SUSTAINABLE FINANCE AND THE BANKS[1]

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ABSTRACT

This paper reviews the growing literature on sustainable finance. The empirical evidence on the key issues is very mixed with the results from ESG literature are especially problematic. The results from the literature on banks and climate change more specifically are clearer with good indications that banks will provide firms with the finance for innovation and its diffusion. Voluntary commitments by banks to operate to reach net zero carbon emissions by 2050 do not appear to be effective and in the transition to a low carbon economy it is not clear that banks are reallocate funds to low carbon sectors or that they are charging higher interest rates to high polluting firms. The evidence on how banks are dealing with the physical risks from climate change are more encouraging in these respects. The literature on central banking and monetary policy generally advocates a return to policies of the 1950s-70s with an emphasis on directed credit, preferential interest rates, reserve requirements, capital and liquidity ratios to promote green finance, but the financial stability-related literature recognizes clearly the need for central banks to be prudent and incorporate climate risks into their operations and policy frameworks.

Key words: Sustainable finance, bank performance, ESG scores, carbon emissions, central bank policies

JEL: E58, F30, F64,G21, O44, Q01, Q32, Q54

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1. INTRODUCTION

Climate change a pressing challenge for sustainable economic development and a major threat to global health. To combat climate change, many countries are introducing policies and regulations, and engaging in moral suasion, to achieve net-zero carbon emissions by 2050. Achieving this goal will involve sums of money that can be hard to comprehend. For example, the IMF's estimates of the global investments required to achieve the temperature and adaptation goals of the Paris Climate Agreement (PCA) range between US$3 to $6 trillion per year until 2050.[2] Since the mobilization of public sector revenues on this scale is highly unlikely, with many major countries already facing debt sustainability, more attention has been focused on private sector led sustainable finance to reduce carbon emissions. The academic literature on sustainable finance has evolved from an early focus on socially responsible investing (SRI) that pitted investing for financial returns against investing out of ethical considerations, that broadened to include the incorporation of environment, social and governance (ESG) considerations into firms' financial decision making, to most recently, and particularly following the 2015 Paris Climate Agreement (PCA), a near explosion in research output on how financial markets and institutions might be better aligned with the goal of combatting climate change, and on the actions need to be taken to protect the financial system and its stakeholders from the possible catastrophic consequences of that change.[3] My purpose in this paper is to review the academic literature on sustainable finance as it relates to banking. To this end, I first examine the relevant ESG literature, including the

[2] See Prasad et al. (2022).

[3] As an indicator of the speed with which the academic literature on sustainable has grown, Diaz-Rainey, et al. (2017) found that of 20,725 articles published in 21 finance journals between January 1998 and June 2015, only 12 articles (0.06%) dealt in some way with climate finance.

relationship to bank financial performance, bank lending and stability.[4] I then turn to the literature on banks and climate change, which examines both the potential opportunities and risks that banking faces. Finally, I look at the literature that links central bank policy and financial regulation to climate change, mainly through central banks' monetary policy and financial stability responsibilities. I emphasize the literature on the opportunities offered by recruiting the banking sector (including the central bank and financial regulators) in the fight against, and the process to deal with, climate change, but also note the risks in doing so, especially for bank stability and the credibility of central bank and regulatory policy. Although substantial attention is focused on harnessing the financial system to combat climate change, that focus should not detract from the need for other, arguably more important, policy actions. Sustainable finance can play only a supporting role in the battle, though this is certainly better than no role at all. The keys to fighting climate change remain fixing the carbon price to make carbon emission very expensive, speeding up the partial transition from coal to gas, and to be successful in R&D (because the carbon emission problem can't be solved with the technology available).[5]

The rest of the paper is organized as follows. The next section reviews the literature on the relationship between ESG and the banks. Section 3 examines the literature on the opportunities and challenges that climate change poses for the banks, and Section 4 looks at the literature on the challenges that climate changes poses for central banks and financial regulators. A final section concludes.

[4] I exclude any discussion of SRI as the related literature has little to do directly with banks and largely failed to pique the interest of banking and finance academics.
[5] Helm (2015) provides a still highly relevant and accessible summary of the issues.

2. SUSTAINABLE FINANCE, BANKS AND ESG

The ESG-related academic literature is very large but mainly concerns nonfinancial firms. Fortunately, that on ESG and banks is much smaller and is relatively recent. As for the literature on nonfinancial firms, the bank-related literature mainly examines the impact of ESG on firm performance (e.g., profitability, efficiency, value, risk taking) in the context of outcomes to be expected from alternative management theories. For example, findings of a positive impact of ESG on bank performance are interpreted as showing support either for a "stakeholder" theory of the firm (e.g., Freeman, 1984; Friedman and Miles, 2006), whereby managing broader stakeholder interests leads to long-term value creation, including by improving relationships and enhancing firms' reputations, or by showing that it mitigates agency problems (e.g., Jensen and Meckling, 1976; Fama, 1980) by ensuring that managerial decisions are made with long-term sustainability and value creation in mind. In contrast, a negative impact on bank performance of incorporating ESG into bank decision making is viewed as consistent with an "overinvestment" theory of the firm whereby ESG diverts scarce resources from the maximization of shareholders' wealth squeezing out investment and undermining bank performance and value (Alexander and Buchholz, 1978; Barnea and Rubin, 2010), or as reflecting agency costs, for example, whereby managers seek to improve their own reputations by investing in ESG at the expense of shareholders (Barnea and Rubin, 2010). As it is for nonfinancial firms, the empirical evidence with respect to the impact of ESG on banks is rather mixed such that we do not have an especially good understanding of whether and under what conditions ESG activities influence bank performance and value.

