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Towards a post-pandemic policy framework to manage climate-related financial risks and resilience

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ABSTRACT

All G20 countries have adopted policies to tame financial instability in response to the COVID-19 pandemic. Post-pandemic financial measures are designed to support bank lending, boost financial markets' liquidity, reduce banks' funding liquidity costs, and allow for a smoother transition in monetary and fiscal policies. However, when analyzed in a broader framework that considers possible interlinkages between the pandemic and threats posed by climate change, these measures are not aligned with the goals of the Paris Agreement. Indeed, there is no evidence that recovery policies to date reflect sustainability priorities nor do they account for climate-related financial risks. The analysis carried out suggests that this failure to account for climate change could amplify the build-up of additional climate-related financial risks and of existing vulnerabilities in the financial system, leading to increased overall exposure to climate risks and thus undermining the low-carbon transition in G20 countries. Against this backdrop, the paper reviews several financial measures to avoid increasing the high carbon bias of existing policies and to explicitly address climate-related risks in the financial sector. The author proposes an enhanced macro-prudential policy framework to achieve three interrelated objectives: tackle climate-related financial risks, scale up green finance for a greener and more sustainable recovery, and preserve the global financial system's resilience.

Key policy insights

- A macro-prudential strategy aligned with the goals of the Paris Agreement is needed to address carbon bias, avoid the increase of climate-related financial risks, and reorient financial flows towards sustainable investments.
- 'Green-enhanced' capital requirements can be used, but they need careful calibration to prevent financial instabilities, while green liquidity instruments pose fewer implementation concerns.
- Climate-related large exposure limits could help contain systemic risks deriving from the materialization of climate risks.
- Harmonized taxonomy and enhanced climate-related disclosure requirements are critical for the correct functioning of proposed climate-related financial instruments.
- Implementing such instruments in a post-pandemic financial policy framework could help underpin a transformative financial response to climate change while strengthening the resilience of the global financial system.

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COVID-19; Green recovery; climate-related financial risks; financial stability; financial resilience; Paris Agreement; climate change

1. Introduction

The socio-economic emergency brought on by the COVID-19 pandemic has forced governments worldwide to build recovery efforts, focused on managing ensuing economic recessions by adopting timely and targeted policies to counteract its adverse effects. Countries experienced the simultaneous materialization of supply and

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demand shocks (del Rio-Chanona et al., 2020; Guerrieri et al., 2020), and, for the first time, both high- and low-income countries experienced recessions at the same time (Nicola et al., 2020). The pandemic also affected the stability of global banking (Elnahass et al., 2021) and financial markets, generating feverish behaviour among investors (D'Orazio & Dirks, 2020).

The pandemic's recessionary framework is aggravated by the challenges posed to the real economy and financial stability by climate change (BCBS, 2020; IAIS, 2020; IOSCO, 2020b; Manzanedo & Manning, 2020; Salas et al., 2020). There can be substantial economic costs and financial losses due to the physical risks of climate change, consisting of increased frequency and severity of extreme weather events (e.g. storms, floods, heat waves) or changes in climate patterns (Batten et al., 2016; Carney, 2015). Firms that incur these losses become more fragile, and this fragility is transmitted to the financial sector via balance sheet interactions. Additionally, a sudden transition to a low-carbon economy through ambitious policy action can provoke the destruction of production capital, the decline in profitability of exposed firms, and stranded fossil fuel assets (Ansar et al., 2013; Cahen-Fourot et al., 2019; Plantinga & Scholtens, 2020). These changes in market activity can be driven by changes in climate policies, economic agents' expectations and behaviours, and technology transformation. Climate change can also affect supply price shocks, market volatility, and economic growth related to inflation through shifts in credit spreads, saving rates, and real interest rates (Krogstrup & Oman, 2019). Physical and transition risks from climate change are thus relevant for monetary policy and financial regulation (Couré, 2018; Monnin, 2018; Schoenmaker, 2021; Schoenmaker & Van Tilburg, 2016). However, financial markets currently show misalignment with commitments to the Paris Agreement and are characterized by a so-called 'carbon bias'; i.e. they favour short-term carbon-intensive assets at the expenses of longer-term 'green' assets, thus contributing to carbon lock-in and path dependence in the financial sector (D'Orazio & Popoyan, 2019; ECB, 2020b; Pfeiffer et al., 2018). Therefore, early action in the direction of 'greening' the financial system and financial regulations can generate considerable benefits in reducing the nature and severity of disruptions to the economy and financial markets from climate change, while further delay implies additional costs (Carney, 2015). Policy action to tackle this unprecedented situation requires a mix of government-financed stimuli, changes in monetary policy conduct, and relaxation of the macro-prudential regulations (Barbier, 2020; Engström et al., 2020).

The financial sector plays a critical role in mitigating macroeconomic and financial shocks brought on both by the COVID-19 pandemic (Reinders et al., 2020) as well as the low-carbon transition (BCBS, 2021b; Bhandary et al., 2021; FSB, 2020; Haigh, 2011; Rozenberg et al., 2013). This paper thus investigates whether financial policies and measures implemented in the aftermath of the height of the pandemic addressed climate change related financial risks and instabilities as well as 'traditional' financial stability challenges.

In particular, this paper's investigation aims to contribute to the debate on policy responses to COVID-19. Existing analyses stress the role of fiscal policies (Barbier, 2020; Engström et al., 2020), discuss the need for 'green' monetary policy measures such as 'green' collateral frameworks and asset purchases programmes (Dikau et al., 2020), or focus on specific geographical areas, such as Latin America (Schydlowsky, 2021) and Asia (Rhee & Svirydzenka, 2021). This paper complements existing literature by focusing on macro-prudential policies in G20 countries and discusses how these countries could address both financial and climate resilience concerns in a post-pandemic policy framework. Macro-prudential policies are indeed important complements to monetary and fiscal policies implemented to offset the damages brought on by COVID-19 (Bénassy-Quéré & Weder di Mauro, 2020; Dixon et al., 2021; Ebeke et al., 2021; Obergassel et al., 2020). Moreover, once the temporary COVID-19 related measures are lifted, financial stability concerns should be considered because imbalances and instabilities could arise. For example, Haselmann and Tröger (2021) note that risks of undercapitalization of Euro Area banks could materialize.

The paper continues with methodology in Section 2, where the scope of the analysis is also laid out. Section 3 presents a review of pandemic-related financial policies created between March and December 2020 and the climate-related financial policymaking of the past 20 years. The focus of the analysis is on G20 countries as they offer an exemplary foundation for the investigation. Besides accounting for almost 85% of global GDP and about 60% of the worldwide population, G20 countries are responsible for 80% of global CO2 emissions; therefore, aside from temporal effects of lockdowns on emissions (Le Quéré et al., 2020), policies implemented in these countries are crucial for determining the global responses to climate change (D'Orazio & Dirks, 2021).

Moreover, since the G20 is composed of developed and developing countries, it represents an interesting pool of countries to analyze pandemic responses.

Since the pandemic and climate change are both threats to financial stability, Section 4 argues that the financial measures implemented following the outburst of the pandemic should have at least included concerns about climate-related risks. This would have implied bolder action taken by prudential and regulatory authorities, using their influential role to encourage a more strategic and risk-sensitive approach to climate change. Moreover, such a response could have contributed to a so-called 'green recovery', which mainly consists of post-COVID-19 fiscal stimulus and bailouts aligned with the goals of the Paris Agreement (Caldecott, 2020; Hepburn et al., 2020; Steffen et al., 2020). Against this backdrop, Section 4 also presents the challenges and opportunities of integrating climate concerns and financial resilience into macro-prudential regulations. Building on these findings, Section 5 proposes a set of climate risk-enhanced measures for a post-pandemic financial policy framework. Concluding remarks and recommendations are offered in Section 6.

