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GREEN CENTRAL BANKING AND REGULATION TO FOSTER SUSTAINABLE FINANCE

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Abstract

As it is becoming clear that climate change will exert a major impact on inflation, economic growth, and financial system stability, central banks and financial regulators have increasingly recognized that they can no longer ignore climate change and other environmental issues. In general, central banks are responsible for achieving price stability under the monetary policy mandate and financial stability under the macroprudential policy mandate. Therefore, it is possible for central banks to consider climate risks within their existing mandates. Moreover, the global financial markets have been facing the problems of mispricing due to the presence of low carbon prices. If these issues are unaddressed, the transition process towards a low carbon economy will remain too slow to achieve carbon neutrality. While governments play the most important role in pursuing climate policy, central banks could contribute to governments' efforts within their existing mandates. Central banks and financial regulators have begun to discuss prudential policy and take measures to cope with climate-related financial risks including climate scenario analysis and/or stress test. Moreover, there are growing discussions on how to include climate risks with respect to the capital adequacy requirements regulation for banks in the Basel framework. Central banks are also encouraged to lead by example through disclosing the impact of climate risks on central banks' own balance sheets, setting a greenhouse gas (GHG) emission reduction target on their operations, and adjusting the composition of various domestic and foreign assets held by central banks for non-monetary and monetary policy objectives. This paper provides an overview of climate-related approaches and practices undertaken by central banks and financial regulators that have become more visible in recent years.

Keywords: climate-related financial risks, climate scenario analysis, climate stress test, monetary policy, asset purchases, credit operations

JEL Classification: E52, E58, E64

Contents

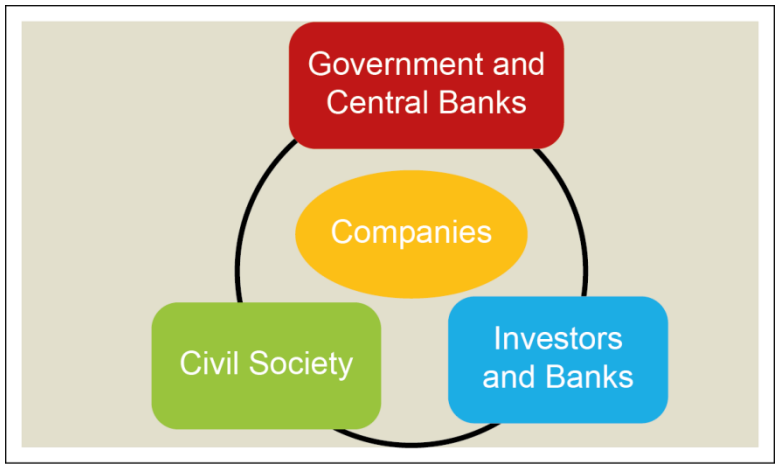
1. INTRODUCTION

It is becoming clear that global warming or climate change will exert a major impact on inflation, economic growth, financial system stability, and financial markets in the foreseeable future. With growing awareness of climate risks, central banks, which used to keep a distance from global warming issues because those issues are not directly relevant to their operations, have increasingly recognized that they can no longer ignore climate change and other environmental issues. Moreover, the global financial markets have been facing the problems of mispricing in the financial markets due to the presence of low carbon prices that do not reflect social costs associated with climate change, including losses of people's lives as well as economic and social losses. If these issues are left unaddressed, the transition process towards decarbonization and low-carbon economy will remain too slow to achieve carbon neutrality.

Climate risks can be dealt with most properly and efficiently if the three pillars—which comprise governments, investors, and the civil societies (including nongovernmental organizations, think tanks, universities, and individuals)—make collective efforts toward influencing corporate behavior and achieving a carbon-free or low-carbon economy (Figure 1). Among the three pillars, governments play the most important role in pursuing climate policy and actively utilize fiscal policy tools (i.e., carbon pricing, public investment, subsidies for research and development [R&D], tax incentives) and environmental regulations to promote greenhouse gas (GHG) emission cuts and related innovation and investment at the private sector level. Governments set climate policy and regulation in line with the Paris Agreement goals and their related carbon neutrality commitments. The timing of adopting necessary detailed climate policy measures and strategies will substantially influence the speed and shape of the transition to carbon neutrality and thus global warming in the world. In general, central banks hold the view that (elected) governments should take the lead in adopting ambitious climate policy measures and that central banks should contribute to governments' efforts by helping to correct mispricing in financial markets as much as possible within their existing mandates. Investors, especially institutional investors who focus on environment, social, and governance (ESG) factors, as well as banks have an essential function in managing climate-related financial risks and collectively allocating funds for financing projects and activities that support transition toward carbon neutrality. Civil societies are also important in monitoring activities of governments, companies, and financial institutions and investigating the effectiveness of the policies and measures adopted with various analyses and activities. These three pillars, if performed collectively, will lead to accelerating the pace toward achieving carbon neutrality.

Central banks cope with financial stability mainly through macroprudential policy including financial supervision and monitoring, while price stability is dealt with through monetary policy. Financial regulators tend to focus on microprudential policy although some central banks are also responsible for both macro- and microprudential policy. There is a growing consensus globally that central banks and financial regulators should view climate risks as one of the major financial risks. Meanwhile, a consensus has not yet emerged as to whether central banks should incorporate climate risks in their price stability mandate and thus in the monetary policy framework. Some central banks appear to place more emphasis on climate-related financial risks and prudential perspectives to cope with financial institutions rather than relating climate risks to price stability and monetary policy.

Figure 1: Three Pillars Needed to Cope with Climate Risks



Source: Prepared by the author.

There are several policy options that central banks and financial regulators might be able to consider, as pointed out in Section 2. Among them, monetary and financial authorities have already begun to consider climate-related financial risks as part of prudential policy. In particular, climate scenario analysis and/or climate stress test is central to maintaining financial stability against climate risks and increasingly adopted by central banks and financial regulators. Some central banks have already begun to conduct climate stress tests that may consider implications on capital adequacy. There have been growing discussions in recent years on how to include climate-related financial risks with respect to the capital adequacy requirements regulation applied to banks in the Basel framework—particularly, standard Pillar 1 capital requirement and/or Pillar 2 capital requirement. Active arguments have been conducted especially by the Bank of England (BOE), the European Central Bank (ECB), and the Bank for International Settlements (BIS). Due to the available data and methodological constraints, the adoption of the Pillar 1 framework may not be feasible in the near future and thus Pillar 2 could be used flexibly. Moreover, various macroprudential policy tools, including the systemic risk buffer (SyRB), which could cope with climate-related systemic risks as a complement to the Pillar 2 framework, could be a potential tool.

Central banks are also encouraged to lead by example through disclosing the impact of climate risks on central banks' own balance sheets in accordance with the guidelines compiled by the Task Force on Climate-Related Financial Disclosures (TCFD). Moreover, some central banks already set a GHG emission reduction target on their operations and adjust the composition of various domestic and foreign assets held by central banks for non-monetary policy objectives. Other central banks have already integrated the environmental factor into their monetary policy measures, such as corporate bond purchases and credit operations, although these measures have not yet become common practices across the globe.

This paper provides an overview of climate-related approaches and practices undertaken by central banks and financial regulators that have become more visible in recent years. The paper comprises five sections. Section 2 takes an overview of the roles of the Financial Stability Board (FSB) and the Network of Central Banks and Supervisors on Greening the Financial System (NGFS) in terms of promoting climate-related financial risk management over the financial system. Actual practices and discussions related to central banks' mandate with regards to price stability and

financial stability in considering climate risks are also examined. Section 3 examines climate-related macro- and microprudential policies and discussions that deal with climate-related financial risks including the capital requirements under the Basel framework. Section 4 examines central banks' climate-related measures. Section 5 concludes.

2. GROWING FOCUS ON CLIMATE RISKS AMONG CENTRAL BANKS AND FINANCIAL REGULATORS

Until recently, many central banks around the world used to emphasize the view that they should be as neutral as possible to the market in order to spread the effects of monetary policies evenly throughout the economy. In particular, the ECB and the BOE used to respect the principle of neutrality when purchasing corporate bonds conducted under the quantitative easing monetary policy. However, from a climate risk perspective, it is known that the current financial market faces problems of mispricing or market failure. If this is not properly addressed, it could delay the achievement of carbon-neutral goals adopted by many governments in the world by around 2050 or a little later by maintaining financial support for carbon-intensive activities. In recent years, central banks and financial regulators have begun to share a sense of crisis that climate change has a major implication on the economy, prices, and financial system so some actions must be undertaken.

2.1 Central Banks' Focus on Climate Risks

Central banks in Europe are by far the world leaders in their response to climate change as well as in their contribution to enriching climate-related discussions. One of the most influential in the early stages was the BOE, which was led by Mr. Mark Carney as governor at the time. In 2015, Mr. Carney gave a historic speech to the insurance industry in London, sounding the alarm that the insurance industry's losses from natural disasters were increasing year by year (Carney 2015). It was emphasized that climate change is increasingly affecting food and water security, property, migration, and political stability, which could undermine the stability of the financial system. He called on the sector to prepare and respond to climate risks.

2.1.1 Climate-Related Physical Risks and Transition Risks

Climate risks are generally decomposed into physical risks and transition risks. Physical risks are becoming increasingly materialized in recent years, with major natural disasters such as hurricanes, typhoons, torrential rains, and floods occurring more frequently and on a larger scale, as well as rising sea levels. Physical risks comprise acute and chronic risks and often damage infrastructure, corporate production facilities, and residential properties, thereby hindering economic activities, reducing food production, creating soaring commodity prices, generating health hazards, and reducing labor productivity. The current global average temperature has already risen by about 1.1°C to 1.2°C from preindustrial times, and damage from extreme climate events is occurring frequently around the world. To cope with physical risks, "climate adoption" policies are essential. To make the economy more resilient to the increasing number of natural disasters, governments need to consider shifting production or housing locations to safer, inland places, building embankments, adopting natural disasters monitoring and warning systems. Companies and individuals also need to consider actions to cope with physical risks.

On the other hand, transition risks are related to the risk stemming from the process of transitioning towards a low-carbon economy through “climate mitigation” policies. Climate policies include: carbon pricing; tighter regulations to achieve GHG emissions, fuel consumption, and energy conservation; the removal of fossil fuel subsidies and an increase in subsidies for greener projects and low-carbon technology development; and an expansion of public investment necessary for decarbonization (e.g., increasing charging stations for electric vehicles (EVs) and fuel cell vehicles, low-emission public road transportation, greening public buildings, forest management and restoration). In implementing these climate policies, companies will respond to them by expanding R&D spending and capital investment in renewable energy, smart grids, EVs, storage batteries, hydrogen fuel, carbon capture storage (CCS), and carbon capture utilization storage (CCUS), etc., and transform their business models into more environmentally sustainable ones. As capital investment and R&D are expensive for companies, there is a risk that such R&D and investment activities will not bear fruit. Nevertheless, such risk and cost must be carefully balanced against new business opportunities and enhancing the sustainability of corporate business models in long-term perspectives.

Transition risks involve the restructuring of carbon-intensive industries and companies. Assets that intensively utilize fossil fuels are likely to become stranded assets in the future because their investment costs cannot be recovered fully under tighter environmental regulations. If many financial institutions invest heavily in such industries and companies, the stability of the financial system might be threatened as well. In addition, there will be an increase in the number of lawsuits against companies that violate strengthened environmental regulation (lawsuits related to physical risks are also possible if the causality from climate change to economic and social losses can be scientifically established). Such companies may face punishments and fines, as well as loss of clients and consumers as a result of deteriorated reputation Transition risks also include the adverse impact on low-income earners and affected small- and medium-sized companies of rising prices due to carbon pricing and carbon tax hikes for a certain period of time—so-called “green inflation.” Governments must perform “just transition” to mitigate such adverse impacts and smoothen the transition process.

2.1.2 Climate Mitigation Policies and Adaption Policies

Physical risks and transition risks are inversely related. If climate policies are not adopted adequately by governments, transition risks remain relatively low, but instead physical risks will increase significantly over time. As a result, the global average temperature could rise to more than 3°C from the current level by the end of this century or even much sooner. To avoid this excessive global warming situation, collective efforts must be made to limit the increase in the global average temperature to 1.5°C or at least well below 2°C by the end of this century. This target limit is in concordance with the 2015 Paris Agreement and the Intergovernmental Panel on Climate Change (IPCC)’s Special Report focusing on the 1.5°C scenario (IPCC 2018). While it is not easy to implement climate policies due to transition risks, it is desirable to start implementing necessary policy actions to reduce GHG emissions as soon as possible. While climate mitigation policies are absolutely needed, the world also needs to implement climate adoption policies.

2.2 Financial Stability Board Promoting the Awareness of Climate Risks

The Financial Stability Board (FSB) is an international body comprising the Group of Twenty (G20) economies and the European Union, together with the BIS, the International Monetary Fund (IMF), the World Bank, etc. to promote international financial stability and to monitor and make recommendations on the global financial system. Its objective is to formulate stronger coherent regulatory, supervisory, and other financial sector policies. In recent years, the FSB has increased its attention to financial risks stemming from climate change and has been demonstrating various initiatives.

2.2.1 Establishment of the Task Force on Climate-related Financial Disclosure (TCFD)

The FSB created the TCFD in 2015 to follow up the G20 decision that recommended organizations and companies disclose the climate-related financial risks and opportunities that they face to their clients, ESG investors, and stakeholders. The TCFD issued its initial recommendations in 2017 and updated them in 2021. The TCFD recommendations have since been widely accepted by many central banks and financial regulators as a basis for climate-related reporting for companies and financial institutions.

The recommendations consist of four pillars: Governance; Strategy; Risk Management; and Indicators&Targets. The Governance pillar focuses on disclosing organizations' governance and climate risks and opportunities, including the board supervision and role of the management. The Strategy pillar describes the "material" climate risks and opportunities identified over the short, medium, and long term and their implications for businesses, strategy, and financial planning. It also includes the climate scenario and/or climate stress test analysis including a 2°C or lower scenario in line with the Paris Agreement, although a 1.5°C scenario is increasingly expected by ESG investors. The Risk Management pillar describes the process of identifying, assessing, managing, and integrating climate risks into the overall risk management. Finally, the Indicators&Targets pillar aims at encouraging investors to deepen their understanding of the risks and opportunities of climate change of their invested companies and to increase more sustainable assets in the investment and loan portfolios by making efforts to align with the Paris Agreement goals. Organizations are expected to disclose information about Scopes 1 and 2, and, if appropriate, Scope 3 GHG emissions (such as those emitted by suppliers and users) and performance against targets (especially GHG emission target in the medium and long term) and to explain how those targets are used to manage their regular climate-related risks and opportunities.

More recently, the global disclosure requirement has been in the process of standardization, led by the International Sustainability Standards Board (ISSB). The ISSB was created by the International Financial Reporting Standards (IFRS) Foundation in 2021 with strong worldwide support from the FSB, various governments, and ESG investors. The ISSB published a draft for global climate-related and sustainability disclosure standards in March 2022 and is scheduled to finalize the draft in the first half of 2023.