2.1 ESG and Bank Financial Performance

Several cross-country studies report ESG as having a beneficial impact on bank financial performance. For example, Wu and Shen (2013) find that it is positively associated with profitability indicators (ROA, ROE, net interest income and non-interest income) in a sample of 162 banks in 22 countries. Shen et al. (2016) report that CSR banks overwhelmingly outperform non-CSR banks in terms of ROA and ROE in sample of 6,125 banks from 18 countries, with the results robust to alternative estimation methodologies. Shakil et al. (2019) find a positive association between ESG and financial performance in a sample of 93 banks operating in emerging economies, but that the effect of corporate governance was not statistically significant, which they explain as reflecting weak corporate governance practices in emerging markets and the lack of legal and regulatory pressure from regulatory bodies. Finally, Lui et al. (2023) find that high ESG scoring US commercial banks had lower nonperforming loans.

Some studies report markedly different effects on financial performance from the ESG components. For example, Miralles-Quirós et al. (2019) study the ESG performance of commercial banks listed on 20 different stock markets over 2002–2015 and report that investors value the different ESG pillars differently with environmental and corporate governance performances positively and significantly valued, but social performance is negatively and significantly valued. In addition, they report that the market valuation of ESG is significantly higher for banks from common law countries with stronger shareholders protection. Similarly, Bătae et al. (2019) report a negative association between social responsibility policies and corporate governance systems and financial performance in a sample of 39 European banks. Buallay (2019) reports from a sample of 235 banks that that environmental disclosure was positively related to banks' ROA and Tobin's

Q, but that corporate social responsibility disclosure was negatively related to ROA, ROE, and Tobin's Q, while corporate governance disclosure negatively impacted profitability but had a positive impact on Tobin's Q. Yet other studies support a negative impact of ESG on bank financial performance. Menicucci, and Paolici (2023) report that ESG policies negatively affect operational and market performance in a sample of 105 Italian banks, which they suggest reflects these banks relative backwardness in embracing sustainability procedures. Yet other studies find no significant effect on bank performance of ESG factors. For example, Carnevale et al. (2012) analyze 130 banks quoted on Eurozone stock markets from which 73 publish sustainability reports and 57 do not publish this kind of information during the period 2002–2008 and find no evidence that investors attribute value relevance to sustainability reports.

Several studies focus more helpfully on the transmission mechanism form ESG to bank financial performance. For example, Cantero-Saiz et al. (2024) report a positive ESG-asset quality relationship in a sample of 96 banks from 33 countries that is reversed at higher high levels of profitability, which they interpret as a moderating role of profitability whereby banks that seek to maximise profits skimp on resources at the cost of a less stable and socially sustainable banking system. Azmi et al. (2021) examine the channels through which ESG activity impacts bank value and find a positive relationship with both cash flows and efficiency; they also report a non-linear relationship whereby low levels of ESG activity positively impact bank value but there are diminishing returns to scale. This might help explain why proponents of both stakeholder theory and trade-off theory have found evidence to support predictions of the relationship between ESG activity and bank value. El Khoury et al. (2023) report a similar result using a sample of 46 banks in the MENAT region.

A number of related studies suggest that ESG scores can impact bank financial performance by affecting bank efficiency. These studies typically find that ESG has beneficial effects in this regard. For example, Cao et al. (2024) use a stochastic frontier analysis in a sample of Chinese banks model to show that increasing ESG investment is beneficial to bank efficiency, especially when the level of fintech is high, though there are differences across the ESG components. Belasri et al. (2020) report a positive impact of CSR on bank efficiency in developed countries, where investor protection is high and in countries featuring a high degree of stakeholder orientation, and Forgione et al. (2020) report that CSR activities have a positive impact on bank efficiency in common law countries and countries where the effectiveness of stakeholder protection is high. Finally, López-Penabad et al. (2023) find evidence of a U-shaped relationship between CSP and bank efficiency, indicating that banks with either high or low corporate social performance levels are the most efficient.