2. Methodology and data collection

We analyzed the pandemic-related financial policies enacted from March to December 2020 and reviewed all existing policy measures implemented by G20 countries. To do so, we relied on three data sources: the World Bank database (Alonso Gispert et al., 2020), the IMF policy tracker database (IMF, 2020), and the Yale Program on Financial Stability COVID-19 Financial Response Tracker (YPFS, 2020). After selecting the G20 countries from the three datasets, we built a policy database, which resulted in 737 policies.[1] The selection of pandemic-related financial policies drew on the taxonomy of prudential policies defined by the Basel III criteria (BCBS, 2011; BCBS, 2017; Drumond, 2009).

Our review of climate-related financial policies followed a similar methodological approach regarding countries and taxonomy of policies, as discussed in Appendix B.1. The period considered in the review spans from 2000 to 2020. However, since no centralized information exists on climate-related financial policies, publicly published documents and reports from the relevant authorities (such as central banks and prudential authorities reports, government statements, banking associations) and websites have been considered in the review. Besides the prudential responses, we also considered other financial policies, namely promotional 'green' credit measures, 'green' financial principles, and other 'green' disclosure requirements, i.e. climate-related disclosure requirements aimed at non-financial institutions, insurance companies, and pension funds. This broader review allows us to have a more comprehensive picture of climate-related financial policies adopted in the G20 in the period analyzed.

3. Pandemic and climate threats to financial stability: policy responses

The pandemic represents a significant challenge to the real economy and financial stability worldwide. Activities in several sectors directly affected by the pandemic have collapsed, and the effects are spreading quickly to other sectors since demand is falling. Because the magnitude and duration of the recession are uncertain, the recovery seems to be highly dependent on the effectiveness of containment measures and policy packages adopted and implemented by governments. Both supply and demand shocks that have followed the pandemic have put pressure on the financial sector because of, among other things, lower corporate profitability and investment, lower household wealth, and an increase in demand for bank credit. However, as pointed out by Giese and Haldane (2020), compared to the global financial crisis of 2007–2008, the financial sector has proven more resilient and is better equipped to sustain financing to the real economy because of the regulatory reforms formulated during this previous crisis (Duca, 2017; Gortsos, 2020; Hlaing & Kakinaka, 2018).

Nevertheless, financial markets and intermediaries face fundamental challenges related to funding and lending activities, which, in turn, imply credit, market, and liquidity risks. Therefore, in response to the pandemic, exceptional measures to sustain the credit supply to the real economy and preserve financial system resilience have been recently approved and advanced by G20 countries.

As shown in Figure 1, all G20 countries have adopted financial measures, ranging from prudential buffers to liquidity requirements to credit guarantees. The mix of policies, however, varies across countries. Capital

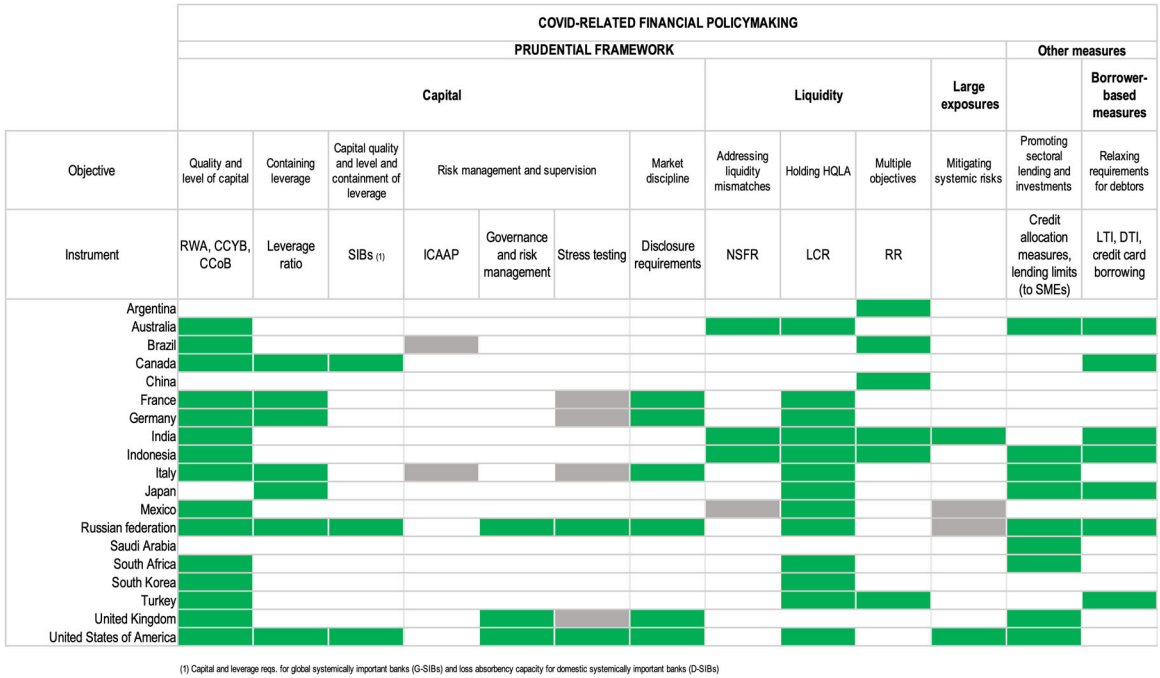

Figure 1. Financial measures adopted in the G20 in response to the COVID-19 pandemic between March and December 2020. Source: Author elaboration on Alonso Gispert et al. (2020), IMF (2020), and YPFS (2020) data.Data are summarized in D'Orazio (2021b). Note: Grey cells indicate the suspension or delay of the measure due to the pandemic. Additional details on the policies implemented at the country level are provided in Appendix A.2.

measures are the most widely adopted, and they have often been implemented in conjunction with liquidity measures that have been allowed to drop temporarily below the minimum requirements (BCBS, 2020). Few countries have decided to allow for a relaxation of borrower-based instruments.

Overall, the G20 eased capital requirements to facilitate the absorption of credit losses and to support lending to real economy sectors. Regulatory authorities promoted the deactivation of existing buffers (such as capital conservation, countercyclical, systemic buffers, and other regulatory buffers introduced) to mitigate system-wide vulnerabilities and to ensure that such buffers would not be used for payouts in the form of dividends, paychecks, or bonuses. The rationale is that if the capital was used to distribute dividends, it would divert financial resources from the main objective of supporting lending to address the pandemic's consequences.

Some countries have also lowered the risk weights for loans directed to small and medium enterprises (SMEs) and to sectors significantly affected by the pandemic.

Our review of pandemic-related financial measures suggests almost no action in the direction of including climate risks or sustaining green lending into pandemic macro-prudential responses. According to our data analysis, only Indonesia has explicitly introduced green priorities in its financial policymaking. The Bank of Indonesia (BoI) decided to lower the minimum limit of down payments on green automotive loans/financing from 5–10% to 0%, in compliance with prudential principles, for banks with a non-performing loans (NPL) ratio below 5% (BoI, 2020).

We thus turned to an in-depth analysis of the engagement of the G20 in climate-related financial policymaking in the past 20 years and detected the adoption of different mixes of policies, as described in detail in Appendix B.2. An overview of the climate-related measures is offered in Figure 2, where the same policy taxonomy as in Figure 1 allows for a comparison with the pandemic-related measures.

