstanding' (Bank of England, 2016c). It also provides a list of the sectoral breakdown of the purchases, according to the Standard Industrial Classification System (SICS). In order to compare with emissions data and the ECB, we have used the list of ISINs of eligible bonds, rather than the sectoral breakdown of purchases, because the latter does not have a breakdown by ISINs and uses different classification system (see below for additional details). Using this ISIN list, we extracted the amounts outstanding, NACE, and BICS category from Bloomberg Terminal.

The ECB publishes a list of the ISINs of securities available for lending, broken down by purchasing central bank. While the ECB does not provide the purchase amounts, it has stated that the purchases reflect 'proportionally all outstanding issues qualifying for the benchmark' (ECB, 2016c). We aggregated this list of ISINs from the purchasing central banks – i.e. the central banks of Belgium, Germany, France, Italy, Spain and Finland – and extracted the amounts outstanding, NACE, and BICS category from Bloomberg.

Using Bloomberg's fixed income security function and the ECB's list of eligibility criteria (ECB, 2016c, 2017a), we then attempted to reconstruct the benchmark, using a series of increasingly targeted searches.

For the ECB, we used a Bloomberg search of active euro-denominated corporate bonds with a maturity of between six months and 31 years, rated investment grade by one of the major ratings agencies, with the issuer domiciled in a euro-area country, with an eligible yield (greater than the deposit facility, i.e. -0.4), eligible as collateral, excluding the following BICS categories: Banks, Commercial Finance, Consumer Finance, Diversified Banks, Financial Services, Funds & Trusts, Government Agencies, Government Regional, Supranationals, Government Development Banks, Winding Up Agencies, Central Bank, and Government Local.

Comparing the benchmark of eligible bonds with the list of holdings with the benchmark (Table 3 above, columns 6 and 7, respectively), the benchmark implied by the Bloomberg search matches fairly closely with the list of ECB purchases, excepting four 'government agencies' that were categorically included from the Bloomberg search though the ECB still considers them eligible for purchase.

For the Bank of England, we performed a Bloomberg search based on their eligibility criteria (Bank of England, 2016c): active sterling-denominated corporate bonds with a maturity of more than a year, minimum amount in issue of £100 million, rated as investment grade by at least one major ratings agency, excluding Banks, Commercial Finance, Consumer Finance, Diversified Banks, Financial Services, Funds & Trusts, Life Insurance, Property & Casualty Insurance, Sovereigns, Government Agencies, Government Regional, Supranationals, Government Development Banks, Winding Up Agencies, Central Bank, and Government Local. This matches the benchmark of eligible bonds less closely, but the Bank of England's stated aim to search for firms making a 'material contribution to the UK economy' suggests a more active selection process.

Industrial classification systems

In Tables 3 and 4 above, the BICS categorisation – Bloomberg Industrial Classification System – was used rather than NACE because the market-level data on sectoral distribution was only available in this format from Bloomberg. The Bank of England uses the Standard Industrial Classification System; we have used the Eurostat system of classification by economic activity – known as NACE – in order to more easily compare their portfolio with the ECB’s, and also to cross-reference the sectors with Eurostat’s data on emissions, which is arranged by NACE sector. We have taken the list of eligible ISINs from the Bank of England’s website and broken it down by NACE and BICS categories, so that we could compare it with the ECB’s holdings, therefore using the benchmark sectoral breakdown because the list of ISINs enables us to extract the relevant NACE categorisation and match it with emissions from Eurostat.

Emissions

The emissions data comes from Eurostat based on country-level data on carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride, expressed in carbon dioxide equivalent and aggregated. We used the most recent and complete data set available, which was from 2013.

Appendix 2: Emissions by NACE sector

Table A1: Euro-area emissions by NACE sector, estimated purchases, and gross value added (GVA)

NACE sector	NACE sector code	Contribution to emissions (%)	Estimated ECB purchases by amount outstanding (%)	Contribution to GVA (%)
Mining and quarrying	B	0.9	1.2	0.5
Manufacturing*	C except C19 and C20	18.6	26.9	14.8
Manufacture of chemicals and chemical products	C20	4.5	4.9	1.1
Manufacture of coke and refined petroleum products	C19	3.8	7.2	0.2
Electricity, gas, steam and air conditioning supply	D	31.7	23.3	1.9
Water supply; sewerage, waste management and remediation activities	E	6.0	1.4	0.9
Construction	F	1.4	1.4	10.9
Wholesale and retail trade	G	2.4	1.2	10.9
Transportation and storage	H	12.0	10.0	5.0
Accommodation and food service activities	I	0.6	0.2	3.0
Information and communication	J	0.3	11.9	4.6
Financial and insurance activities	K	0.2	4.3	5.0
Real estate activities	L	0.3	4.1	11.6
Professional, scientific and technical activities	M	0.5	1.2	0
Administrative	N	0.7	0.1	4.3
Human health and social work activities	Q	0.8	0.5	0
Arts, entertainment and recreation	R	0.2	0.2	1.3

Note: *except petroleum products and chemical products

Sources: ECB (ISINs), Bloomberg (NACE categories), Eurostat (emissions and GVA data), and authors' calculations.

Data as of March 2017.

Table A2: UK emissions by NACE sector, percentage of eligible list by amount outstanding, and gross value added (GVA)

NACE_R2	NACE sector code	Contribution to emissions (%)	Bank of England eligible list of ISINs by amount outstanding (%)	Contribution to GVA (%)
Mining and quarrying	B	4.1	1.5	1.8
Manufacturing	C	12.6	19.4	9.5
Manufacture of chemicals and chemical products	C19	3.4	0.4	0.1
Manufacture of coke and refined petroleum products	C20	2.7	1.8	0.6
Electricity, gas, steam and air conditioning supply	D	33.6	27.6	1.5
Water supply	E	4.8	11.9	1.1
Construction	F	2.4	0.3	5.9
Wholesale and retail trade	G	3.7	4.9	10.7
Transportation and storage	H	16.0	7.3	4.3
Accommodation and food service activities	I	0.9	1.3	2.9
Information and communication	J	0.3	12.5	6.3
Financial and insurance activities	K	0.0	1.9	7.6
Real estate activities	L	0.2	4.7	12.2
Professional, scientific and technical activities	M	0.5	1.2	7.3
Administrative	N	0.6	0.1	4.6
Education	P	0.8	0.9	6.3
Human health and social work activities	Q	1.2	2.5	7.4

Sources: Bank of England, Bloomberg (NACE categories), Eurostat (emissions and GVA data), and authors' calculations.
Data as of March 2017.

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