Finally, a number of studies highlight drawbacks in relying on ESG rating as a determinant of bank (or nonfinancial firm) performance, pointing to the need for greater attention to how the data underlying ESG ratings are generated. For example, Billio et al. (2020) analyze the ESG rating criteria used by prominent agencies and show that the lack of a commonality in the definition of ESG characteristics can lead agencies to have opposite opinions on the same evaluated companies. Berg et al. (2022) document the rating divergence and map the different methodologies onto a common taxonomy of categories and report that the divergence is due 56% to measurement contributes, 38% to scope, 6% to weight. They also report that a "rater effect" whereby a rater's overall view of a firm influences the measurement of specific categories. Huang et al. (2024) show

that in the syndicated loan market banks with poor ESG performance lend to firms with a better ESG performance to improve the reputation of the bank, offering loans with lower interest rate spreads and longer maturities, and demanding fewer covenants and less collateral; they view the lower spread as the "price" paid for trying to cover up their poor ESG performance.

2.2 ESG, Bank Lending and Stability

Several studies suggest that incorporating ESG into bank decision making plays a role in lending relationships and in overall bank stability because banks with higher ESG ratings better scrutinize borrowers and lower borrower default risk. In the case of bank lending, Danisman and Tarazi (2024) examine how the ESG activities of European banks affected their lending during the 2007-09 financial crises and report that lending falls to a lesser extent for banks with higher ESG scores. They show that this is because such banks were less affected by adverse movements in their credit and asset risk and their profitability, and because they faced a lower reduction in market funding. Abdelsalam et al. (2023) and Liu et al. (2023) find that banks that engage in ESGs are less prone to procyclical lending than those that do not with the results more pronounced in the case of environmental activities. There is also evidence that lending relationships transmit an effect of ESG disclosure regulations from banks to borrowing firms. For example, Wang (2023) examines the impact of ESG disclosure regulations in banks' home countries on their lending practices to US firms. They report that banks in more highly regulated countries impose more environmental action covenants in loan contracts and are more likely to terminate a borrower with a bad ESG record. As a result, borrowing firms in these countries improve their ESG performance.

As regards bank stability, Chiaramonte et al. (2022) examine the link between ESG scores and bank stability in a sample of 84 banks from 21 European countries, employing the one-year Merton's Distance to Default to proxy stability. They report that both the composite ESG score and its individual pillars are associated with a reduction in bank fragility, and that the effect is stronger the longer the duration of disclosures, though only the largest banks experienced improvements in stability during the 2008-09 crisis. Izcan and Bektas (2022) use a quantile regression approach to examine the relationship between ESG and idiosyncratic risk in a sample of 31 Eurozone banks and find a significant negative relationship between overall scores and bank idiosyncratic risk for medium- to high-risk levels, with the effect stronger as the riskiness of banks increases. Di Tommaso and Thornton (2020) report a similar result for the impact of ESG scores on bank risk using the z-score measure of risk, and Lupu, et al. (2022) and Aevoae et al. (2023) do so for measures of systematic risk. These results suggesting that higher ESG scores are associated with greater bank stability favor a risk mitigation view of sustainability actions, whereby banks aim at achieving greater trust and credibility.

3. SUSTAINABLE FINANCE, BANKS AND CLIMATE CHANGE

From around the 2010s the fixation in the literature on the effects of integrating ESG assessments into banks' decision making gave way somewhat to studies exploring links between banks and climate change in two contexts. The first of these is the role of banks in the transition to a low carbon economy, especially as regards financing the innovation and diffusion of the technology that will be needed to reduce carbon emissions, and whether have banks begun to "price-in" transition risks in their lending terms. The second context relates to issues arising from

the physical risks posed by climate change, including the resilience of banks and the supply of credit to risk realization, and whether banks are price-in physical risks in their lending terms.

3.1 Banks, Green Innovation and Technology Diffusion

Green innovation and the diffusion of the associated technology are essential for an orderly transition to a net-zero carbon economy as current technology is not sufficient to achieve that goal in a timely manner (Helm, 2015). One thread of research looks the role of banks in the financing and diffusion of innovations that are potentially disruptive for their operations. For example, through their lending relationships with firms, banks build up substantial insider information about them that has value (Boot, 1999; Diamond, 1984) that the new technology could be put at risk. However, the empirical evidence on the link between bank finance and innovation is generally encouraging. For example, Amore et al. (2013) examine the effect of banking development on the quantity and quality of innovation by US manufacturing firms in the context of the deregulation of interstate banking restrictions that allowed out-of-state banks to enter local credit markets. They report a positive relation between banking development and innovation and argue that banks are more willing to take risks and lend to innovative firms when they become more able to diversify their risks geographically after deregulation. Chava et al. (2013) find that intrastate banking deregulation decreases innovation, but interstate banking deregulation increases it suggesting that banks that have their market power increased by intrastate banking deregulation are less incentivized to provide credit for innovative firms. Cornaggia et al. (2015) report that interstate bank branching deregulation was negatively associated with innovation outputs, though this was mainly driven by publicly listed firms. Ayyagari et al. (2011) find evidence that access to bank

finance is associated with greater innovation in a sample of small firms in 47 emerging economies firms in developing countries. Benfratello et al. (2008) report that in Italy increases in the density of local bank branches are associated with growth in firm-level innovation, with the impact stronger for smaller firms in sectors that are more dependent on external finance, and Herrera and Minetti (2007) find that the duration of Italian bank-firm credit relationships is positively associated with firm innovation. Finally, Chava et al. (2017) test whether spreads on bank loans to US firms are affected by the value of a firm's patent stock. They find that firms with significant patenting activity are charged lower loan spreads. Moreover, spreads are lower still for patents that have value to a more general (as opposed to specialized) class of firms, and for which there remains a longer term over which the firm can receive exclusive cash flow rights.