According to our review, some G20 countries, such as the UK and France, have been engaged in green finance policymaking since the early 2000s, with the adoption of climate-related disclosure requirements

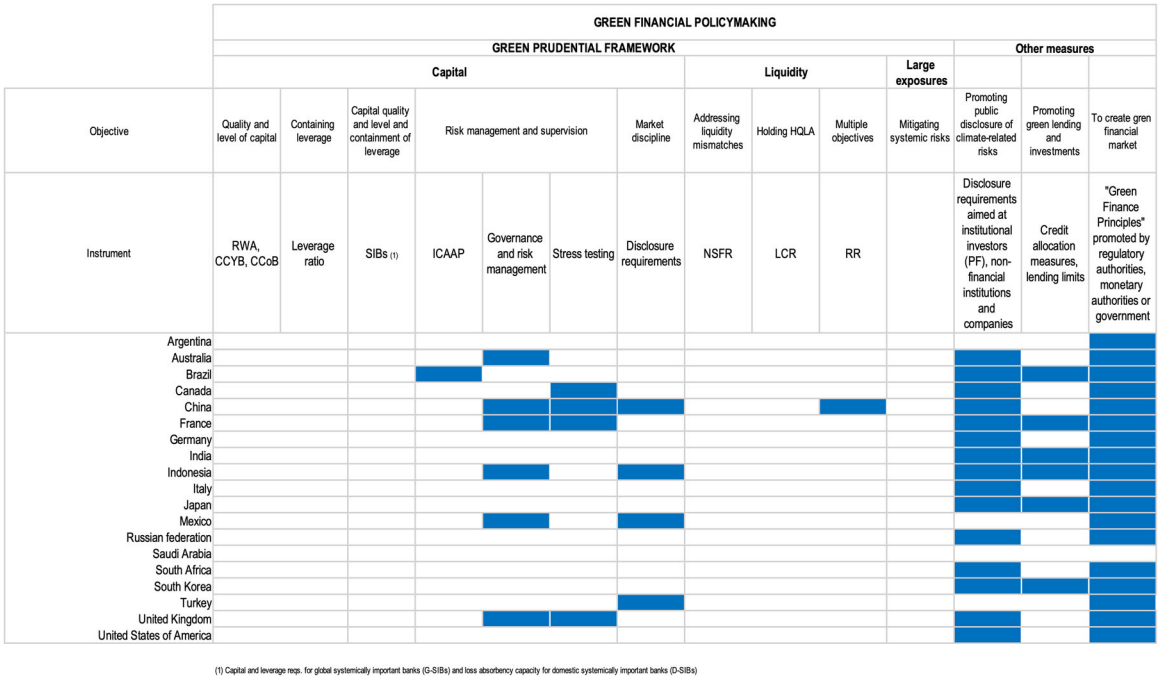

Figure 2. Climate-related (green) financial policymaking in the G20 from 2000–2020. Source: Author elaboration on D'Orazio (2021a) data. Additional details on the policies implemented at the country level are provided in Appendix B.2.

(mainly for non-financial institutions, pension funds, and insurance companies) and the so-called green finance principles and guidelines aimed at creating a financial market aligned with climate change concerns. More recently, the UK and France focused on developing tools to address climate risks while others, including Germany and Brazil, are considering sustainability risk managements and environmental, social and governance (ESG) disclosures. In some cases, e.g. Canada, China, France, and the UK, the attention to climate risks led to the adoption or consideration of quantitative exercises – such as climate-related stress tests – to assess the financial system's resilience to climate exposures.

The majority of G20 countries have adopted or are promoting disclosure requirements for non-financial institutions, and all of them – except Saudi Arabia – have adopted or discussed principles and/or guidelines to include climate risk concerns in financial markets. Finally, we note that only a few of them, principally emerging economies such as Brazil, India and Indonesia, have adopted green credit allocation measures.

4. Opportunities and challenges in integrating climate concerns and financial resilience in macro-prudential regulations

At first glance, the review in Section 3 shows that all G20 countries (except Saudi Arabia) are already equipped to deal with climate-related financial risks, as they have adopted at least one climate-related (green) financial measure (see Figure 2 and Appendix B.2). However, a more in-depth analysis suggests a gloomier picture. First, most countries have adopted only 'soft' measures, such as green finance principles or disclosure requirements aimed at companies or non-financial institutions (see Jackson et al. (2020) for a recent international comparison). Second, only very few countries, namely Canada, China, France, and the UK, actively consider climate-related financial risks through stress tests or scenario analysis exercises to be carried out by financial institutions. Third, mandatory disclosure requirements for commercial banks have only been adopted in developed countries and in a few emerging economies, i.e. China, Indonesia, Mexico, and Turkey. Moreover, the pandemic has delayed the implementation of some critical measures, such as climate-related stress tests for banks. The

Bank of England, for example, has announced that the implementation of this policy is postponed until at least mid-2021 to respond to the significant impact of COVID-19 (BoE, 2020).

The evidence collected so far reveals that the existing financial framework is insufficient to assess the financial system's exposure to climate-related financial risks, nor is it sufficient to reorient financial flows towards sustainable investments. Moreover, the macro-prudential financial policies promoted in response to the pandemic reinforce this framework and can thus amplify existing vulnerabilities related to climate change. The rationale for this is as follows. Since existing macro-prudential financial policies do not integrate concerns related to climate change or green financial policymaking and regulation, they could easily promote an increase in lending to carbon-intensive sectors and reinforce the so-called high 'carbon bias.' In this context, the overall exposure of the G20 to climate-related financial risks is worsened, and the transition towards a low-carbon economy could be negatively affected.

Against this backdrop, we outline a set of prudential instruments, which could be chosen when revisions to regulations are considered. By following the prudential policy classification presented in Section 2, we distinguish between capital, liquidity, and large exposure measures and classify them according to their potential impacts on tackling climate risks, scaling up green finance,[2] and taming financial instability. An overview of the policies and their potential impact the three objectives is offered in Figure 3.

4.1. Capital measures

4.1.1. Capital and leverage instruments

Several options are available regarding measures that aim to affect the level and quality of bank capital, as defined under Pillar I of the Basel Framework. An increase in the share of low-carbon investments could be achieved, for example, by using a 'Brown Penalizing Factor' (BPF) to calculate banks' Capital Adequacy Requirements (CAR); this measure increases the risk weights associated with assets labelled as carbon-intensive, polluting, or those that cause damage to the environment (2DII, 2018). Therefore, it needs to rely on a widely accepted taxonomy to function correctly and to minimize market distortions. An internationally agreed-upon taxonomy and a harmonized regulation across banks would thus be crucial for correctly identifying polluting assets (EBA, 2018; EBF, 2018; TCFD, 2017; TCFD, 2018). Indeed, in the absence of a widely accepted benchmark taxonomy, 'greenwashing' can lead to reputational risk, inadequate accreditation for green-labelled products, and a 'green bubble' because of the increased demand for green assets and a non-increasing quantity of those assets. Other problematic consequences of implementating the CAR-BPF are distributional imbalances

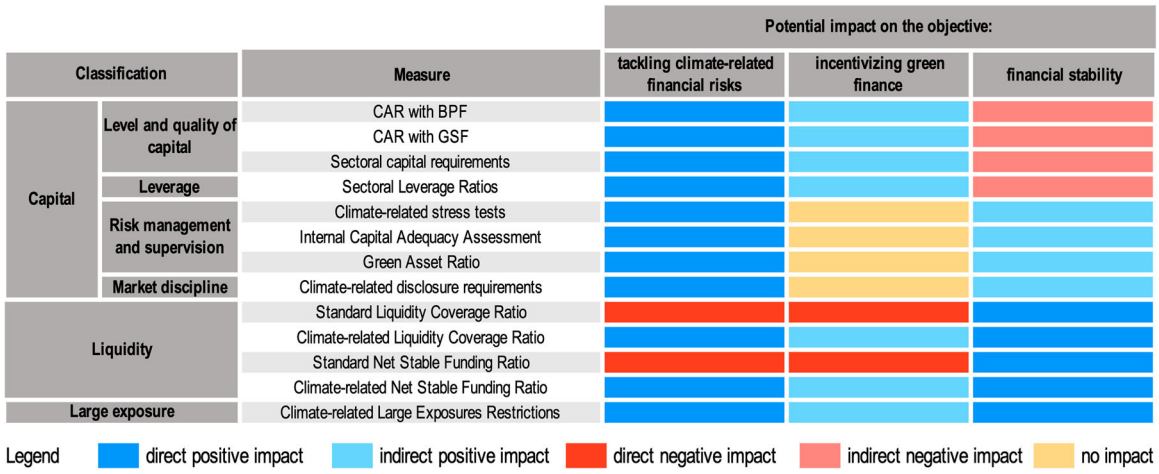

Figure 3. Overview of climate-related macro-prudential policies and their potential impact on tackling climate risks, scaling up green finance and taming financial instability. Source: Author elaboration. Notes: CAR: capital adequacy ratio; BPF: brown-penalizing factor; GSF: green supporting factor.

in certain sectors of the economy (since it favours less carbon-intensive sectors) and impacts on households depending on their income level, as low-income households who cannot afford environmentally-friendly options could be penalized (Berenguer et al., 2020).