2.2.2 Roadmap for Addressing Climate-Related Financial Risks

The FSB issued the final report on the supervisory and regulatory approaches to climate-related financial risks in October 2022. Recommendations for financial supervisors and regulators covered three key Areas: (1) promoting supervisory and regulatory reporting and collection of climate-related data from financial institutions; (2) developing financial system-wide perspectives and possibly supervisory and regulatory tools and policies to address climate risks; and (3) considering other potential macroprudential policies and tools at an early stage. Five associated recommendations related to Area (1) and seven recommendations related to Area (2) were proposed, respectively.

With regards to reporting and data collection related to Area (1), the FSB report recommended that supervisory and regulatory authorities should (a) accelerate the work towards collecting climate-related data and key measurements (including Scopes 1, 2, and 3 GHG emissions to improve the assessment and monitoring of climate risks for financial institutions; (b) improve data quality through reviewing financial institutions' internal audit and assessment functions and considering the need for third-party verification schemes; (c) develop common definitions related to physical risks and transition risks (such as those proposed by the ISSB and other standard-setting international bodies); (d) standardize regulatory reporting requirements proportionately to the nature, size, and risk profiles of a financial institution's activities; and I promote global coordination. In particular, the authorities were encouraged to urge financial institutions to report climate-related qualitative information supplemented with available quantitative information to their supervisors.

On supervisory and regulatory tools related to Area (2), the FSB recommendations for the authorities included (i) focusing not only microprudential measures targeting each financial institution, but also macroprudential measures to consider the implications of climate risks on the whole financial system; (ii) utilizing a climate scenario analysis and/or climate stress test over a longer time horizon as a tool for macroprudential purposes against key financial sectors (i.e., banks and nonbank financial institutions); (iii) using, for example, the NGFS climate and other established scenarios as pointed out in Section 3; and (iv) promoting international discussions and coordination. Starting with credit risk, future climate scenario analysis and/or climate stress test could extend to market risk, then be followed by liquidity and insurance (underwriting) risks as long as they pose material risks and thus influence the resilience of the financial system.

Related to other potential macroprudential policies and instruments related to Area (3), the FSB stressed microprudential instruments alone may not be sufficient to tackle the cross-sectoral, global, and systemic dimensions of climate risks. Hence, the need to examine macroprudential policies and instruments to complement microprudential measures was suggested. The macroprudential policies might include the utilization of capital buffers to cope with unaddressed systemic climate risks. Possible adjustments to existing capital adequacy requirement frameworks can be pursued, as pointed out in Section 3.

As part of its roadmap to address climate-related financial risks, the FSB considers the conduct of peer review over its supervisory and regulatory practices and updates the recommendations in 2025.

2.3 Influential Role of the Network for Greening the Financial System (NGFS)

Various suggestions on central banks' possible positions on and responses to climate risks have been expressed and developed by the Network of Central Banks and Supervisors on Greening the Financial System (NGFS). The Network comprises more than 100 central banks and financial authorities globally. It is a network established at the end of 2017 led by eight monetary and financial authorities, i.e., central banks of France, the United Kingdom, the Netherlands, Germany, the People's Republic of China (PRC), Singapore, Mexico, as well as the Swedish financial regulator. Later, other central banks and regulators joined as members—including the Bank of Japan (BOJ) and the Financial Services Agency in Japan, as well as the Federal Reserve Board (FRB) and the United States Office of the Comptroller of the Currency (OCC). The secretariat is operated at the central bank of France, and the current chairman is Mr. Ravi Menon, the Managing Director of the Monetary Authority of Singapore (MAS) from 2022. The MAS has been strengthening its presence in Asia rapidly with regards to the development of ESG investment and sustainable finance strategies, as well as actively utilizing green digitization, as pointed out in Sections 3 and 4. Seventeen international organizations, including the IMF, the FSB, the BIS, and the Basel Committee on Banking Supervision (BCBS), participate in the NGFS as observers.

Rather than creating and enforcing common regulations, the NGFS aims at encouraging voluntary initiatives among members and encouraging their supervised financial institutions to deepen their understanding of climate risks and improve their risk management. The objective is to share the best practices adopted by some frontrunning members and to enable other members to refer to the financial regulatory and supervising practices in their own jurisdictions. At the same time, NGFS views that central banks should aim to develop sustainable finance markets in order to mobilize the funds necessary for achieving carbon neutrality around the world, as the realization of a carbon-neutral economy requires a large amount of R&D and investment. NGFS has been exploring various ways to incorporate climate risks into the supervision of financial institutions, make comprehensive assessments about the implications of climate change on the financial system, and develop financial markets that promote a low-carbon economy. It has been publishing a series of policy recommendations and guidelines, recently updating them and extending the focus into other environmental issues, such as biodiversity loss.

NGFS also emphasizes that the central bank should adopt its own sustainable investment approach towards its balance sheets and demonstrate it to financial institutions and investors as a role model. For that reason, it calls for the incorporation of environmental criteria into various assets held by central banks as well as some monetary policy tools. This paper refers to "greening monetary policy" as a policy incorporating climate change and other environmental criteria into the assets held by the central bank for monetary policy purposes, the lending facilities provided to eligible financial institutions in terms of conditionality and collateral accepted, and other measures.

Table 1 presents possible climate change responses that central banks and financial regulators might consider—financial stability, macro climate modeling, non-monetary policy asset purchase, monetary-policy asset purchases, and monetary policy-related credit operations. Many central banks and financial regulators have started to consider climate-related financial risks as prudential policy. The details will be described in Section 3. In particular, climate scenario analysis and/or climate stress test, which may consider implications on capital adequacy, are central to maintaining financial

stability against climate risks and are being increasingly adopted by central banks and financial regulators. More than 30 central banks and financial regulators have been implementing climate scenario analysis and/or climate stress test. Among them, the ECB and the MAS released comprehensive results with some quantitative aggregate outcomes in 2022, as shown below. It is highlighted that the ECB also conducted in-depth analysis on the Scope 3 GHG emissions of corporate counterparties. The People's Bank of China (PBOC) also provided some quantitative results.

Incorporating climate criteria in the assets held by central banks for monetary and nonmonetary purposes, as well as credit operations will be covered in Section 4. In particular, the ECB has already incorporated climate criteria in the corporate bond reinvestment program from October 2022. It also plans to introduce the climate criteria in the collateral framework in 2024, and is examining the introduction of climate criteria in the credit assessment framework over supervised large financial institutions. The PBOC has already taken a comprehensive approach toward banks' evaluations, collateral framework, and credit operations. The BOJ also introduced climate criteria in the part of their credit operations in late 2022.

Table 1: Central Banks' Possible Climate Actions

Financial Stability	• Financial Stability • Climate scenario exercise and stress test
Macro-Climate Modeling	• Integrating climate change risk into macroeconomic modeling
Nonmonetary Policy Asset Purchase	• Adopting the environmental criteria (e.g., pension funds and other assets)
Monetary Policy Asset Purchase	• Adopting the environmental criteria to corporate bond purchase or foreign reserves
Credit Policy	• Adopting the environmental criteria to long-term lending, collateral, reserves

2.4 Developing Macro Climate Modeling

Many central banks are developing new models that incorporate climate risks into their macroeconomic forecasting models. Central banks conduct monetary policy decisions based on various economic and financial data, economic and price forecasts based on macroeconomic models, and numerous statistical analyses. It is very challenging to integrate climate risks into macroeconomic models since climate change is expected to affect the economy over a fairly long period of time and greater uncertainty exists with regards to future climate physical risks and transition risks. Central banks regularly present forecasts for the gross domestic product (GDP) growth rate and inflation rate for the next three to four years. Given that climate risks will affect the financial system, GDP, prices, etc., however, central banks increasingly find it necessary to make efforts to develop macroeconomic-climate modeling. In doing so, it is necessary to consider how climate risks are affecting and will affect key macroeconomic variables and thus the transmission channels of monetary policy. Complex questions need to be addressed, such as how climate-related volatility of macroeconomic and financial variables can be priced in, and whether various monetary policy frameworks and

measures affect climate change transmission channels in a different manner. It is important to deepen understanding and consider how to incorporate climate risks into monetary policy management (NGFS 2020d).

Understanding the transmission channels of monetary policy—such as analyzing how climate change affects companies and individuals, and estimating the impact on the natural interest rate, output, and inflation—could become essential in the future in making monetary policy decisions. It is necessary to understand that the time horizons of the impacts of climate risks on inflation and GDP depend on the type of climate risks. For example, transition risks might be roughly concentrated in the first decade or so, during which carbon price increases are implemented under the carbon pricing scheme. Once carbon prices reach more or less socially desirable levels, any further increase will likely be terminated. With regards to physical risks, chronic physical risks may take much longer to materialize and influence the economy after 2050 or later, while acute risks are already generating losses and are expected to continuously increase and generate economic and social losses. Thus, it is important to distinguish these various climate impacts on the macroeconomy, prices, and financial variables and build them into the modeling.

The concept of the natural interest rate is particularly important in making monetary policy decisions. The natural interest rate is a real short-term interest rate that equalizes the supply and demand for funds when the economy is at full employment, with high degrees of capacity utilization, and low and stable inflation. Central banks often judge whether the current monetary easing is sufficient by estimating the natural interest rate and comparing it with the actual real interest rate (roughly, it can be proxied by the short-term money market interest rate minus the inflation rate). For example, if the real interest rate is below (above) the natural interest rate, the monetary policy stance might be assessed as accommodative (tightening). In the downturn or recessionary phase of the business cycles, monetary policy decisions attempt to bring real interest rates below the natural interest rate. The opposite is true when the economy is in the booming or overheating phase. Therefore, the issue of how climate change affects the natural interest rate is important when thinking about monetary policy in the future.

As a purely conceptual consideration, the NGFS report discussed the potential impacts of economic variables that might affect the natural interest rate—namely, economic growth, technology, households' saving and consumption behavior, risk premiums, and fiscal policy. For example, it was pointed out that the effect of economic growth on the natural interest rate can have both upward and downward effects. This is because the materialization of physical risks reduces the supply of labor and production, curbs economic growth, and lowers the natural interest rate. At the same time, countries receiving migrant inflows from countries prone to natural disasters will face an increase in labor supply and economic growth, thereby leading to a rise in the natural interest rate. In addition, technology can also affect the natural interest rate in both upward and downward directions. This is because there is a risk that climate change will restrain innovation and push the natural interest rate down as a result of substantial economic and social losses. At the same time, however, it is also possible that climate policy will promote new innovation, such as renewable and clean energy and hydrogen fuel, at the corporate level, thus raising the natural interest rate.

In contrast to economic growth and technology, the directions of the implications of climate change on the natural interest rate through saving behavior and risk premiums are clearer. The natural interest rate is likely to be depressed in both cases. Precautionary savings, for example, will increase as economic uncertainty caused by climate change increases. Low-income earners (who tend to have a higher propensity

to consume) are less prepared for climate change and thus will likely be hit harder than high-income earners. This in turn widens income and asset inequality, thereby suppressing consumption across the economy and boosting the savings rate. The resultant higher savings rate might lower the natural interest rate. As for the risk premium, demand for safer and liquid assets such as government bonds might increase as companies, financial institutions, and individuals increasingly recognize climate-related uncertainty. Finally, the impact on the natural interest rate through the conduct of fiscal policy is expected to rise. The reason for this is that either climate mitigation policy aiming at reducing GHG emissions or climate adoption policy (preventive measures) against natural disasters will increase fiscal spending and thus public debt, so the natural interest rate is expected to rise.

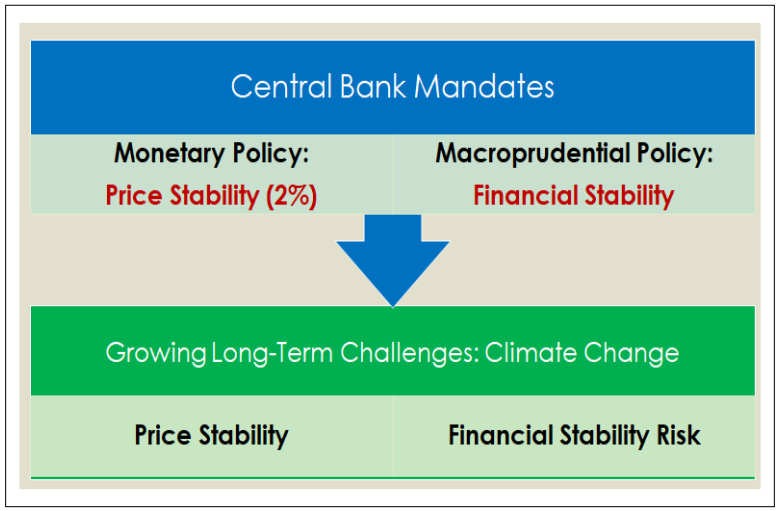
As described above, the natural interest rate is affected by multiple factors which also mutually influence each other. Thus, it is not easy to take into account those complex interactions using an economic model and come up with some reasonable estimates on the natural interest rate. Nonetheless, the first step should be to understand and conceptualize the impacts of climate change one by one. Through this kind of process, central banks are expected to deepen their understanding of how climate change affects monetary policy transmission channels and monetary policy management, and to develop analytical methods. As for the transmission channel of monetary policy, for example, climate change could reduce the value of financial assets held by banks and the value of collateral associated with bank loans, thereby reducing banks' willingness to lend to households and companies and lower the effectiveness of monetary policy. In that case, the effect of stimulating aggregate demand, such as consumption and capital investment through lowering policy, may become weaker.

2.5 Central Banks' Mandates: Financial Stability and Price Stability

Central banks cope with financial stability mainly through macroprudential policy, including financial supervision and monitoring, while price stability is dealt with through monetary policy (Figure 2). There is a growing consensus in the world that central banks and financial regulators should view climate risks as one of the major financial risks; thus, many of them have begun to explore climate scenario analysis and/or climate stress test with regard to their supervised major financial institutions by incorporating longer-term frameworks. This development is strongly supported by the BCBS, which concluded in 2021 that climate risks can be classified using the traditional financial risk categories. Thus, banks should incorporate climate-related financial risks, including credit risk, market risk, and operational risk, by continuously developing their capacity and expertise within the existing Basel Framework covering their conventional stress test (Basel Committee 2022a).

Meanwhile, a consensus has not yet emerged as to whether central banks should incorporate climate risks in their price stability mandate and thus in the monetary policy framework. Price stability is generally placed as the most important or the primary element of central banks' mandate concerning monetary policy. Some central banks include additional mandates (such as the maximum employment objective set by the Federal Reserve System and the maximum sustainable employment objective set by the Reserve Bank of New Zealand), although such additions have not changed the monetary policy framework.