Nevertheless, there are studies that suggest that banks might be reluctant to provide finance for innovation. For example, Minetti (2011) develops a model to show that banks may refuse to finance new technologies if the technology is likely to erode the value of the stock of insider information already accumulated because this information allows them to recover value if a borrower defaults. Using Italian firm-level data, he shows that, in line with the predictions of his model, banks with informationally intensive lending relationships foster incremental technological progress but hinder the introduction of radically new technologies. Nanda and Nicholas (2014) study the effects of negative shocks to the banking system during the US Great Depression in the early 1930s to examine the effect of bank distress on corporate innovation. They find a negative relation between distress and various measures of innovation that is disproportionately stronger for R&D firms that depend more on external finance dependence. Hsu et al. (2014) examine the effects of equity markets and credit markets on technological innovation in a sample of 32

developed and emerging countries using patent data to construct proxies for innovation. They report that equity market development exerts a positive influence on the innovation of industries, whereas credit market development has the opposite, with the negative effect is stronger for industries of greater external financial dependence and high-tech intensiveness. Specifically focusing on green innovations, Degryse et al. (2022) model the impact of a financier's legacy portfolio on its willingness to fund a new technology that may undermine the value of its existing portfolio and use Belgian micro data to show that green corporate innovators are less likely to receive bank credit compared with innovators that do not threaten banks' legacy positions.

The results of studies with respect to banks as agents of diffusion are also generally encouraging. For example, Levine et al. (2018), Xu and Kim (2022) and Gentet-Raskopf (2022) show that when firms gain easier access to bank loans their local toxic emissions tend to reduce. Goetz (2019) reports that US firms that depend on long-term debt financing reduce their toxic emissions when their capital cost declined during the U.S. Maturity Extension Program, and that cheaper funding allowed firms to invest more in capital-intensive measures to reduce emissions. Accetturo, et al. (2022) use text algorithms to extract information on green investments from the financial statements of Italian small businesses and combine it with data from the Italian credit registry to find that an increase in a firms' credit supply raises the likelihood of undertaking a green investment. Apicella and Fabiani (2023) exploit variation across firms in their exposure to surging carbon prices in the EU Emissions Trading System and show that credit access can enable firms to invest in greener technology and reduce the carbon intensity of production. They also report that firms more exposed to higher carbon prices increase their credit demand and expand their production without emitting more carbon. However, the Degryse et al. (2022) study finds that

banks not only ration credit to green innovators but also to firms that merely diffuse green technologies.

3.2 Lending and Firm Carbon Emissions

Another set of studies looks at whether the risks that banks face in the transition to a low carbon economy are reflected in their lending activities. For example, banks can decarbonize their portfolios by divesting from polluting firms and reallocating lending to less emission-intensive firms, or they can continue to lend to polluting firms while pushing them to reduce their emissions, for example, through engagement or by charging them relatively higher lending rates. Many banks have explicitly committed to divestment and engagement through membership of the net zero banking alliance (NZBA), which was announced in October 2021 at a meeting convened by the United Nations as part of COP 26.[6] Joining the alliance constitutes a voluntary commitment by the banks to reach "net-zero" carbon emissions by 2050. The evidence that banks are acting in a manner consistent with net-zero is disappointing. For example, Sastry et al. (2024) find no evidence that net zero banks reduce credit supply to the sectors they target for decarbonization, or that they increase financing for renewables projects, or that they charge relatively higher interest rates to higher-polluting firms. They conclude that net-zero commitments are more consistent with greenwashing by banks. Cowton and Thompson (2000) compare the policies and practices of signatories and non-signatories of the NZBA and find that around one third of signatories fail to incorporate environmental factors into their lending policies, and that overall, there was no difference between signatory and non-signatory banks with respect to the incorporation of such

[6] As of September 2024, the NZBA comprised 144 banks from 44 countries that accounted for $74 trillion assets, or about 41% of global banking assets. https://www.unepfi.org/net-zero-banking/members.

factors in their lending policies. Similarly, Ehlers et al. (2022) find that signatory banks do not charge a higher price on the intensity of carbon emission, and Bruno and Lombini (2023) and Giannetti et al. (2023) find no evidence of divestment from firms with high carbon emissions, In non-carbon studies, Haushalter et al. (2023) find no evidence of divestment from firms engaged in mountaintop removal coal mining, and Bell et al. (2023) find no evidence of lenders charging higher interest rates on riskier mortgages against energy inefficient properties in a study interest rates on mortgages originated in the UK prior to 2018.