The BPF has been recommended as an alternative to the Green Supporting Factor (GSF), which proposes to lower the capital requirement for green assets (Dombrovskis, 2017). However, implementing a GSF could threaten financial stability due to possible mispriced climate risks, i.e. when green assets are considered risk-free or less risky without empirical evidence (Schoenmaker & Van Tilburg, 2016). D'Orazio and Popoyan (2019) and Berenguer et al. (2020) note that relying on these approaches would require recalibrating the risk weight factors of all assets to integrate climate risks in banks' balance sheets fully. However, it is required that the climate-adjusted risk weight of green assets should be lower than the current risk weight to avoid that they would remain constant. Recently, these instruments were studied in the framework of macro-financial theoretical models (see, e.g. Dafermos and Nikolaidi (2021), Dunz et al. (2021)) which show that the GSF increases bank leverage and contributes to scaling up green investments (only in the short run), but it also introduces potential trade-offs on a bank's financial stability; the BPF, instead, reduces output and increases loan defaults.

Building on existing theoretical evidence, we note that both factors could help address the high carbon bias that currently affects the global financial system; they would contribute to addressing climate risks by limiting the financial system's exposure to carbon-intensive assets (see EBF (2018) and Berenguer et al. (2020), for a broader discussion on the integration of climate risks in capital requirements). However, if not correctly calibrated, they could undermine the resilience of the system leading to market distortions and financial bubbles (2DII, 2018; D'Orazio & Popoyan, 2019). These instruments are thus characterized by practical and political challenges, presenting barriers to their implementation in the short term. Further analysis is required to explore their feasibility and effectiveness.

Sectoral capital requirements represent alternative measures that could be adopted when considering bank capital requirements for climate-related financial policymaking. These could effectively address both the climate financial risks and contain the instabilities implied by a transition to a low- or no-carbon economy. If implemented directly, sector capital requirements increase bank fund ratios by offering additional capital buffers. Alternatively, they could imply the need to adopt differentiated risk weights for low-carbon vs. carbon-intensive sectors or technologies within sectors. Additional capital buffers or increased risk weights for carbon-intensive sectors could limit a bank's exposure to that class of assets. Thus, restricting over-leveraging to carbon-intensive sectors increases the system's resilience and indirectly reorient lending to non-polluting sectors. However, they presuppose an increase in the cost of bank capital to penalize polluting sectors, which could lead to market distortions in the short run. Moreover, their implementation is complicated by the evidence that the analysis of exposures at a sectoral level might underestimate the true level of emissions involved in firms' overall value chains (FSB, 2020). Therefore, further research is required in this area before policymakers could safely resort to such an instrument.

A sectoral leverage ratio represents perhaps a more transparent and easier instrument compared to those outlined above. It would be based on evaluating the exposure of the bank's capital to assets related to carbon-intensive sectors, which should be limited to a certain ratio of total assets, the exact ratio to be determined by the regulator (D'Orazio & Popoyan, 2019). This measure, similar to sectoral capital requirements, could be particularly effective in taming instabilities in the financial market as it limits over-leveraging to polluting sectors and indirectly reorients financial flows towards green ones. However, the feasibility of its implementation suffers from the same issues highlighted for sectoral capital requirements.

4.1.2. Risk management and supervision instruments, and market discipline

Risk management and supervision measures are defined under Pillar II of the Basel Framework and are also relevant in the climate-related financial policy framework. Indeed, stress tests could be promoted both as a micro and macro-prudential instrument (Borio et al., 2014; Henry et al., 2013). They provide a valuable tool to assess a bank's performance and risk exposure when used for micro-prudential purposes. When employed for macro-prudential purposes, they reveal how significant economic or financial shocks would affect the banking system as a whole. Indeed, they aim to test the resilience of the largest financial firms' business models or the financial system as a whole to the physical and transition risks from climate change (Battiston et al.,

2017; BCBS, 2021a; Monasterolo, 2020). Moreover, stress tests and most macro-prudential instruments share a common objective, namely building resilience, and they can be considered complements rather than substitutes. Indeed, the indicators used to implement macro-prudential tools can help design the stress test scenarios, and vice versa, capital losses or liquidity shortages revealed by stress tests can help calibrate macro-prudential instruments. Although the literature is still in its infancy, some approaches have been developed to identify the most exposed sectors to climate-related physical risks. Among them, we mention the 'climate-policy relevant sectors' approach by Battiston et al. (2017) and the 'carbon-critical sectors' approach by Faiella and Lavecchia (2020). The information collected by applying these approaches provides a first insight into the financial system's exposure to climate risks and credit risk. It could then be used as a starting point for a more complex climate-scenario analysis.

Finally, among risk management measures, a Green Asset Ratio is relatively easy to implement and implies the assessment of the exposure of banks' portfolios to carbon-intensive assets (EBA, 2019).

Climate-related disclosure requirements are closely related to the measures discussed so far. They play a relevant role in a low-carbon transition framework (TCFD, 2017) because they help quantify the materiality of climate and environmental risks, improve understanding of where carbon-related assets are concentrated in the financial sector, and inform investment, credit, and insurance underwriting decisions. However, implementing these measures is relatively costly, implying that financial institutions should devote resources to build new expertise in this direction. Moreover, they should be based on a harmonized methodology – consistent with the Task Force on Climate-related Financial Disclosures recommendations (TCFD, 2017) – and implemented by all market players (IOSCO, 2020a; Zenghelis & Stern, 2016). Additionally, as noted by the European Banking Federation, because of a lack of common taxonomy and disclosure framework, the introduction of any Pillar I or II measures poses relevant challenges to policymakers (EBF, 2018).

4.2. Liquidity measures

As a response to the 2007–2008 global financial crisis, liquidity regulations were revised to improve the management of market liquidity and funding risks (Goodhart, 2008). In particular, the Basel Committee issued two liquidity standards, namely the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), to explicitly address the excess liquidity risk exposure exposed by the financial crisis (Acharya & Mora, 2015; Cornett et al., 2011). These regulations implied that banks were asked to hold enough high-quality liquid assets (HQLA), such as cash, sovereign and central bank bonds that have 0% risk weight, and corporate bonds with high rating[3] and more stable and longer-term funding sources against their less liquid assets to reduce maturity mismatch risk (King, 2013). The rationale is that allocating more funds to safe liquid assets reduces asset risk in terms of the volatility of asset returns for financial institutions, thus committing them also to removing solvency risk from a portion of their portfolio (Arnold et al., 2012). Consequently, if, on the one hand, existing liquidity requirements increase the financial system's resilience, on the other hand, they tend to hamper green investments. Indeed, the investigations in EBF (2018) and D'Orazio and Popoyan (2019) explain that the LCR could reshuffle banks' balance sheets toward highly-quality liquid assets. Additionally, to comply with the NSFR requirements, financial institutions will become more sensitive to temporal mismatches between assets and funding and, hence, more reluctant to hold long-term (green) assets.

The materialization of climate-related financial risks can also lead to an increase in liquidity risk[4] of financial institutions (FSB, 2020). The financial system could experience serious funding and market liquidity shortages due to asset stranding, which can cause a re-evaluation of those assets, affecting both the financial institutions holding the assets and other institutions connected to them through the banking network. The contagion effect through balance sheets is thus particularly relevant in this climate-related, post-pandemic financial risk framework. Moreover, possible liquidations of several banks' balance sheets can follow the transition, implying a shift in the asset prices (i.e. decline of the price) and margin calls, which may trigger liquidity shortages.

All in all, careful consideration of transition risks points to the need for an 'adjusted' liquidity requirement that could vary over time and considers the instabilities deriving from those risks. In this sense, a 'greened' liquidity coverage ratio could limit capital available for carbon-intensive assets. In contrast, a lower stable

fund ratio in a 'greened' net stable funding ratio could account for increased green assets. Both enhanced measures are relatively easy to implement as they do not require major changes to existing instruments. However, for non-distortionary functioning, the implementation of these instruments would need to rely on a taxonomy to distinguish between green and polluting assets, as already discussed above.