Figure 2: Central Bank Mandates and Growing Long-Term Climate Risks



Source: Prepared by the author.

Dikau and Volz (2021) examined the mandates and objectives of 135 central banks and found that besides a price stability goal, only 15 central banks, or 12%, have explicit sustainability mandates. Meanwhile, central banks that are mandated to support the government's policy priorities besides price stability numbered 54, including the BOE and the ECB, as explained below, and accounted for 40% of the central banks examined. The government policy priorities might possibly include carbon neutrality goals and other sustainability goals committed by the government. The remaining 48% of central banks do not have a direct or indirect mandate requiring them to deal with climate change-related goals. That said, from this group, 33 central banks have addressed climate risks and sustainability challenges. These include central banks in Australia; India; Japan; New Zealand; Mexico; the PRC; Hong Kong, China; the PRC; and the Republic of Korea. These central banks' involvement in climate risks could be justified under the mandate or price stability or financial stability.

Pertaining to the ECB, Article 127(1) of the Treaty of the EU sets price stability as the primary objective of the European System of Central Banks (ESCB) and additionally mentions that "[w]ithout prejudice to the objective of price stability, the ESCB shall support the general economic policies in the [European] Union with a view to contributing to the achievement of the objectives of the Union as laid down in Article 3 of the Treaty on European Union." Article 3 of the Treaty includes the objective of "sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment." This indicates that the ESCB's mandate reflects the EU's environmental objective. In addition, the aforementioned Article 127(1) also stated that the "ESCB shall act in accordance with the principle of an open market economy with free competition, favoring an efficient allocation of resources." This provision could be interpreted as the secondary objective includes avoiding reinforcing market imperfections, such as market failure of mispricing (Schnabel et al. 2022).

With regard to the BOE, price stability is regarded as the primary objective of monetary policy under the BOE Act. Supporting government economic policies, including growth and employment, is also required as the secondary objective under the Act. HM Treasury annually sets out the remit and clearly mentions "sustainable and balanced

growth" as the government economic policy objective. In May 2021, the Chancellor updated the remit on this by redefining the policy "for achieving strong, sustainable and balanced growth that is also environmentally sustainable and consistent with the transition to a net zero economy." With this clearer mandate, the central bank's responsibility for climate risks and other environmental issues became more explicit.

The ECB has already begun to incorporate climate criteria on a path aligned with the Paris Agreement goals through a tilting approach based on issuer-specific climate scores in their corporate bond reinvestment strategies from October 2022. The ECB is so far one of the most environmentally ambitious central banks in the world as its comprehensive climate agenda covers macroeconomic modeling, detailed monetary policy instruments, financial risk assessment including stress test and data collection, as well as policies to promote green finance. The BOE took the first move in announcing a similar approach on corporate bonds in November 2021; however, since then the policy has been terminated due to the decision to sell those bonds. Some central banks including the Federal Reserve and Switzerland appear to place more emphasis on climate-related financial risks and prudential perspectives to cope with financial institutions rather than relating climate risks to price stability and monetary policy.

3. CLIMATE MACRO- AND MICROPRUDENTIAL POLICY RESPONSES

This section takes an overview of prudential policy and measures to cope with climate-related financial risks, including climate scenario analysis and/or climate stress test, as well as recent arguments on including climate-related financial risks with respect to the capital requirements regulation in the existing Basel framework. There is a growing active debate on how climate-related financial risks could be incorporated to the standard Pillar 1 capital requirement and/or Pillar 2 capital requirement. This section takes an overview of those arguments and current positions expressed by the BIS, the BOE, the ECB and others.

3.1 Climate Prudential Policy and Climate Scenario Analysis and/or Stress Test

In April 2019, the NGFS released its first comprehensive report and emphasized that central banks and financial authorities have power to ensure a more resilient financial system against climate risks by clarifying that climate risks contribute to financial risks (NFGS 2019a). Given the fact that climate-related financial risks are not sufficiently incorporated in current asset valuations is a major risk, it was pointed out that NGFS members should take cooperative actions to correct market mispricing. It also proposed support for the formulation of taxonomies for classification, which classifies environmentally sustainable activities—those developed for some time by the EU and recently by some other economies, including the PRC, Singapore, and the Association of Southeast Asian Nations (ASEAN). Furthermore, the NGFS encouraged listed financial institutions (and companies) to disclose information for investors in concordance with the TCFD recommendations.

3.1.1 Climate Scenario Analysis and/or Climate Stress Test

In general, many central banks and financial authorities, such as the case in Europe and the United States, regularly ask financial institutions to assume several extreme scenarios for a relatively short period of up to two to three years ahead and check the adequacy of the institution's capital. This is called a "stress test." For example, the most recent 2022 scenario test by the Federal Reserve and the OCC in the United States conducted a stress test for the period of three years from the first quarter of 2022 to the first quarter of 2025, using the estimates on real GDP, prices, households' disposable income, the unemployment rate, residential and commercial real estate prices, stock prices and their volatility, yields on government and corporate bonds, and economic performance of major foreign economies. The US regulators prepared the baseline scenario and then compared it with a few extremely adverse economic scenarios to find the degree of soundness of financial institutions—namely, capital adequacy. The adverse scenarios, for example, assume that a global recession takes places by putting a heavy strain on the domestic residential and commercial real estate markets and corporate bond markets, causing a sharp rise in the unemployment rate, reducing real GDP, and lowering inflation.

Many of the economic models used for such conventional stress tests are based on short-term economic deviations from long-term economic equilibrium for a period of several years. In other words, the stress test exercises are based on business cycle-based approaches. For this reason, the NGFS views that such conventional stress test approaches are not suitable for analyzing climate risks that cause structural changes in the economy and thus affect the long-term equilibrium itself. Moreover, existing stress tests have a short observation period of just several years ahead, which is also not desirable for analyzing climate change, which requires a longer observation period, such as up to at least 2050 or longer. In addition, conventional analytical models hardly reflect trends in energy and agricultural supply systems. Thus, modeling climate risks requires new analytical models that focus on the interrelationships between physical, transition, and economic risks.

A conventional, simple economic growth model cannot reflect climate policies for mitigating climate risks and the associated costs, as well as complex transition paths such as the impact of climate policies on climate change. Developing models that incorporate climate change require a different mindset and analytical approach. Awareness of these issues has prompted the NGFS to examine and formulate several climate scenarios. Although great uncertainty exists with regards to future projections of the relationship between climate change and the economy and finance, a mechanism that allows monetary and financial authorities to promote understanding about the implications of climate change on financial markets and the economy is still necessary and useful. In addition, once the NGFS can prepare basic climate scenarios that can be commonly applicable to each jurisdiction as a basis, central banks and financial supervisors in each jurisdiction can refine their own sophisticated analytical methods reflecting country- and regional-specific features and agenda.

3.1.2 Top-Down and Bottom-Up Climate Scenario Approaches

NGFS's climate scenario analysis does not aim to predict future outcomes and estimate the impact of climate risks on financial institutions' capital adequacy. Rather, several climate scenarios are prepared based on assumptions of "what if situation A happens or situation B happens in the future?" Through scenario analysis, central banks and financial regulators can give practical advice to supervised financial institutions, which in turn influence their corporate client behavior. Such scenarios are useful not only for central banks and financial authorities, but also for financial

institutions and companies when conducting their own climate scenario analysis in line with the TCFD guidelines.

The purpose of the climate scenario analysis is to have each financial institution adequately understand climate risks and to encourage decarbonization or low carbonization of their financial service activities in the process of improving their risk management. The NGFS calls it a “climate scenario” analysis and does not use the world “climate stress test”. This is perhaps because climate stress test is normally related to the calculation of the capital adequacy of financial institutions against climate risks and is closely related to financial regulations. It will take some time to increase the understanding of financial regulators first and then the understanding of financial institutions about climate-related financial risks. Once the degree of understanding improves, regulators are likely to find it easier to collate information and data (such as financed emissions) from financial institutions, leading to an improvement of monitoring approaches. Hence, the NGFS probably thought that the first step should be limited to climate scenario analysis with the objective of promoting the understanding of climate risks among financial regulators as well as financial institutions supervised by them.

Climate risk scenarios can be analyzed using a top-down or a bottom-up approach. In the top-down approach, central banks and financial regulators estimate the financial impact of climate changes on financial institutions based on financial institutions’ reported data and other macroeconomic and financial data. Since it is implemented under a unified framework, the advantages are that the calculation method is consistent and it is easy to compare financial institutions. However, in many cases, additional qualitative information is required to make more meaningful assessments of risk management for climate risks. In the bottom-up approach, by contrast, regulators select multiple climate scenarios and major economic variables and other factors to be used in the scenarios, but the main exercises are conducted by major financial institutions by requesting them to do their own calculations. The advantage of this approach is that it encourages financial institutions to develop their own internal quantitative and qualitative analytical capabilities and promotes deeper understanding of how climate change will affect the financial institution’s balance sheet under each scenario. It can be expected to facilitate financial institutions’ understanding and encourage voluntary climate change responses. It is also hoped that financial institutions will use this work as an opportunity to select multiple scenarios on their own and further deepen their own analysis within their own capabilities.

3.2 Promoting Climate Scenario Analysis

In June 2020, the NGFS published a first guide to enable central banks and financial supervisors to organize climate scenarios that will affect the financial system and to encourage them to utilize the prepared climate scenarios in the central bank’s monetary policy and financial institution supervision (2020c). The guide offers four steps to do so. As a first step, central banks and financial supervisors prepare climate scenarios for financial institutions, and based on these scenarios, financial institutions and financial systems in their own jurisdictions can fully withstand stress under their respective climate scenarios. It also pointed out that the same approach could be applied to the evaluation of structural changes in the economy and the investment portfolio of central banks.

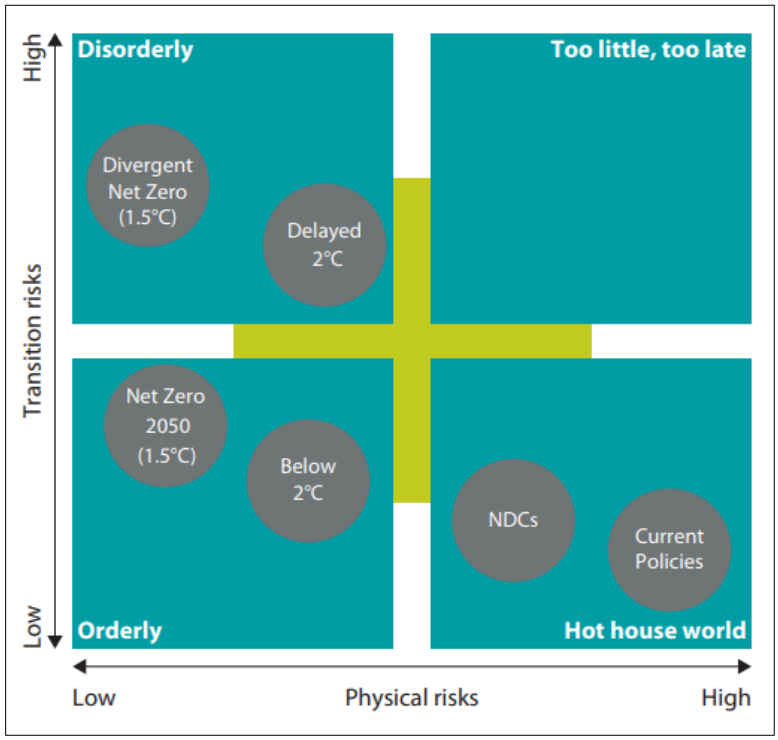
As a second step, apart from the climate scenario analysis to be utilized by central banks and financial regulators in each country or region, the NGFS intends to jointly develop various other reference scenarios with academic experts and institutions and plans to make climate scenario analysis available to members. As the third step, the NGFS indicated its intention to launch the assessment of the impact of climate risks on various economic and financial variables, such as GDP, commodity prices, stock prices, bond yields, and bank loan valuations. Finally, as the fourth step, the NGFS will encourage central banks and financial regulators to publicly disclose the results of their climate scenario analysis. Disclosing information about the results (normally, aggregate results rather than individual institutions' results) will lead to increased awareness of climate risks among financial institutions, which in turn can motivate financial institutions to improve their climate risk management systems voluntarily.

3.2.1 Six Types of Climate Scenarios Presented by the NGFS

The NGFS published for the first time the Climate Scenario Analysis Guidelines for Financial Institutions in 2020, which can be utilized by central banks and financial supervisors (NGFS 2020b). Since its first release in 2020, the NGFS scenarios have been refined every year and the latest report explored a set of six scenarios basically in line with the first report (NGFS 2022a). The six scenarios are decomposed into (1) Orderly scenarios (Net Zero [1.5°C] scenario and Below 2°C scenario); (2) Disorderly scenarios (Delayed 2°C scenario and Divergent Net Zero scenario); and (3) Hot House World scenarios (Nationally Determined Contributions [NDCs] scenario and Current Policies scenario). Transition risks are higher but physical risks are lower under the Orderly scenarios, while transitions risks are limited but physical risks are much higher under the Hot House World scenario (Figure 3).

Orderly scenarios assume the introduction of moderate climate policies in the beginning, which become more stringent over time. As a result, both physical and transition risks can be relatively contained. The Net Zero 2050 scenario envisages that limiting global warming to 1.5°C is feasible as major advanced economies including Australia, Canada, Japan, the United States, the EU, and the United Kingdom promote ambitious climate policies and are accelerating innovations to achieve net zero of GHG emissions by 2050. The Below 2°C scenario is less favorable than the Net Zero 2050 scenario since climate policies are expected to become gradually more stringent. In the case of Disorderly scenarios, transition risks are higher than Orderly scenarios because climate policies are delayed until around 2030, so that more stringent climate policies are necessary later to limit global warming below 2°C under the Delayed transition scenario. Alternatively, divergent climate policies reaching net zero around 2050 are adopted across economies and sectors, so the cost borne by the world is higher under Divergent Net Zero scenario. Finally, Hot House World scenarios assume that global efforts are insufficient to halt significant global warming, even though some climate policies are implemented in some environmentally conscious jurisdictions. Thus, these scenarios show severe physical risks, e.g., global warming and rising sea-levels. The NDCs scenario assumes that all pledged emission reduction targets will be achieved even if most of the economies and regions have not yet begun to implement credible, effective climate policies at a current stage. The Current Policies scenario is likely to generate higher physical risks than the NDCs scenario because of the assumption that only currently implemented climate policies are expected to be maintained in the future.

Figure 3: NGFS Six Types of Climate Scenarios



Source: NGFS (2022a).