Some papers find evidence of lender divestment from firms with high voluntarily reported carbon emissions, however (Kacperczyk and Peydró, 2024; Ye, 2023) and from firms in the coal mining sector (Green and Vallee, 2024, Jung et al., 2022). In addition, Mueller and Sfrappini (2022) examine the effect of climate change-related regulatory risks on credit location, reporting results that vary by geographic region. Following an increase in regulatory risks, in the US banks reallocate credit to firms that could be negatively impacted, whereas European banks lend more to firms that could benefit from environmental regulation. There is also some evidence of lenders charging relatively higher interest rates to and/or disengaging from high polluting firms after the 2015 Paris Climate Agreement (Aslan et al., 2022; Ehlers et al., 2022; Reghezza et al., 2022; Degryse et al., 2023; Delis et al., 2023). Ivanov et al. (2024) show that high-emissions firms most affected by the introduction of California's Cap-and-Trade emissions scheme faced higher interest rates, shorter loan maturities, and less access to term loans from banks. Huang et al. (2021) find that loan default rates and financing costs rose for high polluting firms after the Clear Air Action of 2013 in China. Finally, Kleimeier and Viehs (2021) shows a significant negative relation

between voluntary disclosure of CO2 emissions and loan spreads for informationally opaque borrowers.

3.3 Banks and Physical Risks from Climate Change

Physical risks from climate change-related disruptions (e.g., extreme weather events, a rise in the sea-level) pose potentially significant threat to banks and to financial stability more generally. A growing literature discusses how physical risks have begun to influence banks' balance sheets and lending activities. The literature points to at least four broad conclusions. First, banks have proven to be quite resilient in the face of climate change disruptions. For example, Noth and Schüwer (2023) show that although weather-related natural disasters increase non-performing loans and default probabilities, and reduce asset returns, these effects are generally negligible and short-lived. Blickle, et al. (2021) find that weather disasters have insignificant or only minor effects on US bank performance in part because disasters often increase loan demand and boost bank profits. Klomp (2014) uses data on more than 160 countries to show that, while natural disasters can reduce a bank's distance to default, such negative impacts are mostly concentrated in less developed countries with relatively weak financial regulation and supervision. In contrast, Meisenzahl (2023) uses supervisory data for the largest U.S. banks and finds that after the Paris Agreement banks significantly reduced lending to areas more impacted by floods and wildfires, though the reductions were concentrated among borrowers and products with high credit risk, and low-risk borrowers received more funding even in heavily affected areas.

Second, local banks appear to respond better to physical risk because they can leverage local knowledge. The literature analyses how the presence of different types of banks affects the impact of natural disasters. Cortés (2014) finds that in US counties served mainly by local banks, job creation and job retention among young and small firms are higher following a natural disaster and that local economic growth recovers more quickly. Chavaz (2016) estimates the impact of bank-level diversification on lending during post-hurricane recoveries and reports that local banks originate a higher share of new mortgage and small business loans in affected areas compared to geographically diversified banks. Gallagher and Hartley (2017) studied the New Orleans neighborhoods affected by 2015 Hurricane Katrina and found where more banks are local, total household mortgage debt declined less as local lenders were more likely to make new loans and to continue existing lending relationships. Schüwer et al. (2019) show that after hurricanes struck the Gulf Coast of the US in 2015, income and employment growth was stronger in the affected counties with a relatively large share of independent banks. Islam and Singh (2023) report that larger, geographically diversified banks reduce small-farm lending more relative to their undiversified counterparts in response to abnormally hot temperatures in US counties. Finally, Cortés and Strahan (2017) find that geographically diversified banks in the US reallocate capital out of unaffected counties towards disaster-affected counties where local credit demand rises. There is also evidence that the stabilizing influence of local banks is especially strong when these banks can offload part of the disaster-related credit risk through loan sales or securitization and if they hold some local market power. For example, Ouazad and Kahn (2022) show that lenders are more likely to approve mortgages in the aftermath of natural disasters if they can securitize the loans and offload the climate risk to other parties. Finally, Duqi et al. (2021) find that economic growth recovers faster in US counties in the aftermath of hurricanes that have less-competitive

banking sectors because these banks can deploy the profits accumulate during normal times to increase lending to the local economy.

Third, banks reallocate funds towards disaster-affected areas while decreasing credit to non-affected areas. Koetter et al. (2020) find that German firms benefited when banks increased their lending to regions affected by heavy flooding in 2013. Rehbein and Ongena (2022) compare firms in non-flooded areas that are connected to disaster-exposed banks with those in the same regions that are unconnected to such banks and find that banks reduce lending in non-flooded areas in order to provide loans to flood-affected firms.

Finally, banks are generally pricing in physical risks from climate change. For example, Javadi and al Masum (2021) report that firms in locations with higher exposure to climate change pay significantly higher spreads on their bank loans. Correa et al. (2022) analyze how natural disasters affect the loan pricing of US corporate borrowers that are indirectly at risk of future extreme weather events and report that charge higher spreads on loans to exposed borrowers following natural disasters. Nguyen et al. (2022) show that banks charge higher interest rates for mortgages on properties exposed to a greater risk of sea-level rise. Finally, Meisenzahl (2023) uses supervisory data on large U.S. banks to determine they became more sensitive to physical risks after the Paris Climate Agreement and reports that banks significantly reduced lending to US counties more impacted by climate change.