4.3. Large exposures restrictions

The experience of the 2007–2008 global financial crisis points to the utility of large exposure restrictions to increase the financial system's resilience and reduce the build-up of vulnerabilities (Claessens & Kodres, 2014; Laeven et al., 2010). These measures are intended to act as a backstop to prevent an institution from incurring disproportionately large losses because of the financial failure of an individual client or group of connected clients due to the occurrence of unforeseen events (BCBS, 2014). Large exposure restrictions are thus particularly relevant in the post-pandemic transition. In a framework designed to catalyze and accelerate the pace of green investments, vulnerabilities to such financial failures could be considered as stemming from exposure to carbon-intensive assets or clients dependent on these. This instrument can thus serve as a complement to standard risk-based capital requirements; it could contain the maximum possible losses a bank could incur in the case of bankruptcy or default of a counterpart in the case, for example, of a sudden policy transition to achieve a low-carbon economy. As discussed in D'Orazio and Popoyan (2019), if applied by considering sectoral exposures, a green-enhanced 'large exposures restrictions' measure could help ensure that a bank's solvency is not affected in the case of materialized climate-related financial risks.

5. Towards a post-pandemic macro-prudential strategy?

Our analysis of pandemic-related measures reinforces the view of several economists that current policy efforts are not enough to handle threats posed by climate change at the global level (see Hepburn et al. (2020) for a recent survey of economic experts on international pandemic recovery policies). Misalignment with the goals of the Paris Agreement can be identified in recent reviews of policy and progress. Indeed, despite growing engagement to 'green' central banks and related policy (see de Galhau et al., 2019; Elderson, 2018; Lane, 2019; NGFS, 2019, among others), many commentators still favour a more cautious approach. The most relevant among them are those arguing about the risk of 'stretching' monetary policy and its mandate to cope with climate change challenges (see Elderson, 2021; Rudebusch et al., 2019; Weidmann, 2019, among others), and those arguing about the market neutrality principle as discussed in Van't Klooster and Fontan (2020). We note, however, that the debate is gradually evolving towards a more critical approach to market neutrality in the context of climate risks and climate change mitigation. Among others, Isabel Schnabel, a current member of the ECB's Executive Board, recently stated that in the presence of massive market failures such as climate change, 'market neutrality may not be the appropriate benchmark for a central bank when the market by itself is not achieving efficient outcomes' (Schnabel, 2020b). Other researchers and policymakers point out that the monetary and regulatory authorities' interventions to design new instruments and preference for green asset purchases may distort markets (see, among others, the discussion in Breitenfellner et al., 2019; Campiglio et al., 2018; Couré, 2018; de Galhau et al., 2019; Pereira Da Silva, 2020). Finally, the lack of standardized and internationally agreed-upon green vs. polluting vs. neutral technology taxonomies, and related disclosure requirements, is slowing change. The failure of international agreement on this topic presents hurdles for regulatory authorities and central banks to adopt green prudential measures as part of the response to the pandemic. Additionally, the lack of international harmonization is generally considered an obstacle to a correct evaluation of the sources of climate risks and thus becomes a barrier to action (see, e.g. OMFIF, 2019).

Because of the threats climate change poses to financial stability, we maintain that post-COVID-19 financial reform measures should, to some extent, include green or climate-related priorities. We believe this is particularly relevant and complementary to the claim that the post-pandemic stimulus and bailouts need to be compatible with the objectives of the Paris Agreement (Caldecott, 2020). Although countries with more concentrated banking systems may prove to be more resilient to the pandemic (Danisman et al., 2021), any

post-pandemic framework will be particularly challenging from a financial stability point of view due to high debt levels, especially among non-financial firms across the world (Cevik et al., 2020), and a resulting increase in default risk, liquidity risk and asset risk (Elnahass et al., 2021).

To complement fiscal or monetary policies implemented to offset the damages brought on by COVID-19, we propose using an enhanced climate-related macro-prudential framework to guide action. The rationale for this is that macro-prudential policies are important complements to monetary and fiscal policies (Beck, 2020; Bénassy-Quéré & Weder di Mauro, 2020; Dixon et al., 2021; Ebeke et al., 2021; Obergassel et al., 2020) and could support green market development to enhance the transition towards relevant green economic sectors (Allan et al., 2020). One way to do this is to establish policy and provide guidance to banks on considering and reflecting on financial risks related to climate change. Using this framework will help avoid an increase in carbon bias and help manage climate-related risks in the financial sector.

Based on the results of our analysis, we maintain that when temporary, pandemic-related prudential measures are lifted, financial regulators should devote particular attention to achieving three interrelated objectives: tackle climate-related financial risks, scale up green finance for a greener recovery, and preserve the financial system's resilience (i.e. financial stability).

6. Conclusions and recommendations

This review focuses on pandemic-related financial policies implemented between March and December 2020 in G20 countries. The findings show the role these policies may have in supporting bank lending, boosting financial market liquidity, reducing banks' funding liquidity costs, and allowing a smoother transmission of monetary and fiscal policies in this recessionary period. However, when analyzed in a broader framework that considers possible interlinkages of responses to the pandemic with the threats posed by climate change, it appears that these policies are not aligned with the goals of the Paris Agreement. The review shows indeed that they are not addressing physical and transition risks related to climate change that could hit the financial system. We argue that policymakers in the G20 should be alerted that the pandemic-related recovery measures could be promoting an increase in lending to carbon-intensive sectors, thus worsening countries' overall exposure to climate risks, negatively affecting the green transition, and raising risks to the financial system as a whole. Against this backdrop, five main recommendations emerge.

First, particular attention should be devoted to capital and liquidity measures. We stress that the requirements should not be too low to avoid worsening credit and solvency risks (Cornett et al., 2011; Gefang et al., 2011; Giese & Haldane, 2020) or undercapitalization (Haselmann & Tröger, 2021). We also advocate for further studies on how to integrate climate risk in capital requirements because they could represent an important instrument to jointly address climate risks and scale up green finance. However, without internationally harmonized taxonomies and disclosure approaches, modifying capital requirements to favour green assets, or to penalize polluting assets, would pose significant challenges to policymakers and negatively affect the financial system's resilience. Enhanced liquidity instruments, by comparison, pose fewer implementation concerns and could therefore be promoted immediately to address carbon bias and indirectly incentivize green finance.

Second, to avoid over-leveraging, (standard) leverage ratios should be used and closely observed to carry out monitoring exercises designed to enhance green investments. The combination of standard and green financial tools would prove particularly helpful to assess exposure to carbon-intensive sectors and the implied risks associated with a low-carbon transition.

Third, developing climate-related large exposure limits would help contain systemic risks deriving from the materialization of climate risks.

Fourth, we stress the importance of climate-related risk assessment by promoting mandatory climate-related stress tests and climate-related internal capital adequacy assessments. Some countries' experiences in (pilot) climate stress tests, e.g. in France, UK, and the Netherlands (outside the G20), have proven successful (Allen et al., 2020; BoE, 2019a; Vermeulen et al., 2018). Similar exercises could thus be promoted across other G20 countries and replicated in the context of the post-pandemic framework. Other measures that could be supported in this policy area are the Internal Capital Adequacy Assessment Process (ICAAP) implemented in

Brazil and the green asset ratio proposed by the European Banking Association. The former would enhance climate risk management at the individual bank level (EBF, 2018); the latter could be used to evaluate the exposure to carbon-intensive assets (EBA, 2019).

Finally, for the correct functioning of the proposed climate-related instruments, we advocate using a harmonized taxonomy of financial assets, such as the one proposed at the European level (see EP, 2019). Beyond this, there is also a need for an enhanced climate-related disclosure requirement framework, which should be made mandatory for all financial institutions.