3.2.2 BOE's Climate Biennial Exploratory Scenario Analysis (CBES)

The BOE made the first move among the other central banks and financial regulators in the world with regards to the climate scenario analysis. Under the leadership of then-Governor Carney, it began to work on climate risks from an early stage through its Prudential Regulatory Authority. In 2015, the central bank analyzed the impact of physical and transition risks on balance sheets for major insurance companies and in 2018 for major banks. Based on these pilot experiences, the Bank became the world's first central bank to issue a supervisory statement in 2019 to major banks and insurance companies to encourage them to take a more strategic approach toward climate-related financial risks. In 2020, it published an open letter to CEOs of financial institutions, providing more detailed guidance on how to have an approach to manage climate-related financial risks by the end of 2021. In October 2021, the central bank released the Climate Adaptation Report, highlighting the progress that has been made on financial institutions' climate change risk management (BOE 2021).

With regard to the comprehensive climate scenario analysis, the BOE prepared the analysis of the climate scenario since 2019, announced the detailed approach in 2020, released a data template in 2021, and conducted its first detailed bottom-up scenario exercise on climate risks—the so-called climate biennial explanatory scenario (CBES) analysis—involving seven large banks and twelve (large or large general) insurance companies in the United Kingdom (UK) in June 2021. These banks covered about 70% of UK bank lending to companies and households in the UK. Large insurance companies covered about 60% of the life insurance market by asset sizes, or UK and general insurance companies also accounted for 60% of the market by gross written premium. Sectors included all those ranging from agriculture (particularly crop and animal production), mining (extraction), manufacturing (automobile, coke and petrol, food, chemical), electricity, construction, wholesale/retail trade, and to (land and air)

transport. The exercise targeting banks focused on credit risk, emphasizing risks related to large corporate counterparties. Banks' assets in the exercise included domestic and international (residential and commercial) mortgages, corporate loans, car finance and other consumer credit. The exercise targeting insurers focused on changes in invested assets, reinsurance recoverables, and insurance liabilities. Insurers' assets in the exercise included government bonds, other bonds, equities, derivatives, property, reinsurance assets, and others.

The purpose of the exercise was to investigate the financial system's resilience against physical and transition risks under three NGFS scenarios: the Net Zero scenario; the Delayed scenario; and the Current Policies scenario. The aggregate results of the bottom-up method of climate scenario analysis were published in 2022 (BOE 2022a). Loss projections for banks focused on credit risk associated with their lending activities. The focus on insurers was on changes in the value of invested assets and insurance claims. The analysis did not seek to assess the full impact on financial institutions' income and capital positions. The analysis found that climate risks could exert downward pressures on the profitability of banks and insurance companies in the UK, but the overall costs could be lower through early and well-managed actions to curb GHG emissions. Some initial costs borne by banks and insurance companies may be ultimately passed onto their customers, such as companies and households. Such adverse impacts would be large in the Current Policies scenario, where physical risks will be substantially high. The BOE acknowledged that banks and insurance companies in the UK had made good progress in some aspects of their climate risk management, although further improvements should be made.

3.2.3 ECB's Climate Prudential Approaches and Stress Test

The ECB has also made substantial efforts to develop comprehensive approaches in dealing with climate change for financial institutions. In September 2020, the ECB consulted with major banks about its supervisory approach related to climate change. Based on the feedback, in October 2020, a risk-based supervisory approach (focusing on areas perceived to be high risk) was adopted to implement oversight to ensure that the safety and soundness of supervised banks against climate change and worsening environmental issues are maintained. Emphasizing that climate change mitigation policies should be the responsibility of elected governments of member countries, financial institutions should reflect climate and environmental risks in their investment and loan balance sheets. The central bank stressed the importance of ensuring financial system resilience, which should be confirmed through the supervisory process. Such prudential policy could also help correct mispricing of climate risks, which in turn can support the efficient and smooth transition of the economy towards a carbon-neutral economy. In addition, the central bank acknowledged that banks' information disclosure and available data are currently scarce and need to be improved further. The ECB plans to assess whether financial institutions' business activities are sustainable and sufficiently resilient through conducting self-evaluation in accordance with the supervisory guideline. As a first step, a plan was announced to conduct supervisory evaluations of banks' business activities from 2022 and to cooperate with relevant EU authorities.

In 2022, the ECB conducted its first bottom-up climate stress test for 41 large financial institutions (ECB call it a "stress test"). It was conducted to assess supervised institutions' degree of preparation for managing climate risks. The results will supplement the ongoing supervisory review of banks' climate and environmental risk management practices. The 2022 climate risk stress test results found that banks have made considerable progress with respect to their climate stress-testing capabilities. As

the exercise revealed many deficiencies, data inadequacies, and inconsistencies across banks, it was stressed that they should make substantial further progress in their approaches in the near future (ECB 2022a). It was found that those large banks generated non-negligible income from activities related to 22 of the most GHG-emitting industries, with the share of interest income related to these industries amounting for more than 60% of total nonfinancial corporate interest income, on average. Given that the possible losses arising from the exposure crucially depend on their client companies' transition plans, banks should increase and emphasize their customer engagement as a priority to gain further insights into those plans. The results also highlighted that those large banks would likely face acute physical risks in Europe (i.e., drought and heat events, and flood risk) and such risks depend significantly on the geographical location of their lending activities, leading to non-negligible losses in some cases.

The ECB conducted (1) a short-term, three-year Disorderly Transition Risk scenario and the two Physical Risk scenarios (flood risk and drought, and heat risk), and (2) the 30-year transition scenarios in line with the NGFS scenarios. With regards to the short-term scenarios, the combined credit risk and market risk losses for the 41 banks would amount to around €70 billion. However, the central bank stressed that this estimate would likely understate the actual risk for several reasons. First, the scenarios were not adverse relative to other regular stress test scenarios since no economic downturn accompanying the negative climate effects was envisaged. In addition, the data and modeling approaches underlying the banks' projections are still at a preliminary stage, with climate factors only captured to a limited degree. In addition, the exposures covered in the scope of this exercise only accounted for around one third of the total exposures of the 41 banks.

Under the 30-year Transition scenarios, losses that may occur in the context of the transition to a more sustainable environment are projected to be notably lower under the Orderly scenario (phasing-in of sustainable climate policies) than in the case of Delayed and Disorderly transition paths. The exercises revealed that many banks lacked clearly defined long-term strategies for credit allocation policies that reflect the various transition paths, suggesting that large banks must formulate their long-term strategic planning (e.g., green transition plans and targets) soon. The exercise also revealed that many banks are still at an early stage in terms of factoring climate risks into their credit risk models. In many cases, credit risk parameters projected by banks were found to be insensitive to the climate risk shocks captured in the scenarios.

3.2.4 PBOC's Climate Stress Test and Implication on Banks' Capital Adequacy

The first climate stress test was performed by the PBOC against 23 major banks, including policy banks and major commercial banks in the PRC in 2021, and the results were published in February 2022. The exercises focused on the impact of an increase in GHG emission costs on the repayment capability of companies in carbon-intensive industries, including thermal power, steel, and cement, and the subsequent impact on the asset quality and capital adequacy levels of banks. The capital adequacy ratio for these banks was 14.89% at the end of 2020. The exercise found that this capital adequacy ratio could fall to 14.57% under the lightly adverse climate scenario, but the ratio could fall to 14.27% under the more severe climate scenario (China Banking News 2022).

The PBOC stated that all the banks in the exercises satisfied capital adequacy ratios because lending to the carbon-intensive industries constituted a small percentage of their total loans. Nonetheless, the deputy governor published a note and stressed that the companies in the carbon-intensive sectors should promote emission cuts to prevent a decline in their repayment capacity envisaged under various climate stress scenarios. Anticipated rising emission costs and the strengthening of climate policies would promote industrial restructuring and would likely generate stranded assets and other transition risks (Reuters 2022). The PBOC plans to cover other emission-intensive industries in the future stress test exercises. Meanwhile, the government introduced the emission reduction program operated under the national emissions trading scheme (ETS), introduced in 2021 to reduce emissions of the coal- and gas-fired power plants. The ETS plans to cover cement, steel, and other carbon-intensive sectors in the future.

3.2.5 BOJ's Climate Scenario Analysis

In August 2022, the Financial Services Agency and the BOJ jointly released results of a bottom-up pilot scenario analysis on three major banks and three major insurance companies, using the three main climate scenarios (Net Zero 2050, Delayed Transition, and Current Policies scenarios) developed by the NGFS (Financial Services Agency and BOJ 2022). For banks, the analysis covered credit risk. Banks chose materially important emission-intensive sectors by themselves. They used their own analytical framework and modeling developed to capture sector-specific risk factors, and estimated additional credit costs for the entire sector examined based on a group of sampled companies. As for other sectors including households, banks were allowed to use macroeconomic indicators (such as customizing their stress test models). This exercise was not intended to assess quantitative impacts of climate change on financial institutions due to data availability and methodology constraints. Based on banks' credit exposures as of end-March 2021, the results indicated that the banks' estimated increase in annual credit costs due to transition and physical risks was considerably lower than their average annual net income. These results were similar to the results published by those financial institutions in their sustainability reports. The Financial Services Agency and the BOJ, however, advised caution about this exercise's results because of large differences in models, sectors, variables, and assumptions adopted by the banks, even though the results demonstrated the capacity of each bank to conduct a risk analysis. The exercise also revealed that it is important to improve comparability across banks, including through encouraging the use of common assumptions, which will be necessary to deepen understanding of the issues in climate risk estimation and enhancing risk management at individual banks.

With regard to insurance companies, the exercise focused solely on physical risks (in particular, acute risks from typhoons and floods) related to their underwriting business. These companies assessed the magnitude of climate-driven physical risks in light of changes in insurance claim payments by using the climate scenarios built on an intensified magnitude of specific natural disasters. The results showed that claim payments increase as temperatures rise. At the same time, it was also revealed that analyzing only specific scenarios (such as natural disasters) is insufficient to assess changes in the probability and frequency of the occurrence of climate-driven natural disasters in the future. The results also varied among insurance companies due to the lack of uniform assumptions and risk models adopted by each nonlife insurance group. The report also acknowledged the need to consider conducting a stochastic analysis as a future analysis by considering the probability of occurrence of various climate scenarios, incorporating the impact of future climate change and using the same risk model across the nonlife insurance companies.

3.2.6 MAS's Industry-Wide Stress Test Incorporating Macroeconomic and Financial Implications

The MAS has been working on a financial industry-wide stress test (the so-called "Industry-Wide Stress Test") and adopted the first test in 2018 for insurance companies on a scenario featuring extreme flooding. These participating insurance companies needed to consider the impact of higher claims on their balance sheets arising from damage incurred to insured properties. Subsequently, more work was conducted to deepen understanding of climate risks for financial institutions by the MAS. The exercise was conducted for banks and insurance companies in 2020 and 2021. The financial stability review's special features on climate change reported the preliminary results, including a description of MAS's multiyear iterative approaches for climate stress tests and climate-related modeling. In addition, climate risk transmission channels to financial stability and potential second-order effects were described.

Building on these earlier experiences, the MAS adopted more comprehensive bottom-up climate scenario exercises in 2022 for selected major banks and insurers in Singapore to raise their awareness of the potential economic and financial implications of climate risks. It was also aimed at deepening understanding for both the MAS and financial institutions to improve the capability to cope with climate risks. Participating banks accounted for more than 70% of total domestic nonbank lending in Singapore. Participating insurance companies covered more than 90% of total assets for direct life and composite insurance companies, and more than 70% of gross weighted premiums for direct general insurance and reinsurance companies. The exercises incorporated long-term climate scenarios using three climate scenarios developed by the NGFS (Orderly Transition Net Zero 2050 scenario, Disorderly Transition scenario, and No Additional Policies scenario) as part of the broader 2022 Industry-Wide Stress Test exercise. The Disorderly Transition scenario used Delayed Transition scenario. The No Additional Policy scenario examined the potential implications of heightened physical risks over both the short and long term. Moreover, NGFS's Current Policies scenario was also performed to reflect an acute physical risk shock over the short term, focusing on a 1-in-200-year flooding event within the ASEAN-5 economies. Results of the exercises were published in the MAS Financial Stability Review 2022 (MAS 2022b). The report stressed that the 2022 climate scenario analysis provided an opportunity for participating banks and insurers to start incorporating climate risks into their risk assessment frameworks. This could help develop internal capabilities and also utilize third-party expertise. Like other central banks and regulators, the analysis found large data and methodological gaps. This suggested the need to improve data collection and model development works soon.

As for the short-term impacts, the exercises showed that a 1-in-200-year flooding event in the ASEAN-5 economies under the No Additional Policies scenario brought significant disturbances to their economic activities. This led to a decline of ASEAN-5 GDP by 5.1% in level terms by the end of 2022 compared with the No Flood scenario. The shock exerted a disproportionately large impact on sectors that rely heavily on physical capital stock (such as manufacturing and construction). These companies might end up ceasing operations temporarily due to a lack of access to physical capital stock, power failures, and damaged equipment. Flood-related damages and the disruption to supply chain networks were found to contribute to inflationary pressures across the ASEAN-5 economies and thus their major trading partner economies. Based on these results, participating banks projected that they would need to prepare additional provisions to account for flood-driven credit losses. This could lead to higher credit costs. The magnitude of the rise in credit costs was diverse among participating banks, mainly because of different business models adopted and divergent lending

activities extending across the ASEAN-5 economies. Moreover, locational differences resulted in divergent severity from the flood event. Flood mitigation and adaptation policies and measures adopted by the governments in the region also influenced the credit losses. On aggregate, participating banks projected that their flood-driven credit losses in 2022 would amount to about 15% of their net profits. Participating general insurance and reinsurance companies projected a significant increase in gross incurred claims in 2022. This was primarily because the impact was severe on their property business services related to flood-driven damages on residential and commercial properties. While these projected gross incurred claims subsequently fall in 2023 and 2024, they remain slightly high compared with the end of 2021 levels.

As for the longer-term exercises, it was found that both physical and transition risks could potentially exert a significantly large impact on banks' and insurance companies' balance sheets. For participating banks, the probability of defaults related to their climate-relevant sector credit exposures was projected to rise over time under all three climate scenarios. These results reflected heightened credit stresses driven by both transition and physical risks. On transition risks, most banks projected a sharp increase in the probability of defaults by 2040 under the Disorderly Transition scenario compared to the Orderly Transition scenario. This credit deterioration was mostly pronounced in relatively emission-intensive sectors (i.e., fossil fuels and energy-intensive manufacturing sectors). As for physical risks, several banks projected that their probability of defaults would rise significantly under the No Additional Policies scenario. This is because sharp temperature rises lead to chronic changes in living conditions including deterioration of people's health, lower labor productivity, reduction in agricultural production, and higher sea levels. On an annualized basis, the associated credit losses could amount to 8% or 9% of banks' net profits each year. This could cause a downward pressure persistently on banks' profitability.