4. SUSTAINABLE FINANCE AND CENTRAL BANKS

The literature on role of central banks in climate change falls into two broad categories. One category seeks to recruit central banks in the fight against climate change through the employment of traditional and nontraditional monetary policy instruments to promote green activities at the expense of others. On balance, this literature amounts to a call for less prudent monetary policies on the part of central banks. The second category recognizes the financial stability implications of climate change and the need to integrate climate-related risks into supervision and stability modelling. The balance of this literature is for more prudent policies. Both strands of the literature are relatively new and to a large extent comprise policy papers from various thinktanks and official financial institutions.

4.1 Monetary policy and climate goals

That monetary should play a role in combatting climate change is not immediately obvious (Brunnermeier and Landau, 2021). First, the link between climate change and monetary policy is not close. The conventional wisdom is that monetary policy influences the economy over 1½ to 2½ years and not at all in the long-term, whereas climate change is a long-term issue that requires appropriately long-term policies. Second, central banks are non-elected agents with well-specified mandates to contain inflation and stabilize the economy, which would not appear to include using their instruments to allocate resources and direct credit to achieve climate goals. In democratic societies there is generally quite strong agreement that decisions on allocating resources and redistributing incomes, including to fight climate change, should be taken by elected bodies. Nevertheless, several recent papers aim to push central banks to interpret their mandates

more broadly and use their monetary policy instruments to create incentives for the provision of green finance.

Since the financial crisis, central banks in many countries have expanded their balance sheets hugely to the extent that those balance sheets are now commensurate to the size of the national economy. This has led to calls for central banks to be more proactive in financing the climate transition by orienting quantitative easing to the purchase of green assets. For example, Schoenmaker (2021) outlines a proposal to tilt the European Central Bank's (ECB) purchases away from carbon-intensive firms so that low-carbon firms would see a lowering of their bond yields. In related papers, Ryan-Collins et al. (2013), Anderson (2015) and Van Lerven and Ryan-Collins (2018) advocate having the central bank eliminate assets with high carbon intensity from its portfolio.[7] However, research on the bond yield effects generally of QE suggest that in practice targeting a meaningful differential in the yield on a particular class of bonds is difficult. For example, Boneva et al. (2022) show that the Bank of England's corporate bond purchase scheme in 2016 lowered eligible bond yields by only between 2 to 5 basis points relative to non-eligible investment grade bonds in the context of an overall yield decline of about 15 basis points; and De Santis (2020) reports that the ECB's operations only achieved a yield differential of about 15 basis points between eligible and ineligible investment grade bonds in the context of overall yield declines of 500 basis points. Formal modelling of the preferential treatment of green corporate bonds in central banks collateral frameworks is also not very encouraging. For example, Pelizzon

[7] Some central banks have responded positively with respect to the greening of quantitative easing. For example, in May 2021 the Bank of England announced that it would target targeting a 25% reduction in the weighted average carbon intensity (WACI) of its Corporate Bond Purchase Scheme portfolio by 2025, and that firm would need to satisfy climate-related eligibility criteria for their bonds to be purchased. The Sveriges Riksbank began buying green bonds as part of its asset purchase program in 2021; and the ECB started to include green bonds in its asset purchase program in 2021

et al. (2024) and Giovanardi et al. (2021) find very limited climate change mitigating effects of preferential treatments, and that these likely came at the cost of an increase in firm risk-taking. In modelling the interactions between climate change and monetary policies Diluiso et al (2021) find that inflationary pressures from climate change policies may require tighter monetary policies overall. Finally, Abiry et al. (2022) find that green QE leads to a partial crowding out of private capital in the green sector and to a very small reduction of the global temperature by 2100, and that a moderate global carbon tax of 50 USD per ton of carbon is 4 times more effective.

Several papers advocate the adaption of traditional monetary policy instruments to channel more funds toward green firms. For example, Campiglio (2016) advocates differential minimum reserve requirements for banks according to the carbon footprint of their liabilities. Vona et al. (2018), Oustry et al. (2020) and Bolton et al. (2020) argue that central banks should provide guarantees and preferential interest rates to banks and revise the collateral eligibility criteria for refinancing operations to offer an incentive for firms to reduce emissions in order to obtain cheaper financing.[8] Mandel et al. (2019), Schoenmaker and Schramade (2019) and Bhattacharya et al. (2015) suggest sector-specific credit guidance from central banks to channel more funds toward green sectors while restricting lending to high-carbon industries on the basis that targeted investments can accelerate the transition to a low carbon economy. More extreme, Krogstrup and Oman (2019) and Monnet and van 't Klooster (2023) argue that central banks should impose binding rules on the growth of credit for low carbon projects as a criterion for banks accessing refinancing. Filardo et al. (2019), Bolton et al. (2020) and Schoenmaker and Schramade (2019) argue that central banks should include green bonds or investments in sustainable assets in their

[8] The Bank of Japan implemented a green lending scheme in 2021 whereby it provides funds to financial institutions a zero interest rates, with the stipulation that these funds be used to finance green projects.

foreign exchange reserves to support global demand for green financial products and integrate climate risk management into central bank operations.[9] Finally, Campiglio (2016) and Prasad et al. (2022) advocate that central banks use forward guidance policies to raise market expectations regarding green investments.