Calling for a coherent macro-prudential strategy that is aligned with the Paris Agreement does not imply that the burden of addressing the climate change emergency should be carried by central banks and financial regulators alone. Instead, it emphasizes the crucial role they could play in reducing systemic risks related to the low-carbon transition, directing capital flows to meet climate objectives, incentivizing financial institutions to factor climate risks into decision-making, and protecting investors from market failures related to possible abrupt changes in climate (Gunningham, 2020). As discussed in Schnabel (2020a), 'COVID-19 provides a chance to build a greener economy. [. . .] And it is a chance to make a deeper and greener financial market that reduces the costs of transitioning towards a low-carbon economy'.

Unfortunately, according to our analysis, this chance was missed in the first phase of pandemic recovery policy response. Nevertheless, more could be done in the upcoming months, when adjustments will be required, and new measures will be promoted. Stronger coordination among countries will be needed to define such a resilient and green macro-prudential framework at the international level.

Notes

1. For further details, see Appendix A.1.
2. Green finance has received particular attention in the past years for its role in catalyzing the transition towards sustainability (Falcone, 2020). Recently, Mark Carney's commitment as UN Special Envoy for Climate Action has sparked a renewed interest in this topic. In his last public statements, he argued that achieving climate goals will require all forms of finance and that coordinated action is needed to ensure that the financial sector can allocate capital to manage risks and seize opportunities in the transition to net-zero (Carney, 2021a, 2021b).
3. To qualify as HQLA, according to the Basel Committee on Banking Supervision, assets should be liquid in markets during a time of stress and, ideally, be central bank eligible. For additional insights, see BCBS, 2019.
4. Liquidity risk is the risk that a solvent bank is unable to meet its cash flow needs using its own stock of liquidity and borrowed funds without materially affecting its daily operations or overall financial condition.

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References

Acharya, V. V., & Mora, N. (2015). A crisis of banks as liquidity providers. *The Journal of Finance*, *70*(1), 1–43. https://doi.org/10.1111/jofi.12182

Allan, J., Donovan, C., Ekins, P., Gambhir, A., Hepburn, C., Reay, D., Robins, N., Shuckburgh, E., & Zenghelis, S. (2020). A net-zero emissions economic recovery from COVID-19. *COP26 Universities Network*.

Allen, T., Dees, S., Chouard, V., Clerc, L., de Gaye, A., Devulder, A., Diot, S., Lisack, N., Pegoraro, F., Rabate, M., Svartzman, R., Vernet, L. (2020). Climate-related scenarios for financial stability assessment: an application to France. *Banque de France July 2020, WP 774*.

Alonso Gispert, T., Feyen, E., Kliatskova, T., Mare, D. S., & Poser, M. (2020). COVID-19 pandemic: A database of policy responses related to the financial sector. *World Bank Finance, Competitiveness, Innovation Global Practice*.

Ansar, A., Caldecott, B., & Tilbury, J. (2013). Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets? *Smith School of Enterprise and the Environment, University of Oxford working paper*.

Arnold, B., Borio, C., Ellis, L., & Moshirian, F. (2012). Systemic risk, macroprudential policy frameworks, monitoring financial systems and the evolution of capital adequacy. *Journal of Banking & Finance*, *36*(12), 3125–3132. https://doi.org/10.1016/j.jbankfin.2012.07.023

Barbier, E. B. (2020). Greening the post-pandemic recovery in the g20. *Environmental and Resource Economics*, *76*(4), 685–703. https://doi.org/10.1007/s10640-020-00437-w

Batten, S., Sowerbutts, R., & Tanaka, M. (2016). Let's talk about the weather: the impact of climate change on central banks. Technical report, Bank of England.

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., & Visentin, G. (2017). A climate stress-test of the financial system. *Nature Climate Change*, *7*(4), 283–288. https://doi.org/10.1038/nclimate3255

BCBS. (2011). Basel III: A global regulatory framework for more resilient banks and banking systems. *Basel Committee on Banking Supervision*.

BCBS. (2014). Supervisory framework for measuring and controlling large exposures. Technical report, BCBS - Basel Committee on Banking Supervision - Bank for International Settlements.

BCBS. (2017). Basel III: Finalising post-crisis reforms. *Basel Committee on Banking Supervision*.

BCBS. (2019). LCR – Liquidity Coverage Ratio. LCR30 – High-quality Liquid Assets. *Basel Committee on Banking Supervision*; Version effective as of 15 Dec 2019.

BCBS. (2020). Basel committee coordinates policy and supervisory response to COVID-19. Press release, BCBS - Basel Committee on Banking Supervision - Bank for International Settlements. URL: https://www.bis.org/press/p200320.htm

BCBS. (2021a). Climate-related financial risks – measurement methodologies. Technical report, BCBS - Basel Committee on Banking Supervision - Bank for International Settlements.

BCBS. (2021b). Climate-related risk drivers and their transmission channels. Technical report, BCBS - Basel Committee on Banking Supervision - Bank for International Settlements.

Beck, T. (2020). Finance in the times of coronavirus. *Economics in the Time of COVID-19 73*.

Bénassy-Quéré, A., & Weder di Mauro, B. (2020). Europe in the time of COVID-19: A new crash test and a new opportunity. *Europe in the Time of COVID-19*, 1.

Berenguer, M., Cardona, M., & Evain, J. (2020). Integrating climate-related risks into banks' capital requirements. *Institute for Climate Economics (I4CE). Paris*.

Bhandary, R. R., Gallagher, K. S., & Zhang, F. (2021). Climate finance policy in practice: A review of the evidence. *Climate Policy*, *21*(4), 529–545. https://doi.org/10.1080/14693062.2020.1871313

BoE. (2019a). The 2021 biennial exploratory scenario on the financial risks from climate change. Technical report, Bank of England.

BoE. (2020). Statement by the prudential regulation authority on prioritisation in light of COVID-19. Technical report, Bank of England.

BoI. (2020). Bi 7-day reverse repo rate tetap 4,00%: Bersinergi mendorong pemulihan ekonomi nasional. Technical report, Bank of Indonesia.

Borio, C., Drehmann, M., & Tsatsaronis, K. (2014). Stress-testing macro stress testing: Does it live up to expectations? *Journal of Financial Stability*, *12*, 3–15. https://doi.org/10.1016/j.jfs.2013.06.001

Breitenfellner, A., Pointner, W., & Schuberth, H. (2019). The potential contribution of central banks to Green finance. *Vierteljahrshefte zur Wirtschaftsforschung*, *88*(2), 55–71. https://doi.org/10.3790/vjh.88.2.55

Cahen-Fourot, L., Campiglio, E., Dawkins, E., Godin, A., & Kemp-Benedict, E. (2019). Capital stranding cascades: The impact of decarbonisation on productive asset utilisation. *WU Vienna University of Economics and Business*.

Caldecott, B. (2020). Post COVID-19 stimulus and bailouts need to be compatible with the Paris agreement. *Journal of Sustainable Finance & Investment*, 1–8. https://doi.org/10.1080/20430795.2020.1809292

Campiglio, E., Dafermos, Y., Monnin, P., Ryan-Collins, J., Schotten, G., & Tanaka, M. (2018). Climate change challenges for central banks and financial regulators. *Nature Climate Change*, *8*(6), 462–468. https://doi.org/10.1038/s41558-018-0175-0

Carney, M. (2015). Breaking the tragedy of the horizon - climate change and financial stability (speech). *Bank of England, Speech*.

Carney, M. (2021a). Building a private finance system for net zero. *UK COP 26 - Report*.

Carney, M. (2021b). Investing in net-zero climate solutions creates value and rewards. *United Nations - Climate Action*.

Cevik, S., Miryugin, F., et al. (2020). Leverage shocks: Firm-level evidence on debt overhang and investment. Technical report, International Monetary Fund.

Claessens, M. S., & Kodres, M. L. E. (2014). *The regulatory responses to the global financial crisis: Some uncomfortable questions*. International Monetary Fund.

Cornett, M. M., McNutt, J. J., Strahan, P. E., & Tehranian, H. (2011). Liquidity risk management and credit supply in the financial crisis. *Journal of Financial Economics*, *101*(2), 297–312. https://doi.org/10.1016/j.jfineco.2011.03.001

Couré, B. (2018). Monetary policy and climate change, speech by B. Couré, member of the executive board of the ECB, at a conference on "scaling up green finance: The role of central banks". *European Central Bank*.