As for insurance companies, physical and transition risks were projected to adversely affect both assets and liabilities under the static balance sheet assumption. Insurance companies projected a decline in the market value of their emission-intensive sector credit exposures and sovereign debt holdings under the three climate scenarios because of a persistent rise in interest rates across the horizon covered. The gradual rise in interest rates over the longer term are likely to be related to policy responses to inflationary pressures driven by higher carbon prices and supply-side disruptions caused by the materialization of physical risk events. General insurance companies would experience a smaller decrease in the market value of their debt holdings due to the shorter maturities of their asset holdings. For life insurance companies, a rise in interest rates would also lead to a decline in their policy liabilities, thus partially mitigating the adverse impact on their overall balance sheet positions.

Insurance companies projected that the market value of emission-intensive sector equity holdings would increase over the scenario observation period because of continued economic growth. However, this increase in the market value varied depending on climate scenarios. By 2050, the market value of those equity holdings was projected to be highest under the Orderly Transition scenario, followed by the Disorderly Transition scenario and then the No Additional Policies scenario. The difference in the results arose from the adverse impact of heightened transition and physical risks on equity valuations. Such shocks on those equity holdings emerged especially over the period of 2030–2035 under the Disorderly Transition scenario. This is because the necessary abrupt and sharp rise in carbon prices left some carbon-intensive assets stranded in emission-intensive sectors. With regards to the liabilities side, general insurance and reinsurance companies projected the largest increase in unexpired risk reserves under the No Additional Policies scenario. This was because of

the severe stresses arising from physical risks (such as rising temperatures and sea levels), as well as their higher frequency and severity of natural disasters. Nonetheless, the projected increase is unlikely to be large since insurance companies tend to have short contracts and thus could adjust premiums to offset the impact from changes in claims. Meanwhile, increases in projected unexpired risk reserves under the Orderly Transition and Disorderly Transition scenarios were milder due to the relatively limited physical risks materialized.

3.2.7 FRB's Plan to Conduct Climate Scenario Analysis

The US Federal Reserve Board (FRB) announced in September 2022 that six of the nation's largest banks will participate in a bottom-up pilot climate scenario analysis exercise. The exercise aims at enhancing the capabilities of financial supervisors and financial institutions to quantify and manage climate-related financial risks. Related details of climate, economic, and financial variables used for the exercise will be published soon. Based on the analysis on the impact of the climate scenarios on specific portfolios and business strategies of participating financial institutions, the Federal Reserve will review the analysis and begin engaging with them to build their capacity to manage climate-related financial risks. The exercise will be launched in early 2023 and is expected to conclude toward the end of the same year. Insights gained from the exercise will be published at an aggregate level, including lessons learned about identifying potential risks and risk management practices. The central bank stressed that this climate scenario analysis is separated from the bank stress test regularly conducted to examine whether large banks have enough capital to continue lending to households and businesses during a severe recession. It was emphasized that the climate scenario analysis is exploratory in nature and does not have capital consequences. By considering a range of possible future climate scenarios, the exercise could also help participating large financial institutions and financial supervisors in deepening their understanding of how climate-related financial risks may materialize and could differ from historical experience.

3.2.8 The Review of Climate Scenario Analysis Exercises by the NFGS and FSB

In November 2022, the NGFS and the FSB jointly published a report on initial findings from climate scenario analyses conducted by various central banks and financial regulators (NGFS 2022b). The report was also sent to G20 leaders ahead of the Bali Summit that year. Although the climate scenarios prepared by the NGFS helped to provide reference, it was found that they were not sufficient to enable a good comparison across financial institutions and economies due to the significant variations in the scope and objectives among central banks and financial authorities.

According to the report, the overall impacts of climate risks were not small but were contained from the perspective of the domestic financial system because most of those climate risks were likely to be concentrated in some sectors and regions. The report admitted that these findings could be too optimistic given that many companies have not yet disclosed Scope 3 GHG emission data. Scope 3 emission could account for about 70% of total emissions in most sectors. The report emphasized that tail risks and spillovers associated with climate change developments may be large and might not be manageable. The measures of exposure and vulnerability are likely understated because many climate exercises have not captured second-round effects, potential nonlinearity features of climate risks, and other potentially large risks (such as abrupt fire sales of assets in emission-intensive sectors). These exercises are still exploratory so that the results do not yet translate into micro- or macroprudential policy actions and

assessments. Further efforts among central banks and financial regulators are needed to improve data availability and consistency/comparability at the global level through deeper cross-border cooperation.

3.3 Green Capital Requirements Regulation and Associated Discussions

With growing understanding that climate risks will have a significant impact on the stability of the financial system, some central banks and financial regulators have begun to review prudential regulations beyond promoting data collection and improving monitoring and supervisory capacities. It is true that it may take some time to implement standardized regulatory approaches at a global level given that climate scenario analyses in many jurisdictions have revealed that financial institutions have not yet deepened understanding of climate risks and risk management approaches. Divergent approaches adopted by financial institutions regarding their risk assessment and strategies also require some time to form consensus about common approaches. The data including Scope 3 of corporate counterparties also need to be collected with more uniform methodologies. Nonetheless, it is still worthwhile to begin to consider possible implications of climate risks on existing financial regulations.

Financial regulations that are important for prudential perspectives mainly refer to the Basel capital adequacy and liquidity regulations (liquidity coverage ratio and stable funding ratio). Those were established by the BCBS to ensure the soundness of financial institutions given that disruptions to the financial system could generate adverse impact on the whole economy. These financial regulations have been adjusted and updated over time to reflect the emergence of new types of risks that have often been revealed at the time of various financial and economic crises. Regarding capital requirements, financial institutions are permitted to take flexible approaches, such as the internal ratings-based approach for credit risk, and thus new emerging risks can be dealt with flexibly by individual financial institutions within the approach.

3.3.1 BCBS Capital Regulatory Requirement

Aiming at having a safe and sound financial system, the Basel framework comprises three pillars with regards to capital requirement—Pillar 1 (minimum regulatory requirements); Pillar 2 (supervisory review process); and Pillar 3 (disclosure requirement). Pillar 1 (minimum capital regulatory requirements) covers regulatory rules on minimum loss-absorbing capital requirements based on the ratio of a bank's capital to its risk-weighted assets. The risk-weighted assets are calculated by assigning different risk weights to a bank's assets, reflecting the fact that some assets are riskier than others. Risks generally cover credit risk, market risk, and operational risk here. Credit risk generally necessitates larger capital requirements than other risks and are calculated to reflect unexpected losses for a particular stress level calibrated over one year. Two approaches are permitted—the standardized approach with fixed risk weights applied or the internal ratings-based approach whose parameters are estimated by a bank's internal models. Market risk capital requirement focuses on the risk of losses resulting from changes in market prices (e.g., equity prices), while operational risk copes with the risk of losses driven by inadequate or failed internal processes.

In addition to the 8% minimum capital requirements, capital buffers are also required to be added to the minimum requirements. These capital buffers include the capital conservation buffer, the countercyclical capital buffer, and the global systemically important bank (G-SIB) buffer. The capital conservation buffer is designed to ensure

banks hold additional usable capital that can be utilized when losses arising from a significant sector-wide downturn occur. The countercyclical capital buffer aims at counter procyclicality in credit cycles to strengthen the resilience of the banking sector and financial regulators increase the buffer when cyclical systemic risk (such as excessive lending leading to a deterioration of loan quality and hence potential losses) appears to be rising. The G-SIB buffer is designed to increase resilience of global systemically important banks as a going concern to offset the potential greater impact that the distress or failure of such banks would exert.

Meanwhile, Pillar 2 complements Pillar 1 and refers to capital buffers utilized to ensure banks place sound internal processes and utilize proper risk management techniques to support their business activities. It is based on sound supervisory judgment about corporate governance related to risk management and misconduct risk. In addition, risks that are covered but not fully captured under Pillar 1 should be included here. Banks must maintain their capital structure above the minimum level set by Pillar 1. Banks are required to assess the internal capital adequacy for covering all potential risks related to their operations—including interest rate risk in the banking book, nonfinancial risks (e.g., strategic risk, business model risk, and reputation risk), and credit concentration risk. There are four principles: One principle related to banks and three principles related to financial regulators. The first principle requires banks to perform regularly an internal capital adequacy assessment process (ICAAP) as an integrated approach to risk management and capital management to determine a strategy for maintaining the necessary capital level. Thus, ICAAP is an essential part of Pillar 2. Meanwhile, the three other principles require supervisors to review and evaluate banks' ICAAP and strategies, require banks to conduct businesses above minimum capital requirements, and urge supervisors to take early actions using various supervisory tools and activities. Pillar 3 focuses on supervision through enhanced market transparency and market discipline to strengthen financial system stability.

3.3.2 Discussions about Pillar 1 Versus Pillar 2 Framework to Cope with Climate Risks

There is a growing debate on how to incorporate climate-related financial risks into the Basel framework, particularly with regards to the standard Pillar 1 capital requirement or Pillar 2 framework. The BCBS examined this issue in 2021 and concluded that climate risk drivers, including physical and transition risks, can be translated into traditional financial risk categories, rather than representing a new type of risk. Traditional risk categories include credit risk, market risk, operational risk, as well as liquidity risk and reputational risk (BCBS 2021b, 2021c). This suggests the view that climate-related credit risk, market risk, and operation risk could be covered under the existing Basel framework.

The Financial Stability Institute published a report in February 2022 and stressed that Pillar 2 could be the candidate for incorporating climate risks and maintaining sufficient capital to cope with those risks given the longer time horizons and the higher degree of uncertainty associated with the materialization of such risks (Coelho and Restoy 2022). The report by the Financial Stability Institute also pointed out that adjusting standard Pillar 1 instruments for the sake of incorporating climate risks could be challenging at this stage since Pillar 1 capital requirements are calibrated for a one-year time horizon based on historical loss experience given that such historical loss data are not available for climate risks. More forward-looking approaches are necessary when calibrating capital requirements related to climate risks. By contrast, the Pillar 2 approach could conduct capital assessment using climate scenario analysis and/or climate stress test. In particular, climate stress test might enable financial regulators

to consider the potential impact on the profitability and balance sheets of financial institutions under various climate scenarios. Financial regulators in turn could use these exercises to promote financial institutions' awareness of potential deficiencies in their climate risk management framework, thus requiring financial institutions to improve their risk management practices and enhance their loss-absorption capacity (and hence increase capital buffer). The report by the Financial Stability Institute stressed that more flexible approaches are possible using the Pillar 2 framework than the Pillar 1 framework. This view is consistent with a conventional view that Pillar 1 requirements should be calibrated based on each bank's actual risk of incurring losses over a one-year time horizon as well as based on historical loss experiences rather than forecasts. Thus, it was stressed that these approaches are not suitable for coping with climate risks.

Meanwhile, Manifest Climate (2022) pointed out some rationales for adjusting the Pillar 1 capital requirement with regards to climate risks. First, there are differences between the objective of the Pillar 1 (capital requirements based on risk assessments) framework and the current actual practice of Pillar 1 (setting capital requirements based on a one-year time horizon and historical loss experience) framework. Regarding climate risks, these impacts are unlikely to be extrapolated adequately using historical loss experiences anyway because most of the financial effects have not yet materialized and cannot be modeled precisely. Therefore, the practice of setting the capital requirements should evolve to incorporate climate risks. Second, the historical experiences related to the implementation of the Pillar 1 framework suggests that a "risk-based" approach is not based on some objective formula, but rather the subjective interpretations of financial regulators and financial institutions. For example, the Basel framework allows banks to calculate the Pillar 1 requirements for their credit portfolios using a standardized approach or an internal ratings-based approach. While the former standardized approach appears to be based on an objective formula, the risk weights reflect information from external credit rating agencies, whose approaches could also be subjective and not fully science-based. The 2008 Lehman shock was also attributable to the improper credit risk ratings associated with complex financial assets. Moreover, some financial regulators intentionally apply lower risk weights for bank exposures to small- and medium-sized enterprises to promote credit extension. Meanwhile, the latter internal ratings-based approach enables banks to adopt their own credit rating models to determine appropriate risk weights reflecting a borrower's actual probability of default and a bank's loss given default. However, there is room for discretion since these values are determined using banks' own data and models. For these reasons, Manifest Climate stressed that it is still worthwhile to consider incorporating climate risks under the Pillar 1 framework.

In the process of responding to public consultation on the BCBS document related to the 18 principles pointed out below, the Climate Safe Lending Network (CSLN) also stressed the importance of the Pillar 1 framework. It criticized the BCBS for having failed to consider the most effective, feasible approach using Pillar 1 capital measures to improve banks' capital adequacy against climate-related losses (Climate Safe Lending Network 2022). The CSLN is made up of financial institutions, NGOs, and policy experts and stressed that Pillar 1 measures would correct the underpricing of both micro- and macroprudential climate-related risks and prevent the build-up of assets, which would either be stranded (causing financial stress in the economy) or cause losses and damage through more severe climate impact (also causing financial stress in the economy, potentially irreparably). Adjusting the Pillar 2 framework proposed by the Financial Stability Institute is not favored by the CSLN. Even though the Pillar 2 requirement provides financial regulators with an array of tools, such as capital add-ons, to address risks not fully captured or covered under the Pillar 1

framework, the CSLN stated those measures are not being used in practice. This may be because financial regulators' lack the confidence or competence to utilize them in response to climate risks (Manifest Climate 2022). In practice, financial regulators use Pillar 2 only as remedying bank-specific issues to manage risks identified under the Pillar 1 framework. Thus, Pillar 2 capital add-ons are unlikely to be applied at a size and scale needed to capture climate risks. Regarding the Pillar 3 requirement, the CSLN also proposed that the BCBS should consider mandatory disclosure of all GHG accounting per asset and asset category, including both on-balance sheet and off-balance sheet elements. The data should include the corporate client Scope 3 GHG emissions for the most emission-intensive sectors.

3.3.3 BCBS Guidance Related Climate-Related Financial Risks

In November 2021, the BCBS published a public consultation document on 18 principles for the effective management and supervision of climate-related financial risks (BCBS 2021a). This publication aims at promoting a principles-based approach to improve both banks' risk management and supervisors' practices related to climate-related financial risks. Following the consultation and various responses, the BCBS published a finalized guideline in June 2022 (BCBS 2022a). Principles 1 through 12 provide banks with guidance on effective management of climate-related financial risks, while principles 13 through 18 provide guidance for prudential supervisors. The proposed principles attempted to achieve a balance in improving practices related to the management of climate-related financial risks and providing a common baseline for internationally active banks and supervisors, while maintaining sufficient flexibility given the high degree of heterogeneity and the nature of evolving practices in this area. In particular, Principle 5 is related to capital and liquidity adequacy and states that banks should identify and quantify climate-related financial risks and incorporate those risks (that are assessed as material) over relevant time horizons into their internal capital and liquidity adequacy assessment processes, including their stress testing programs, where appropriate. Banks should include climate-related financial risks assessed as material over relevant time horizons that may negatively affect their capital position (i.e., through their impact on traditional risk categories) in their ICAAP. It was also stressed that banks should look at the impact of those risks on their liquidity position in their internal liquidity adequacy process.