Another set of papers argues for a more proactive prudential policy by central banks to fight climate change. For example, Schoenmaker and van Tilburg (2016), Battiston et al. (2017), Campiglio (2016) all advocate the use of lower prudential requirements, including reduced capital or liquidity buffers as a way to incentivize banks to engage in green lending. Oehmke and Opp (2022) discuss whether a financial regulator might prevent financial instability and foster the green transition through differentiated capital requirements in a model of banking capital requirements regulation and a policy maker with a broader mandate to address global warming. They find that these tools might be effective in preserving the stability of the financial system, but they have little ability to foster green investments or address climate change. To their credit, these authors generally emphasize the need for careful implementation to balance the promotion of sustainable finance with maintaining financial stability. A recent study by Miguel et al. 2024) casts doubt on the likely success of differential prudential arrangements. These authors analyze how capital requirements from environmental risk exposure affect bank lending to the corporate sector, and how these effects transmit to real economic activity and to GHG emissions by exploiting the introduction of a policy in Brazil that required banks to incorporate environmental risks in their capital assessments. They report that although large banks reallocated their lending away from

[9] The People's Bank of China started to include green bonds in its foreign exchange reserves in 2021.

exposed sectors, the credit contraction had no substantial impact on the real activity and GHG emissions of these sectors, as smaller banks expand their lending afterwards.

The proposals to employ traditional monetary instruments and of prudential policy to mitigate climate change are problematic in several respects. The notions of directed credit, preferential interest rates, and preferential prudential ratios harks back to the discredited development policies that prevailed during the 1950s to 1970s but were largely abandoned because they resulted in serious resource misallocation as the result of a combination of poor administrative decisions, political pressures, and corruption.[10] A policy of preferential, green-related policies would almost certainly be subject to similar pressures as parties sought to have their activities included as 'green'. It also seems likely that green activities will be intrinsically riskier and would, *per se*, more appropriately be charged an interest rate premium and be subject to higher capital and liquidity buffers!

4.3 Financial stability and climate change

Climate change could increase financial-system vulnerabilities through losses to levered financial intermediaries, disrupting the functioning of financial markets, or leading to a sudden repricing of large classes of assets. Several papers focus on the risks to financial stability from the process of transitioning to a low-carbon economy, especially from the re-evaluation of carbon-intensive assets as a result of shocks from policy changes, technological shifts, and changes in market preferences. For example, Battiston et al. (2017) and Stolbova et al. (2018) use a network-

[10] For a still excellent survey of these issues, see Fry (1994).

based approach to understand how climate-related risks can propagate through the financial system, emphasizing the systemic nature of transition risks and their potential to cause financial instability, particularly through interconnected financial institutions. They also develop a model to stress-test the financial system under various transition scenarios, demonstrating how sudden policy changes or shifts in market expectations can lead to significant financial losses. Anderson et al. (2018) investigate the potential impact of transition risks on future stock market returns, focusing on how climate policies and changes in market sentiment could affect the valuation of companies and financial markets. They highlight the risks to financial stability from abrupt market adjustments. van der Ploeg and Rezai (2020) explore how the transition to a low-carbon economy can lead to asset stranding, particularly in carbon-intensive sectors, and discuss the potential cascading effects of asset stranding on the financial system, leading to systemic risk. Caldecott et al. (2021) discuss the concept of stranded assets and the transmission channels of climate related risks and the possible effects on societies, economies, and the financial system. They also discuss recent central bank and supervisor responses, including climate disclosure and stress testing.[11]

Another set of papers focuses on the physical risks to financial stability that are linked to the economic damage from climate-related events. Several studies discuss the potential impacts on financial systems and markets of these risk materializing. For example, Burke et al. (2015) explore the potential of climate change to depress output growth and adversely affect financial markets and stability. Klusak et al. (2023) examine the impact of natural disasters and climate change on sovereign risk, highlighting how these events can increase the cost of borrowing for affected countries, potentially leading to financial instability. Giglio et al. (2019) find that physical

[11] Campiglio et al. (2023) provide a comprehensive review of the literature on the impact of climate-related risks on the price of financial assets.

risks like natural disasters are increasingly being incorporated into market pricing, with implications for financial stability. Battiston et al. (2017), examine how climate change poses long-term financial risks to financial institutions and markets, and discuss the direct impact of physical risks on financial stability and the role of networks in propagating these risks. In addition, several recent papers have explored the potential impact of physical risks being realized employing on financial in macro models (e.g., Dietz et al., 2016; Dafermos et al., 2017, 2018; Bovari et al., 2018).