Dafermos, Y., & Nikolaidi, M. (2021). How can Green differentiated capital requirements affect climate risks? A dynamic macrofinancial analysis. *Journal of Financial Stability*, *54*, 100871. https://doi.org/10.1016/j.jfs.2021.100871

Danisman, G. O., Demir, E., & Zaremba, A. (2021). Financial resilience to the COVID-19 pandemic: The role of banking market structure. *Applied Economics*, *53*(39), 4481–4504. https://doi.org/10.1080/00036846.2021.1904118

de Galhau, V., et al. (2019). Climate change: central banks are taking action. In *Financial Stability Review - Greening the financial system: the new frontier*, pp. 7.

del Rio-Chanona, R. M., Mealy, P., Pichler, A., Lafond, F., & Farmer, D. (2020). Supply and demand shocks in the COVID-19 pandemic: An industry and occupation perspective. *arXiv preprint arXiv:2004.06759*.

Dikau, S., Robins, N., & Volz, U. (2020). A toolbox of sustainable crisis response measures for central banks and supervisors–second edition: Lessons from practice. *Grantham Research Institute on Climate Change and the Environment, London*.

Dixon, J., et al. (2021). The role of macro-prudential policy in the insurance sector: Experience during the COVID-19 crisis. *Is Macro-Prudential Policy Resilient to the Pandemic?*, *49*(March 2021). https://blocnotesdeleco.banque-france.fr/sites/default/files/medias/documents/820101_fsr_2020_en.pdf#page=49

Dombrovskis, V. (2017). Greening finance for sustainable business. *Speech by Vice-President for the Euro and Social Dialogue, Financial Stability and Financial Services Valdis Dombrovskis* (SPEECH/17/5235).

D'Orazio, P. (2021a). Data on climate-related financial policies in G20 countries. *FigShare*, https://doi.org/10.6084/m9.figshare.16358961

D'Orazio, P. (2021b). Pandemic-related financial policies in G20 countries. *FigShare.*, doi:10.6084/m9.figshare.14706444.

D'Orazio, P., & Dirks, M. W. (2020). *COVID-19 and financial markets: Assessing the impact of the coronavirus on the eurozone*. Number 859. Ruhr Economic Papers.

D'Orazio, P., & Dirks, M. W. (2021). Exploring the effects of climate-related financial policies on carbon emissions in G20 countries: A panel quantile regression approach. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-15655-y

D'Orazio, P., & Popoyan, L. (2019). Fostering Green investments and tackling climate-related financial risks: Which role for macro-prudential policies? *Ecological Economics*, *160*, 25–37. https://doi.org/10.1016/j.ecolecon.2019.01.029

Drumond, I. (2009). Bank capital requirements, business cycle fluctuations and the Basel accords: A synthesis. *Journal of Economic Surveys*, *23*(5), 798–830. https://doi.org/10.1111/j.1467-6419.2009.00605.x

Duca, J. V. (2017). The great depression versus the great recession in the us: How fiscal, monetary, and financial polices compare. *Journal of Economic Dynamics and Control*, *81*, 50–64. https://doi.org/10.1016/j.jedc.2017.05.008

Dunz, N., Naqvi, A., & Monasterolo, I. (2021). Climate sentiments, transition risk, and financial stability in a stock-flow consistent model. *Journal of Financial Stability*, *54*, 100872. https://doi.org/10.1016/j.jfs.2021.100872

EBA. (2018). Green finance: Encouraging green loans is a sensible idea. (Originally published in Dutch daily het financieele dagblad on 16 January 2018).

EBA. (2019). Action plan on sustainable finance. Technical report, European Banking Authority.

Ebeke, M. C. H., Jovanovic, N., Valderrama, M. L., & Zhou, J. (2021). *Corporate liquidity and solvency in Europe during COVID-19: The role of policies*. International Monetary Fund.

EBF. (2018). Towards a green finance framework. *European Banking Federation report*.

ECB. (2020b). ECB report on institutions' climate-related and environmental risk disclosures. Technical report, European Central Bank - Banking Supervision.

Elderson, F. (2018). From mission to supervision: putting sustainable prosperity on the agenda of the Dutch central bank. *LSE sustainable finance leadership series*.

Elderson, F. (2021). Greening monetary policy. *Blog post by Frank Elderson, Member of the Executive Board of the ECB, 13 February 2021*.

Elnahass, M., Trinh, V. Q., & Li, T. (2021). Global banking stability in the shadow of COVID-19 outbreak. *Journal of International Financial Markets, Institutions and Money*, *72*, 101322. https://doi.org/10.1016/j.intfin.2021.101322

Engström, G., Gars, J., Jaakkola, N., Lindahl, T., Spiro, D., & van Benthem, A. A. (2020). What policies address both the coronavirus crisis and the climate crisis? *Environmental and Resource Economics*, *76*(4), 789–810. https://doi.org/10.1007/s10640-020-00451-y

EP. (2019). Establishment of a framework to facilitate sustainable investment. *Legislative resolution of 28 March 2019 on the proposal for a regulation of the European Parliament and of the Council on the establishment of a framework to facilitate sustainable investment European Parliament (COM(2018)0353 – C8-0207/2018–2018/0178(COD))*.

Faiella, I., & Lavecchia, L. (2020). The carbon content of Italian loans. *Journal of Sustainable Finance & Investment*, 1–19. https://doi.org/10.1080/20430795.2020.1814076

Falcone, P. M. (2020). Environmental regulation and Green investments: The role of Green finance. *International Journal of Green Economics*, *14*(2), 159–173. https://doi.org/10.1504/IJGE.2020.109735

FSB. (2020). The implications of climate change for financial stability. *Financial Stability Board*, 1–35. https://www.fsb.org/2020/11/the-implications-of-climate-change-for-financial-stability/

Gefang, D., Koop, G., & Potter, S. M. (2011). Understanding liquidity and credit risks in the financial crisis. *Journal of Empirical Finance*, *18*(5), 903–914. https://doi.org/10.1016/j.jempfin.2011.07.006

Giese, J., & Haldane, A. (2020). COVID-19 and the financial system: A tale of two crises. *Oxford Review of Economic Policy*, *36* (Supplement 1), S200–S214. https://doi.org/10.1093/oxrep/graa035

Goodhart, C. A. (2008). The regulatory response to the financial crisis. *Journal of Financial Stability*, *4*(4), 351–358. https://doi.org/10.1016/j.jfs.2008.09.005

Gortsos, C. V. (2020). The response of the European central bank to the current pandemic crisis: Monetary policy and prudential banking supervision decisions. *European Company and Financial Law Review*, *17*(3–4), 231–256. https://doi.org/10.1515/ecfr-2020-0017