The BCBS has been investigating the extent to which climate-related financial risks can be adequately incorporated in the existing Basel framework by identifying potential gaps and considering possible enhancements to the framework. This assessment is being conducted across the regulatory, supervisory, and disclosure dimensions. Subsequently, the BCBS developed responses in the form of frequently asked questions in late 2022 to clarify how climate-related financial risks might be captured under the existing Pillar 1 standards without making any changes to the standards themselves (BCBS 2022b). This is consistent with BCBS's conclusion made in 2021 (as pointed out above) that climate risks can be captured in the traditional financial risk categories, including credit, market, operational, and liquidity risks (BCBS 2021b, 2021c).

3.3.4 Using Pillar 1 Capital Requirement to Prevent Climate Risks

Adjusting the Pillar 1 capital requirement to prevent banks from increasing fossil fuel investment was proposed by Finance Watch in 2021. This appears to be an approach used to "prevent" climate risks through prudential supervision rather than coping with them. Financial Watch is a European NGO located in Brussels, Belgium aimed at solving environment and disparity issues through the active use of the power of

finance. It urged the EU to adjust the Pillar 1 capital requirement aggressively (Finance Watch 2021). Under the current EU regulatory framework, the capital adequacy ratio (ratio of capital to risk-weighted assets) sets a risk weighting of 20% to 150% for investments and loans to companies. On such practices, Finance Watch criticized that the risk weight is very low and instead proposed increasing the risk weights on fossil fuel-related investments to 125%, and on new fossil fuel extraction and production to 1250%. Finance Watch views that Pillar 1 could be an appropriate place for considering asset-specific prudential capital for banks' fossil fuel assets. This proposal intends to require more capital to conduct fossil fuel extraction and thus reduce profitability in their business. It also advocated that insurance companies should raise minimum capital requirements for equity investments in fossil fuel assets with regards to their solvency margin ratios used to measure their soundness.

This "one-for-one" approach is supported by the CSLN, which was in favor of implementing capital charges on fossil fuel assets under the Pillar 1 requirement. To do so, defining climate-harmful activities using taxonomies for bank prudential purposes is necessary. Such an approach could have a large impact on banks' capabilities to mitigate credit risks, contributing to containing global climate risks for bank prudential purposes. Capital requirements that apply to financing a gas field operation, for example, would help to protect banks against asset-level stranding risks.

One challenge with regards to this standardized approach is that the higher risk weights are applied only directly to fossil fuel-related investment and so that other GHG emission-intensive manufacturing, services, and agricultural activities are not covered. Ideally, the risk weights under the Pillar 1 framework should be applied to all exposures across banks' portfolios, based on the degree to which business activities contribute to climate change (this could be estimated using a banks' client companies' carbon footprint). The higher that borrower's emissions, the higher the multiplication factor applied to their baseline risk weighting (Manifest Climate 2022). However, it may take time to adopt this approach because of a lack of data, insufficient disclosure, a lack of standardized disclosure and calculating approaches, etc. On this front, the standardization efforts led by the ISSB is a welcome step, but it is likely to take time to collect reliable corporate counterparties' Scope 1, Scope 2, and Scope 3 data.

The NGFS also pointed out challenges related to the one-for-one approach using Pillar 1 capital requirements. This is due to a lack of reliable data and methodologies for quantifying climate risks and calibrating prudential requirements. Moreover, the lack of a risk-oriented taxonomy that promotes a common definition of "green" and "brown" assets makes it difficult to apply risk differentials between "green", "non-green" and "brown" assets (NGFS 2020a). Another challenge is that the available historical data indicate the insignificance of risks stemming from climate change and the energy transition. The reliance on backward-looking models also poses substantial analytical challenges. Furthermore, the divergence between the timing to see a materialization of climate risks and the one-year time horizon used by financial institutions' risk management or by financial regulators for prudential framework is problematic. As compared to banks, on the other hand, most nonlife insurance undertakings have the option of repricing their contracts every year. This in turn helps to mitigate the loss potential of future climate risks since higher insurance payouts to pay for property damage, for example, can be balanced out by charging higher premiums.

3.4 BOE's View: Using Capital Requirements for Improving Soundness, Not for Preventing Climate Risks

The BOE's Prudential Regulation Authority released its Climate Adaptation Report in 2021—the first report of its kind issued by a financial regulator in the world. The report indicated the BOE's intention to take into account capital requirements under the existing Basel framework as part of its climate prudential policy. It also reflected its expectation that banks would incorporate judgments of their exposure to climate-related financial risks in the manner in which they had already been assessing their own capital requirements for other financial risks (BOE 2021). Capital adequacy requirements could be used to improve the resilience and soundness of financial institutions against potential climate-related losses. Thus, it may be feasible to require banks with large GHG emission-intensive assets to secure a larger amount of capital.

At the same time, however, the Climate Adoption Report stressed that careful considerations would be necessary for the following rationale. Using the capital requirement framework to address the "causes" of climate change and thus encourage GHG reductions to mitigate climate change would not be desirable. This is because financial institutions make business decisions about where to invest and finance from the perspective of various opportunities and costs. Thus, addressing the "causes" of climate change could be more effectively addressed by government-led climate policy. Climate policy through active use of emission regulations and carbon pricing is more effectively able to promote behavioral changes of companies, financial institutions, and individuals. On the other hand, responding to the "consequences" of climate change means "adapting" actions toward climate change, whereas responding to "causes" corresponds to "mitigation" actions, such as reducing GHG emissions. In order to cope with the risk of incurring losses from investment and loan portfolios as the consequence of climate change, the soundness of banks can be improved by raising the credit risk weights. This is a tool to promote banks' "adapting" actions.

The above views reflect the BOE's concerns that using historical data in the case of climate-related financial risks will be less useful in calibrating future risks since such risks are likely to materialize over short-, medium-, and long-term horizons and grow over time. Historical data could be altered by tipping points and climate policy interventions. This means that the issue of quantifying climate risks for capital requirement purposes is still nascent and inconclusive, requiring further research. According to the BOE, banks are able to cope with crime risks using Pillar 1 and Pillar 2 capital requirements under the existing Basel framework. Financial institutions are expected to capture and examine capital needs related to climate-related financial risks. For example, banks can adjust credit risk assumptions on banks' probability of default and loss given default in the internal ratings-based approach under the Pillar 1. Banks can also consider add-ons under the Pillar 2 framework if their material risks are not captured well by the Pillar 1 framework. The BOE suggested that capital add-ons can be used in response to significant weaknesses prevailing in firms' risk management and governance. Meanwhile, insurance companies can be required to assess their capital adequacy through their own risk and solvency assessment practices. However, unlike banks, the insurance regulatory regime does not have a Pillar 2 add-on framework.

While these existing regulatory capital measures could capture the consequences of climate change to some extent through reference to credit ratings and the accounting regime, the BOE warned that this practice is imperfect due to capability and regime gaps. Capability gaps refer to the difficulties inherent in estimating climate-related financial risks due to a lack of relevant granular data or modeling techniques that can

fully incorporate climate factors. The climate scenario analysis pointed out above might help reduce capability gaps. On the other hand, regime gaps refer to possible challenges in capturing climate-related financial risks due to the design or use of methodologies in capital regimes themselves. In the microprudential regulatory regime, methodologies are mostly calibrated using past data to capture risks evolving over a relatively short-term time horizon. While this helps ensure capital is set in a more objective and quantifiable manner, there is a risk of underestimating future climate-related financial risks. The macroprudential regime for banks can take a more flexible approach to time horizons, but its current application might be less suitable to noncyclical risks, such as climate risks, that increase gradually over an extended period of time. In insurance, the capital regime does not contain an analogous capital buffer aimed at macroprudential risk (BOE 2021). The BOE stated that it might consider whether to strengthen the capital adequacy framework after 2022 onward, if necessary.

The BOE's Prudential Regulatory Authority published guidance toward financial institutions and indicated the supervisor's expectations that financial institutions should maintain adequate capital to cope with climate-related financial risks.

3.5 ECB's Approach Towards Active Use of Capital Requirements

The ECB is taking the lead in terms of clarifying the steps toward implementing capital requirements to cope with climate-rated financial risks. Essentially, three steps are being taken to guide banks to meet all supervisory expectations by the end of 2024 in accordance with its Guide on Climate-Related and Environmental Risks published in 2020 (ECB 2020). As a first step, the ECB expects banks to adequately categorize climate and environmental risks and to conduct a full assessment of their impact on the banks' activities by March 2023. As for the second step, banks are expected to include climate and environmental risks in their Governance, Strategy, and Risk Management by the end of 2023. Banks should prepare plans for transition toward a low-carbon economy and actively engage with their corporate clients. They should set interim targets or begin to limit their risk-taking to meet their long-term climate commitments. As a final step, banks are expected to meet all remaining supervisory expectations on climate and environmental risks by the end of 2024.

The EU's Capital Requirements Directive requires financial institutions to maintain sound, effective, and comprehensive strategies. The Directive also requires banks to assess and maintain, on an ongoing basis, the amounts, types, and distribution of internal capital that they consider adequate to cover the nature and level of the risks to which they are or might be exposed. In addition to any existing material risks, banks are expected to consider any risks that may arise from pursuing their strategies or from relevant changes in their operating environment. To meet this, banks' assessment of materiality plays an essential role in their ICAAP and risk management. Many banks are already assessing capital adequacy in the context of climate and environmental risks as part of their ICAAP. Generally, such assessments are conducted using climate scenario analysis to take into account forward-looking factors over a longer time horizon. The ICAAP includes a description of the scenarios related to transition and physical risks, and a calculation of the scenario impact on quantitative metrics (such as provisions, capital, and profitability).

3.5.1 ECB's View on Using Pillar 1 Capital Requirement

The ECB in principle supports the view of utilizing Pillar 1 requirements to cope with climate risks. At the same time, however, the ECB admitted there are many challenges to capturing climate-related financial risks so that some of the principles and methodologies used under the Pillar 1 framework might not be applicable, especially considering the forward-looking nature of climate risks. This is because some parts of the Pillar 1 Basel framework are backward-looking and depend on consistent, historical data. By contrast, climate risks require new types of granular data and more innovative models to quantify the key drivers of physical risks and transition risks. The lack of reliable data on climate-related financial risks represents a major challenge to the application of the Pillar 1 framework (ECB 2021). Thus, a fundamental review of the Pillar 1 framework might be necessary before application. The ECB concluded that supervisory measures, including Pillar 2 requirements, may be desirable to address the climate risk exposure of individual banks.

Meanwhile, the European Banking Authority (EBA) published the Discussion Paper in May 2022 to explore the role of climate and environmental risks in the prudential frameworks for credit institutions and investment firms (EBA 2022). The Authority requested feedback from stakeholders, particularly as to whether and how climate and environmental risks can be incorporated into the Pillar 1 prudential framework. The EBA also launched discussions on the potential incorporation of a forward-looking perspective in the prudential framework and stressed the importance of collecting relevant and reliable information on climate and environmental risks and their impact on financial institutions' financial losses. The consultation was held until August 2022 and a final report is scheduled to be released in 2023.

3.5.2 Consideration of Climate Risk Buffers as Macro Prudential Measure

With regard to the macroprudential approach, the ECB stressed that such an approach may be necessary as an important complementary tool in addressing the climate-related challenges and risks for the banking sector. As a first step, the application of existing macroprudential tools, particularly existing capital-based macroprudential tools, could be used to help limit the accumulation of climate risks and increase banks' resilience if these risks materialize. Such tools might also influence the allocation of new funds toward investments less exposed to climate risks. Also, by helping to reduce banks' climate risk contributions, such macroprudential tools could exert additional mitigating effects on the economy-wide accumulation of climate risks. Moreover, the ECB also expressed views that it may be worthwhile considering quantitative and qualitative restrictions on banks' portfolios in order to contribute to limiting the accumulation of climate risks, notwithstanding the presence of operational and legal hurdles (ECB 2021).

As a related issue, the ECB and the European Systemic Risk Board (ESRB) published a joint report in 2022 on the issue of how climate shocks can influence the financial system in Europe, and proposed the use of macroprudential capital buffers (ECB and ESRB 2022). They identified several amplifiers of climate risks across the financial system. For example, transition risks might be magnified because of economic and financial linkages between banks and between banks and their corporate counterparties. In contrast, physical risks might be amplified through the interdependent occurrence of large natural disasters (i.e., water stress, heat stress, and wildfires), which might happen in clusters together and exacerbate each other and in turn transmit through to market dynamics.

The ECB and the ESRB also jointly performed climate scenario analysis and suggested that climate risks might evolve within the financial system in a specific order. First, unforeseen climate shocks could have an abrupt impact on market prices—initially, such shocks may adversely affect the portfolios of investment funds, pension funds, and insurance companies. Second, this sudden market repricing could drive companies into default, thus giving rise to losses for exposed banks. Under the Disorderly Transition scenario (assuming an immediate and substantial increase in carbon prices in later periods), respective market losses of insurance companies and investment funds could potentially amount to 3% and 25% on stress-tested assets in the near term. The Orderly Transition (Net Zero by 2050) scenario could mitigate such repricing shocks and thus the fallout for companies and banks, which in turn reduces the probability of corporate defaults by around 13%–20% by 2050 as compared with the Current Policies scenario. This lower repricing shock could also reduce credit losses for banks. The report demonstrated that climate risks could quickly spread throughout the entire financial system under the Disorderly Transition scenario, where financial market losses from abruptly repricing climate risks could also affect investment funds and insurance companies and trigger corporate defaults and credit losses for banks.

By demonstrating the systemic nature of climate risks, the report indicated that macro- and microprudential policies should be adopted together to mitigate the systemic nature of climate risks. The ECB and ESRB viewed that a comprehensive approach including the commonly applied Pillar 1 framework would ensure a certain degree of consistency to cope with climate risks. However, insufficient data and methodological difficulties suggest that more work is needed to consider the effective utilization or revision of the current Basel capital requirement framework, which fully captures the unique features of climate risks. Based on this recognition, the ECB and the ESRB suggested that the macroprudential tool might be able to address the systemic features of climate risks and this tool should complement the Pillar 2 framework. The macroprudential approach should be sufficiently flexible for climate risks since the impact of climate risks is highly uncertain.

As a suggested tool, the ECB and the ESRB suggested that the systemic risk buffer (sectoral SyRB) in its sectoral application could be used not only to limit the accumulation of climate risk concentration, but also to enhance the resilience of banks against the materialization of climate risks. The sectoral use of the SyRB had already been indicated by the European Commission to cope with certain sets or subsets of exposures to climate-related physical risks and transition risks in the past. The sectoral use of the SyRB may be adequate enough to discourage concentrated exposures to climate risks. This sectoral use of the sectoral SyRB would imply higher capital requirements, thus increasing banks' resilience against the materialization of climate risks.