Academic research on the role of central banks in responding to climate change to ensure financial stability is very recent and has focused on integrating climate risks into central bank operations and policy frameworks. For example, Bolton et al. (2020) argue that climate-related risks are "green swan" events—unpredictable and potentially catastrophic—making them difficult to manage using traditional financial stability tools and call for central banks to take a more proactive role in addressing climate risks through stress testing and integrating climate risks into monetary policy. Murphy et al. (2021) analyze the ways central banks can incorporate climate risks into their monetary policy and financial stability frameworks, including climate-related stress testing, and the integration of climate risks into macroprudential regulation. Campiglio et al. (2023) examine how central banks can use their regulatory and supervisory powers to mitigate the risks that climate change poses to the financial system, including the use of climate-related stress tests and adjustments to capital requirements, to enhance the resilience of the financial system to climate risks. Battiston et al. (2017) present a framework for conducting climate stress tests on the financial system, emphasizing the interconnectedness of financial institutions and the potential for systemic risk; they suggest how physical, and transition climate-related risks might be integrated

into existing stress-testing methodologies. Dafermos et al. (2021) explore how climate change could affect central banks' balance sheets, particularly through their role in financial stability and argue for the integration of climate risks into central banks' stress-testing frameworks. Allen et al. (2021) review the existing methodologies for climate stress testing and discusses the challenges central banks face in implementing these tests. Other papers in this field include Dikau and Volz (2018), Vermeulen et al. (2021), and Thoma et al. (2021).

In spite of the increase in the breadth and depth of the academic literature on climate-related risks for financial stability in recent years, serious research challenges remain. First, companies' exposures to climate-related risk remain opaque, which means that Investors and policymakers have limited information on which they can make reasonable risk assessments. Second, there is not enough understanding of how climate events can trigger abrupt price corrections on financial market, which means that there might be pervasive mispricing (underestimation) of risk, which could lead to excessive levels of effective leverage that could create asset price bubbles. Finally, climate shocks can happen rapidly and on a scale such that aggregate exposures to climate risks can happen rapidly such that risks may be systematically correlated across levered financial intermediaries. In particular, historical data may be of limited use to forecast future climate scenarios, which greatly reduces the accuracy of models that estimate risks.

5 CONCLUSIONS

This paper has reviewed the growing literature on sustainable finance, including the key studies on the effects of incorporating ESG activities into bank decision making, the literature on

aligning banks and financial markets with the goal of reducing carbon emissions more specifically, and the literature linking central banks to climate change through their monetary policy and financial stability responsibilities. As in many other areas of banking, economics and finance, the empirical evidence on the key issues is very mixed, reflecting differences in country and bank samples, methodological approaches, the variation in ESG ratings, and the limited reliability of voluntarily reported and imputed data on carbon emissions. The results from ESG literature are especially problematic and it would be fair to say that, apart from generally positive studies of the impact of ESG scores on banks stability, we do not have an especially good understanding of whether and under what conditions ESG activities influence banks.

The results from the literature on banks and climate change more specifically, while also mixed, are a little clearer. We can be reasonably sure that banks will provide firms with the finance for innovation and its diffusion, even though they may have legacy positions to protect as a result of insider information stemming from bank-client relationships. It seems relatively clear that banks' voluntary commitments to operate to reach net zero carbon emissions by 2050 may not be worth much. Similarly, in the transition to a low carbon economy we cannot be confident that banks are reallocate funds to low carbon sectors or that they are charging higher interest rates to high polluting firms. In contrast, the evidence on how banks are dealing with the physical risks from climate change is encouraging. Banks, and local banks in particular, appear to have been resilient in the face of past natural disasters, often maintaining the supply of credit in affected areas, including by reallocating funds from elsewhere, and there is more evidence that physical risks are being priced into the terms of bank loans.

The literature on central banking and climate change is largely unhelpful as regards monetary policy operations and on the right track but too recent to have a major influence on financial stability operations. Many papers linking monetary policy to climate change advocate a return to policies of the 1950s, 60s, and 70s with an emphasis on directed credit, preferential interest rates, reserve requirements, capital and liquidity ratios in the name of promoting green finance. These polices as a means of favoring a particular credit streams have been discredited and largely abandoned for good reasons. Fortunately, major central banks have yet to take the policy recommendations on board and look unlikely to do so. On the other hand, central banks face a major task in dealing with the transition and physical risks from climate change and the early literature in this regard recognizes clearly the need for central banks to be prudent and incorporate climate risks into their operations and policy frameworks. This is a major challenge for central banks given the opaqueness of bank and firm exposures to climate risk, our limited understanding of how climate events trigger abrupt price changes, and the fact that aggregate exposures of banks to major climate events are likely to be highly correlated. Academic research in these areas is relatively new, but potentially of great importance in assisting central banks in meeting their financial stability responsibilities.

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