Guerrieri, V., Lorenzoni, G., Straub, L., & Werning, I. (2020). Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages? Technical report, National Bureau of Economic Research.
Gunningham, N. (2020). A quiet revolution: Central banks, financial regulators, and climate finance. *Sustainability*, *12*(22), 9596. https://doi.org/10.3390/su12229596
Haigh, M. (2011). Climate policy and financial institutions. *Climate Policy*, *11*(6), 1367–1385. https://doi.org/10.1080/14693062.2011.579265
Haselmann, R., & Tröger, T. (2021). When and how to unwind COVID-support measures to the banking system? Technical report, SAFE White Paper.
Henry, J., Kok, C., Amzallag, A., Baudino, P., Cabral, I., Grodzicki, M., Gross, M., Halaj, G., Kolb, M., Leber, M., Pancaro, C., Sydow, M., Vouldis, A. T., Zimmermann, M., Żochowski, D. (2013). A macro stress testing framework for assessing systemic risks in the banking sector. *ECB Occasional Paper* (152).
Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J., & Zenghelis, D. (2020). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? *Oxford Review of Economic Policy*, *36*(Supplement 1), S359–S381. https://doi.org/10.1093/oxrep/graa015
Hlaing, S. W., & Kakinaka, M. (2018). Financial crisis and financial policy reform: Crisis origins and policy dimensions. *European Journal of Political Economy*, *55*, 224–243. https://doi.org/10.1016/j.ejpoleco.2017.12.005
IAIS. (2020). International association of insurance supervisors executive committee takes steps to address impact of COVID-19 on the insurance sector. Technical report, International Association of Insurance Supervisors, Basel March 28 2020.
IMF. (2020). Policy responses to COVID-19 - policy tracker. Technical report, International Monetary Fund.
IOSCO. (2020a). Iosco annual meeting addresses the impact of COVID 19 and other critical matters on securities markets. Technical report, IOSCO/MR/28/2020 Madrid, 23 November 2020.
IOSCO. (2020b). Iosco statement on application of accounting standards during the COVID-19 outbreak. Technical report, IOSCO/MR/08/2020 Madrid, 03 April 2020.
Jackson, G., Bartosch, J., Avetisyan, E., Kinderman, D., & Knudsen, J. S. (2020). Mandatory non-financial disclosure and its influence on csr: An international comparison. *Journal of Business Ethics*, *162*(2), 323–342. https://doi.org/10.1007/s10551-019-04200-0
King, M. R. (2013). The Basel iii net stable funding ratio and bank net interest margins. *Journal of Banking & Finance*, *37*(11), 4144–4156. https://doi.org/10.1016/j.jbankfin.2013.07.017
Krogstrup, S., & Oman, W. (2019). *Macroeconomic and financial policies for climate change mitigation: A review of the literature*. International Monetary Fund.
Laeven, L., Igan, D., Claessens, S., & Dell'Ariccia, G. (2010). Lessons and policy implications from the global financial crisis. *IMF Working Papers*, *044*..
Lane, P. (2019). Climate change and the Irish financial system. *Bank of Ireland*, *1*(EL/19).
Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., ... & Peters, G. P (2020). Temporary reduction in daily global co 2 emissions during the COVID-19 forced confinement. *Nature Climate Change*, *10*(July 2020), 647–653. https://doi.org/10.1038/s41558-020-0797-x
Manzanedo, R. D., & Manning, P. (2020). COVID-19: Lessons for the climate change emergency. *Science of the Total Environment*, *742*, 140563. https://doi.org/10.1016/j.scitotenv.2020.140563
Monasterolo, I. (2020). Climate change and the financial system. *Annual Review of Resource Economics*, *12*(1), 299–320. https://doi.org/10.1146/annurev-resource-110119-031134
Monnin, P. (2018). *Central banks and the transition to a low-carbon economy*. Technical report, Discussion note 2018/1. Council on Economic Policies.
NGFS. (2019). A call for action - climate change as a source of financial risk, first comprehensive report. *Network for Greening the Financial System*.
Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., Agha, M., & Agha, R. (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International Journal of Surgery (London, England)*, *78*, 185. https://doi.org/10.1016/j.ijsu.2020.04.018
Obergassel, W., Hermwille, L., & Oberthür, S. (2020). Harnessing international climate gov- ernance to drive a sustainable recovery from the COVID-19 pandemic. *Climate Policy*, 1–9. https://doi.org/10.1080/14693062.2020.1835603
OMFIF. (2019). Tackling climate change: The role of banking regulation and supervision. Technical report, Official Monetary and Financial Institutions Forum.
Pereira Da Silva, L. (2020). Green swan 2: Climate change and COVID-19: reflections on efficiency versus resilience. *based on remarks at the OECD Chief Economists Talk Series, Paris, April 23rd and a Research Webinar at the BIS, May 13th, available at:* https://www. *bis. org/speeches/sp200514. htm*
Pfeiffer, A., Hepburn, C., Vogt-Schilb, A., & Caldecott, B. (2018). Committed emissions from existing and planned power plants and asset stranding required to meet the Paris agreement. *Environmental Research Letters*, *13*(5), 054019. https://doi.org/10.1088/1748-9326/aabc5f
Plantinga, A., & Scholtens, B. (2020). The financial impact of fossil fuel divestment. *Climate Policy*, *21*(1), 1–13. https://doi.org/10.1080/14693062.2020.1806020
Reinders, H. J., Schoenmaker, D., & Van Dijk, M. A. (2020). Is COVID-19 a threat to financial stability in Europe? *CEPR Discussion Paper No. DP14922*.
Rhee, C., & Svirydzenka, K. (2021). *Policy advice to Asia in the COVID-19 Era*. International Monetary Fund.

Rozenberg, J., Hallegatte, S., Perrissin-Fabert, B., & Hourcade, J.-C. (2013). Funding low- carbon investments in the absence of a carbon tax. *Climate Policy*, *13*(1), 134–141. https://doi.org/10.1080/14693062.2012.691222

Rudebusch, G. D., et al. (2019). Climate change and the federal reserve. *FRBSF Economic Letter*, *9*(March 2019). https://glennrudebusch.com/wp-content/uploads/2019_FRBSF-EL_Climate_change_and_the_Fed.pdf

Salas, R. N., Shultz, J. M., & Solomon, C. G. (2020). The climate crisis and COVID-19—a major threat to the pandemic response. *New England Journal of Medicine*, *383*(11), e70. https://doi.org/10.1056/NEJMp2022011

Schnabel, I. (2020a). Never waste a crisis: COVID-19, climate change and monetary policy - speech by Isabel Schnabel, member of the executive board of the ECB, at a virtual roundtable on "sustainable crisis responses in Europe" organised by the inspire research network, 17 July 2020. Technical report, European Central Bank.

Schnabel, I. (2020b). When markets fail – the need for collective action in tackling climate change speech by Isabel Schnabel, member of the executive board of the ECB at the European sustainable finance summit, Frankfurt am main, 28 September 2020. *European Central Bank*.

Schoenmaker, D. (2021). Greening monetary policy. *Climate Policy*, *21*(4), 581–592. https://doi.org/10.1080/14693062.2020.1868392

Schoenmaker, D., & Van Tilburg, R. (2016). What role for financial supervisors in addressing environmental risks? *Comparative Economic Studies*, *58*(3), 317–334. https://doi.org/10.1057/ces.2016.11

Schydlowsky, D. M. (2021). Green financial regulatory policy for Latin America in the aftermath of COVID-19. *Global Development Policy Center - Boston University March* 2021.

Steffen, B., Egli, F., Pahle, M., & Schmidt, T. S. (2020). Navigating the clean energy transition in the COVID-19 crisis. *Joule*, *4*(6), 1137–1141. https://doi.org/10.1016/j.joule.2020.04.011

TCFD. (2017). Final report: Recommendations of the task force on climate-related financial disclosures. *Task Force on Climate-related Financial Disclosures*.

TCFD. (2018). TCFD: 2018 status report. *Task Force on Climate-related Financial Disclosures*.

Thomä, J. and Hilke, A.. (2018). The green supporting factor. quantifying the impact on European banks and green finance. Technical report, 2 Degrees Investing Initiative.

Van't Klooster, J., & Fontan, C. (2020). The myth of market neutrality: A comparative study of the European central bank's and the Swiss national bank's corporate security purchases. *New Political Economy*, *25*(6), 865–879. https://doi.org/10.1080/13563467.2019.1657077

Vermeulen, R., Schets, E., Lohuis, M., Kolbl, B., Jansen, D.-J., Heeringa, W., (2018). An energy transition risk stress test for the financial system of the Netherlands. Technical report, Netherlands Central Bank, Research Department.

Weidmann, J. (2019). Climate change and central banks. In *Welcome address at the Deutsche Bundesbank's Second Financial Market Conference, Frankfurt am Main*, Volume 29.

YPFS. (2020). Yale program on financial stability, COVID-19 financial response tracker. Technical report, Yale Program on Financial Stability.

Zenghelis, D., & Stern, N. (2016). The importance of looking forward to manage risks: Submission to the task force on climate-related financial disclosures. *Policy Paper by the Grantham Research Institute on Climate Change and the Environment, London School of Economics*, *July*(2016). http://eprints.lse.ac.uk/id/eprint/67133