Compared to the sectoral SyRB, the SyRB does not differentiate sectors. The SyRB already constitutes a part of the existing macroprudential tools. Thus, this tool could be used as a general tool to guard against systemic aspects of climate risks that are not necessarily linked to the concentration risk of individual financial institutions. The SyRB aims to address systemic risks that are not covered by (a) the aforementioned capital requirements regulation, (b) the countercyclical capital buffer, and (c) global systemically important banks (G-SIBs) and other systemically important institution buffers. By avoiding a distinction between sectors, the SyRB could be viewed as a less challenging tool compared with a sectoral SyRB. In the case of using the SyRB, a flat SyRB could be envisaged to address unexpected climate-related exogenous shocks.

This climate-related SyRB could potentially be released as a new separate climate risk buffer, if desirable.

3.5.3 ECB's Analysis on Good Practices Developed by Banks

Over the past periods, several financial institutions in Europe have introduced advanced ways to integrate climate and environmental risks into capital adequacy assessment. While climate scenarios developed by the NGFS and the IPCC are often utilized, banks also implement different internal approaches for credit, market, and operational risks. In many cases, the capital adequacy assessment is made by banks when the decision is made to allocate additional economic capital specifically for climate and environmental risks.

With regard to good practices performed by banks in terms of capital adequacy assessment for credit risk, the ECB picked one bank that not only utilized climate scenarios developed by the NGFS and the IPCC for physical and transition risks assessments, but also used them for performing stress test simulations on the bank's portfolios (ECB 2022b). Using externally available data (such as asset-level and price data) and corporate client data, the simulations estimated the impact of the climate scenarios on the bank's earnings before interest, taxes, depreciation, and amortization. The results help the bank to estimate corporate client level probabilities of default under different climate scenarios until 2030. These stressed client-level probabilities of default were subsequently aggregated to sector level to develop sectoral heatmaps. Such heatmaps could be used to identify sectors most significantly impacted by climate and environmental risks. The bank then calculated the difference between the stressed portfolio probabilities of default and the baseline portfolio probabilities of default. When the calculated difference exceeded the materiality threshold, the bank decided to allocate an economic capital buffer for the relevant amount of exposure at risk under the Pillar 2 framework.

Concerning good practices performed by banks related to capital adequacy assessment for operational risk in the ICAAP, the ECB chose one bank that identified four plausible climate scenarios where climate risks could trigger material operational risks in the next 12 months. The four climate scenarios included: (a) damage to physical assets; (b) business disruption and system failures; (c) noncompliance with climate-related laws, rules, and regulations; and (d) reliance on outsourcing. In each climate scenario, the loss estimates were calculated by considering various hypothetical impacts, including potential remediation costs, legal costs, and forgone revenue. These estimates were supplemented by historical loss events or entity-specific data. Based on the outcomes of the climate scenarios, the bank decided to allocate the economic capital buffer to cover the risks as regulated in the Pillar 2 framework.

With regards to good practices conducted by banks related to capital adequacy assessment for market risk, the ECB highlighted one bank that assessed the effects of climate risks on market risks for its trading book. This bank used climate scenario analyses for physical and transition risks. For transition risks, the bank used climate scenarios developed by the NGFS and the IPCC as an input in order to develop a more granular internal scenario as an extension. All relevant market risk exposures on bonds, equities, and derivatives were used for the Base Line and Disorderly Transition scenarios with different severity levels. On the sensitivity analysis, profit and loss simulations were conducted to examine the impact of selected variables (for example, carbon prices or credit spreads) of affected sectors. For the physical risks, several stress testing scenarios were used to assess and quantify the impact of extreme weather events on the profit and loss for its trading book. The positions examined

included equities, securitized products, commodities, and foreign exchange rates. The stress impact was modeled with the assumption of a sell-off of those assets in the case of reduced prices. Based on the stress test results, the bank decided to prepare a regulatory buffer for climate and environmental risks related to market risk as regulated in the Pillar 1 framework.

4. CLIMATE-RELATED MONETARY AND NON-MONETARY POLICIES

This section focuses on climate-related measures that have been initiated by central banks to improve their risk management and help foster a sustainable finance market, which is essential to achieve carbon neutrality in the world. Realizing a carbon-neutral economy requires a large amount of investment and the mobilization of funds for that purpose. For this reason, the NGFS is calling on central banks to consider climate criteria with regards to investments in their own assets. This also reflects a view that it is important for central banks to set an example for financial institutions and investors and demonstrate their approach to green investment.

4.1 Central Banks' Actions toward Decarbonization and Low-Carbonization

Many central banks have already begun to promote financial institutions supervised/monitored by central banks to disclose climate-related information, collect relevant data from financial institutions, and encourage financial institutions to improve climate-related risk management through enhancing surveillance measures and conducting bottom-up climate scenario analysis and/or climate stress test, as pointed out in Section 3. Central banks are also encouraged to lead by example through disclosing the impact of climate risks on central banks' own balance sheets and assets held to meet monetary and non-monetary policy objectives in accordance with the TCFD guidelines. Setting a GHG-emission reduction target on their operations, including printing central bank notes and other operations, as well as financed emissions, is also possibly considered. Climate criteria could also be applied to the collateral framework through adjusting collateral eligibility and haircuts applied to collateralized assets.

4.1.1 Assets Held by Central Banks for Monetary Policy Purposes

The NGFS outlined its first practical approach toward integrating environmental perspectives into central bank asset management policies and provided recommendations with detailed practical examples (NGFS 2019b). Central banks tend to hold domestic and foreign assets for various objectives. Central banks' portfolios could be classified into four types of assets: assets which are held for monetary policy purposes; assets that are held for non-monetary policy purposes; assets that are held for managing employees' pension assets; and assets that are managed on behalf of third parties.

Central banks hold the first type of assets held for monetary policy purposes as a result of conducting monetary policy following mandates set by the Central Bank Law and other related laws. A number of central banks hold assets as a result of implementing quantitative easing as part of unconventional monetary policies in the face of the effective lower bound on their short-term policy rates. Such central banks typically hold government bonds denominated in their own currencies. Besides government bonds,

for example, the Federal Reserve in the United States holds agency mortgage-backed securities and agency bonds. The ECB holds covered bonds, corporate bonds including green bonds, and some other regional bonds. The BOJ holds not only high-rated corporate bonds and commercial paper, but also stock exchange-traded funds and real estate investment trusts. Moreover, some central banks conduct long-term credit operations for eligible financial institutions, including banks. For example, the ECB implemented three rounds of long-term low-cost lending to financial institutions under the Targeted Long-term Refinancing Operations. The BOJ has also been implementing various long-term fund-supplying operations for some time.

The NGFS highlighted several possible monetary policy options for central banks to take in contributing to greening the financial market and the carbon neutrality goals, as illustrated in Table 2 (NFGS 2021a). The options included asset purchases, credit operations, and collateral (utilized in central banks' operations against financial institutions when central banks conduct credit operations). While many central banks conduct short-term credit operations for financial institutions, only a number of central banks provide long-term credit operations (such as those with maturity or one year or longer). Asset purchases could take a tilting approach (i.e., increasing the weight of greener assets in total asset purchased) and in some cases a negative screening approach (i.e., divesting assets in case bond issuers fail to meet climate criteria). Currently, the ECB has been incorporating climate criteria into the reinvestment corporate bond framework through a tilting approach since October 2022. The reinvestment framework has been used since purchasing net financial assets was terminated in early July 2022. Meanwhile, the BOE was the first central bank to adopt a tilting approach to its reinvestment corporate bond framework by setting the emission-cut target on its holdings of corporate bonds—before the decision to sell all the holdings of assets, including corporate bonds. A tilting approach appears desirable if promoting carbon emission-intensive sectors and companies to make greater efforts to reduce emissions. A negative screening might be considered as a last option after observing corporate behavior for some time; and it may also depend on government's climate policy and detailed strategies.

In addition, credit operations listed in Table 2 could take the form of lowering interest rates if financial institutions have better climate-related lending performance; lowering interest rates when the composition of low-carbon assets accepted as collateral is greater; and, providing access or greater access to central banks' lending facilities conditional on financial institutions' climate-related lending performance. Central banks could establish new long-term credit facilities by proving long-term low-interest finance based on the volume of extending green loans and/or investing green bonds. The provision of new finance to such financial institutions has been practiced for the first time by the PBOC since November 2022 and then by the BOJ since December 2022, as explained below.

While asset purchases are limitedly exercised, central banks in emerging and developing countries often intervene in the foreign exchange market to mitigate fluctuations in their exchange rates (see Table 1). When their exchange rates appreciate sharply, foreign exchange intervention is often carried out by purchasing foreign currency from the foreign exchange market and supplying the domestic currency to the market in exchange. As a result, many central banks maintain large amounts of foreign currency denominated assets in the form of foreign reserves. Since these assets are held mainly for foreign exchange market intervention, the composition of foreign currency asset holdings is determined by several criteria (liquidity, creditworthiness, return, etc.). Central banks tend to hold foreign currencies in the form of deposits and government bonds issued mainly by major advanced countries, such

as the United States, due to the high liquidity and depth of the bond market. The NGFS argues that within the mandate, it is possible to change the investment mix from the climate change risk perspective. However, one crucial difference between foreign reserve management and domestic asset management from the perspective of promoting sustainable finance market is that the former supports sustainable foreign markets, including the green bond market, while the latter helps to foster the domestic market. The MAS adopted emission targets on its investment portfolio mostly arising from foreign reserves based on the carbon intensity of its equities and corporate bonds portfolio (Scopes 1 and 2 emissions), as described below.

Table 2: Selected Stylized Options for Adjusting Central Banks' Operational Frameworks to Climate Risks

Asset Purchases	
(1) Tilting Purchases	Skew asset purchases according to climate-related risks and/or criteria applied at the issuer or asset level
(2) Negative Screening	Exclude some assets or issuers from purchases if they fail to meet climate-related criteria
Credit Operations	
(3) Adjust pricing to reflect counterparties' climate-related lending	Make the interest rate for central bank lending facilities conditional on the extent to which a counterparty's lending (relative to a relevant benchmark) is contributing to climate change mitigation and/or the extent to which they are decarbonizing their business model
(4) Adjust pricing to reflect the composition of pledged collateral	Change a lower (or higher) interest rate to counterparties that pledge a higher proportion of low-carbon (or carbon-intensive) assets as collateral or set up a credit facility (potentially at concessional rates) accessible only against low-carbon assets
(5) Adjust counterparties' eligibility	Make access to (some) lending facilities conditional on a counterparty's disclosure of climate-related information or on its carbon-intensive/low-carbon/green investment
Collateral	
(6) Adjust haircuts	Adjust haircuts to better account for climate-related risks. Haircuts could also be calibrated such that they go beyond what might be required from a purely risk mitigation perspective in order to incentivize the market for sustainable assets.
(7) Negative Screening	Exclude otherwise eligible collateral assets, based on their issuer-level climate-related risk profile for debt securities or on the analysis of the carbon performance of underlying assets for pledged pools of loans or securitized products. This could be done in different ways, including adjusting eligibility requirements, tightening risk tolerance, introducing tighter or specific mobilization rules, etc.
(8) Positive Screening	Accept sustainable collateral so as to incentivize banks to lend or capital markets to fund projects and assets that support environmentally friendly activities (e.g., green bonds or sustainability linked assets). This could be done in different ways, including adjusting eligibility requirements, increasing risk tolerance on a limited scale, relaxing some mobilization rules, etc.
(9) Align collateral pools with a climate-related objective	Require counterparties to pledge collateral such that it complies with a climate-related metric at an aggregate pool level.

Source: Prepared by the author based on NFGS (2021a).

4.1.2 Assets Held by Central Banks for Non-Monetary Policy Objectives

Regarding assets held for objectives other than monetary policy, including the second and third types of assets, some central banks maintain assets for the purpose of funding their operational costs (such as personnel costs, computer system development costs, banknote issuance costs, etc.). Other central banks manage assets for the purpose of earning some return while accepting a certain amount of risk. Moreover, some central banks manage various financial assets for the purpose of deepening their understanding of market trends and conditions through actual investment. However, it is necessary for these non-monetary policy operations not to affect the conduct of monetary policy. Central banks' assets management for non-monetary policy purposes tends to cover a wider range of assets than the monetary policy objective because of greater considerations on returns.

As for the third type of assets, some central banks manage pension funds for central bank employees and the composition of these assets is determined by the nature of pension liabilities and fiduciary duty. The pension funds often manage an even wider variety of domestic and foreign assets than the first and second types of assets. As long as fiduciary duties are met, there is room to integrate the environmental standard into asset management. Since this asset management is longer-term oriented than the first and second types of assets, central banks need to pay less attention to short-term fluctuations in asset prices. Therefore, it is more suitable for environmental-oriented investment. The fourth type of assets are assets managed by some central banks on behalf of third parties. Some central banks, for example, manage foreign reserves and sovereign wealth funds on behalf of local governments.

In recent years, an increasing number of central banks in the world are introducing climate criteria for the management of these non-monetary policy-related assets not only in Europe but in other economies. The Banque de France, for example, is globally recognized as an environmentally conscious central bank, as evidenced by the fact that it serves as the secretariat for the NGFS. Banque de France was the first central bank in the world that applied a responsible investment approach to its portfolio of funds and pension obligations in 2018. Under this policy, the central bank excluded investments in companies with high GHG emissions from the stocks invested by the fund and increased the weight of investment in companies with high ESG scores. A similar approach has been applied to managing pension assets by the end of 2022. Banque de France also made the commitment that divesting coal-related investments will take place by 2024 at the latest. As a founding member of the NGFS, De Nederlandsche Bank (DNB)—the Dutch central bank—became the first central bank to sign the United Nations Principles for Responsible Investment in 2019. ESG perspectives are incorporated into non-monetary policy related to foreign currency-denominated assets and domestic assets. Furthermore, companies involved in the production of cluster bombs, landmines, chemical weapons, biological chemical weapons, nuclear weapons, etc., are excluded from investment targets. Based on the United Nations Global Compact Principles as the minimum ethical standards, the DNB practices negative screening to exclude problematic companies from investment targets.

4.1.3 Central Banks' Collateral and Reserve Requirements Frameworks

Central banks could consider applying green or environmental standards into the conduct of monetary policy, particularly through adjusting the collateral framework and the reserve requirements. With regards to the collateral framework (see Table 2), possible options could be accepting green assets as the collaterals used for central banks' lending schemes, reducing the degree of haircuts (thus accepting higher value) on those collaterals based on climate-related criteria, and adopting the negative or

positive screening criteria to the eligibility of collaterals based on climate standards. The PBOC explicitly included green financial bonds into the eligible criteria of the central bank's lending scheme in 2018. In 2021, the ECB is preparing to limit the share of assets issued by entities with high carbon emissions that can be accepted as collateral from 2024.

In addition, reserve requirements, which obligate financial institutions to hold the minimum amount of reserve balances (liquid deposits) with their central bank, could be used to promote green monetary policy. For example, differential reserve requirements could be applied to the composition of banks' portfolios. By allowing lower (higher) required reserve rates for financial institutions that hold greener, less carbon-intensive assets, central banks might be able to promote financial institutions' green investment (Dikau and Ulrich Volz 2018).

4.1.4 Central Banks' Climate-Related Financial Disclosure

An increasing number of countries and regions are urging companies and financial institutions to promote climate-related financial disclosure in accordance with the TCFD guidelines, as pointed out in Section 2, and additional guidelines. On this front, the NGFS has expressed the view that central banks themselves should also act as a role model by actively disclosing the financial impact of climate change based on the TCFD guidelines as a way to encourage such information disclosure by financial institutions (NGFS 2021b).

The TCFD guidelines set out principles for disclosure based on four standard pillars (Governance, Strategy, Risk Management, and Indicators&Targets). Under the *Governance pillar*, the NGFS suggested that central banks could incorporate climate risks into all their operations, which extend beyond the conduct of monetary policy. Central banks could describe how their board of directors understand climate risks and responds to them with clear organizational setting. On the *Strategy pillar*, it was suggested that focus could be given to the issue of how to make the financial system, the macroeconomy, and the central bank more resilient to climate risks through pursuing various central banking operations and the conduct of monetary policy. In the *Risk Management pillar*, central banks should specify the detailed risk management methods for specific operations, if possible. Furthermore, with regards to the *Indicators&Targets pillar*, it was suggested that central banks could disclose GHG emissions from central bank operations, including printing central bank notes and holdings of financial assets (Scope 3). At the same time, setting short- and medium-term emission targets, and, if possible, a long-term carbon-neutral target, for these emissions is considered desirable.

4.2 BOE as Front-Runner on Climate-Related Financial Disclosure

The BOE has been taking the lead among the central bank community in conducting climate-related disclosures in line with the TCFD guidelines. In 2020, the BOE became the first central bank in the world to disclose detailed information in line with the TCFD guidelines. It also aims to promote the creation of norms for central banks and the financial sector around the world by practicing best practices itself. The report is published and revised annually. The latest climate-related financial disclosure report was published in 2022 (BOE 2022b).

4.2.1 BOE's Climate-Related Governance Structure

According to the 2022 disclosure report, the section related to the *Governance pillar* explained that the central bank's management of climate risks is supervised by its Court of Directors. This Court acts as a unitary board comprising of five executive members (the governor and seven nonexecutive members). One of the nonexecutive members includes a chair chosen by the Chancellor of the Exchequer. The Court sets the organization's strategy and budget and makes important decisions on resourcing and appointments. The Audit and Risk Committee is placed as a subcommittee of the Court to assist it in maintaining effective risk management, internal controls, and financial reporting. The Court reviews the central bank's progress against climate risk targets annually, with the results included in the Bank's Annual Report.

The BOE has three statutory policy committees: the Monetary Policy Committee (MPC), the Financial Policy Committee (FPC), and the Prudential Regulation Committee (PRC). The Chancellor of the Exchequer issues remits and recommendations to these policy committees. The BOE Act 1998 requires that the Chancellor of the Exchequer specify the definition of price stability and the government's economic policy objectives for the MPC at least once in every period of 12 months. Price stability has been defined as 2% based on the 12-month increase in the consumer prices index. The government's economic policy objective had been defined as "achieving strong, sustainable and balanced growth". In March 2021, the Chancellor updated the MPC's remit to refine the government's economic strategy for "achieving strong, sustainable and balanced growth". The expression was revised by adding "that is also environmentally sustainable and consistent with the transition to a net zero economy" after the aforementioned expression. This statement reflects the government's commitment to meet the net-zero GHG emissions target by 2050 by passing laws to end the country's contribution to global warming by 2050.

In 2022, furthermore, the BOE received two additional climate-related recommendations, from the Chancellor, to the FPC and the PRC, in order to address global energy shortage issues. These committees were required to "…have regard to the government's energy security strategy and the important role that the financial system will play in supporting the UK's energy security—including through investment in transitional hydrocarbons like gas—as part of the UK's pathway to net zero." Based on these remit and recommendation letters, the BOE's climate strategy is currently formulated. Governance of climate-related works at a management level is led by the two Executive Sponsors for climate change. One is the Executive Sponsor for the Bank's policy functions who is Executive Director for Financial Stability Strategy and Risk and the other is the Executive Sponsor for climate change across the internal operations who is the Chief Operating Officer.

4.2.2 BOE's Climate-Related Strategy

With regard to the section related to the *Strategy pillar*, the BOE clarified that its work on climate change aims to play a leading role in ensuring the financial system and the macroeconomy become more climate resilient. To do so, the central bank intends to enhance its resilience to climate risks and its support for the transition to a net-zero economy. To achieve these climate objectives, the central bank put five key goals in place. These are: (1) enhancing the financial system's resilience toward climate-related financial risks; (2) supporting an orderly economy-wide transition toward net-zero emissions; (3) promoting effective TCFD-aligned climate disclosure; (4) contributing to a coordinated international approach toward the climate change agenda; and (5) demonstrating best practices through acting on the central bank's own operations. The 2022 disclosure report stressed that progress had been made with these five goals

over the past year, including the publication of the results of the central bank's climate CBES exercise for major UK banks and insurers, as mentioned in Section 3. The central bank also actively communicates with Parliament, companies and business leaders, financial market participants, and civil societies on exploring climate issues and exchanging views. The Prudential Regulatory Authority and the Financial Conduct Authority have also jointly organized the Climate Financial Risk Forum with a financial industry group to share best practice and accelerate financial institutions' capabilities to address climate change and risk management. The Forum published a series of climate-related practical guides and toolkits in 2020 and 2021.

With regards to its micro- and macroprudential measures to enhance resilience to climate-related financial risks at both the individual financial institution and the financial system-wide levels, the BOE's Prudential Regulatory Authority became the first prudential regulator in 2019 to publish a comprehensive set of supervisory expectations on how banks and insurance companies should enhance their approaches to managing climate risks. This publication was followed by guidance reflecting feedback for financial institutions. The guidance included the supervisor's expectations that financial institutions should maintain adequate capital to cope with climate-related financial risks, as pointed out in Section 3. The deadline for financial institutions to fulfill the supervisory expectations was by the end of 2021. In late 2021, the Prudential Regulatory Authority published a progress report and concluded that financial institutions had made good progress in incorporating climate risks into governance frameworks. However, it acknowledged that common challenges remain with regards to data gaps and modeling complexities. To overcome some of the challenges, alternative approaches (such as the use of proxy data, expert judgment, and assumptions) were suggested as interim tools. The regulator also emphasized that its supervisory approach would shift its focus from assessing financial institutions' implementation in light of its supervisory expectations to actively supervising financial institutions from the end of 2021. This means that the regulator will look at whether financial institutions could demonstrate effective and active management of climate risks through regular supervisory engagements and reviews. Financial institutions are now requested to submit clear transition plans and take further assurance actions if progress is judged insufficient. The BOE is also working with the government and other financial regulators to support the adoption of mandatory TCFD-aligned disclosure requirements applied across the economy by 2025.

4.2.3 BOE's Risk Management and Indicators&Targets

With respect to the section related to the *Risk Management pillar* and the *Indicators&Targets pillar*, the BOE's 2022 disclosure report acknowledged that the central bank is exposed to climate risks across both its physical operations (e.g., emissions from its buildings and travel) and its financial operations (e.g., financial asset portfolios held for monetary policy purposes). The BOE implemented several measures to enhance its management of climate risks. Since June 2021, for example, the central bank's important metrics related to climate risks have been reported regularly to its executive and nonexecutive risk committees and periodically to the Court of Directors. The central bank produced internal guidance to promote assessment and reporting on climate risks. This aim was to encourage more comprehensive thinking within the BOE about the impact of climate risks and to increase internal consistency on reported risks.

One of the important contributions initiated by the BOE has been its efforts to demonstrate best practices in climate risk reporting by disclosing climate risk analysis on its asset holdings. In 2022, the central bank broadened its carbon emission metrics to include financed emissions in line with the TCFD guidelines (BOE 2022b). The BOE also continues to strengthen its forward-looking risk measures by incorporating the latest climate scenarios presented by the NGFS, as pointed out in Section 3. With regards to asset holdings, the 2020 disclosure report pointed out that climate performance related to its sovereign asset holdings across a range of indicators remained better than reference portfolios and in line with previous trends. The carbon emission related to its sovereign government bond holdings is measured by the Weighted Average Carbon Intensity (WACI), as recommended by the TCFD guidelines. This measure fell and remained lower than a Group of Seven (G7) reference portfolio, thus indicating the lower carbon footprint in the United Kingdom relative to other advanced economies.

Regarding sterling nonfinancial (investment grade) corporate bond holdings, the BOE announced its intention to align its Corporate Bond Purchase Scheme portfolio in line with the 2021 revision of its MPC's remit, described above. The central bank published an associated comprehensive framework, including a tiling approach that incentivizes stronger climate-performing companies in accordance with a climate scorecard. An interim target on reducing the WACI of the portfolio was set at 25% between 2020 and 2025. The WACI of the corporate bond holdings as of February 2022 fell 8% on a year-on-year basis to 233 tons of CO_2 per £ million of revenue (tCO_2e/£mn revenue)—18% below the level reported in the 2020 climate disclosure report. Subsequently, however, the central bank decided to stop purchasing new corporate bonds and shifted to the reinvestment strategy. Accordingly, the climate target was decided to be applied to the reinvestment framework of the Corporate Bond Purchase Scheme. An initial program of reinvestment operations was conducted from November 2021 to January 2022. In February 2022, the central bank made a monetary policy decision to reduce holdings of its entire portfolio, including government and corporate bonds, by ceasing reinvestment programs. Sales of corporate bonds will also be conducted and completed fully by the end of 2023 or early 2024, subject to market conditions. Thus, greening corporate bond holdings was terminated.

Concerning emission from operations, the BOE is exploring its strategy to reduce emissions from its physical operations toward achieving net zero by 2050. It monitors its exposure to transition risks by tracking its carbon emissions arising from physical operations. In 2022, the central bank's carbon emission achieved lowest level since the emission target was set in 2015/2016. The amount of carbon emission has fallen by 9% percent (1,027 tCO2e) compared to 2020/2021, and by 51% (10,311 tCO2e) compared to the baseline year of 2015/2016. The reduction in emissions since 2021 was mostly attributable to changes in banknote production, mainly due to a decline in demand for banknotes driven by the impact of the COVID-19 pandemic and thus a decline in the number of banknotes printed. Notwithstanding that this recent decline could be temporary, the BOE stressed that the decrease in carbon intensity is expected to generate a permanent change (BOE 2022b). The impact of the COVID-19 pandemic on emissions also continued to be felt because of the low levels of air travel by staff. While this impact is likely to be temporary, new ways of working among BOE staff is unlikely to revert to the 2019/2020 level. The central bank's efforts to shift to renewable electricity also contributed to a decline in emissions from operations.

4.3 ECB's Approach on Climate-Related Financial Disclosure and Asset Management

The ECB views that climate risks must be considered in fulfilling price stability and financial stability mandates. Besides considering climate risks in the financial stability assessment and risk management improvement, the ECB has been attempting to integrate climate criteria in managing various assets held by the ECB for monetary and non-monetary purposes.

4.3.1 Promoting Common Stance for Managing Non-Monetary Policy Portfolios

The Eurosystem members, which comprise the ECB and all national central banks of the euro area economies, are solely responsible for their own non-monetary policy portfolios. Nonetheless, they agreed in 2021 to work jointly to bring the common stance for climate-related sustainable and responsible investment principles with regards to euro-denominated non-monetary policy portfolios managed under their own responsibility. This decision is consistent with the recommendations by the NGFS to improve climate risk management related to central banks' balance sheets noted above. The Eurosystem has also decided to start climate disclosures for these portfolios within two years using the TCFD recommendations as the initial framework and reporting them in the Indicators&Targets pillar. The ECB and some national central banks (such as those in France and the Netherlands) have already been applying sustainable and responsible investment practices in the management of their non-monetary policy portfolios. The common stance is expected to promote disclosures and understanding of climate risks and help Eurosystem members to contribute to the transition to a low-carbon economy and to the EU's climate goals of achieving net-zero emissions by 2050 and 55% compared to the 1990 level by 2030 as an intermediate target.

4.3.2 Introducing Climate Criteria in the Corporate Bond Reinvestment Strategy

In July 2022, the ECB announced the inclusion of climate criteria in its corporate bond purchases, collateral framework, disclosure requirements, and risk management, in line with its climate action plan presented one year ago. All these measures are viewed in line with the Eurosystem's primary objective of maintaining price stability and are consistent with the EU's climate neutrality objectives (i.e., supporting the green transition of the economy), as pointed out in Section 2. As for corporate bond holdings, the ECB currently conducts only reinvestment purchases since net asset purchases including other bonds were terminated from April 2022 with regards to the Pandemic Emergency Purchase Program, and from July 2022 with regards to the Asset Purchase Program. Under the reinvestment framework, the ECB decided to gradually decarbonize its corporate bond holdings from October 2022 by adopting a tilting approach. Namely, the ECB intends to increase the share of asset holdings held by the Eurosystem towards bonds issued by better climate performers. The judgment is made based on the degree of GHG emission cut, the ambitiousness of carbon reduction targets, and the extent of climate-related disclosures. The total volume of corporate bond purchases remains to be determined by monetary policy considerations in achieving the ECB's inflation target. This climate-related reinvestment strategy not only aims to mitigate climate-related financial risks on the Eurosystem balance sheet, but also to incentivize bond issuers to reduce their emissions and improve disclosures. The

ECB plans to start publishing climate-related information on corporate bond holdings regularly from the first quarter of 2023.

The July 2022 decision was followed up in September 2022 with more detailed information regarding the overall climate score used to tilt corporate bond holdings. The overall climate scores comprise the following three subscores: The backward-looking emissions subscore; the forward-looking target subscore; and the climate disclosure subscore. The backward-looking emissions subscore is assessed based on bond issuers' past GHG emission performance relative to their peers in a specific sector, as well as compared with all eligible bond issuers. Companies that reduce higher amounts of GHG emissions receive a higher score. The forward-looking target subscore is evaluated based on the GHG emission targets set by issuers. As companies with more ambitious emission reduction targets receive a better score, this scoring approach intends to provide an incentive to cut their emissions. The climate disclosure subscore is judged based on the assessment of the quality of issuers' disclosure on GHG emissions. As a higher score is given to the companies with higher quality disclosures, issuers are encouraged to improve disclosures. The scoring and the methodologies utilized will be reviewed regularly and might be adjusted if new favorable developments emerge in terms of data collection, modeling, tighter regulation, and risk assessment capabilities.

4.3.3 Introducing the Climate Criteria in the Collateral Framework

With regards to collateral framework, the ECB decided in July 2022 to limit the share of bonds issued by high carbon-emitting issuers that can be accepted as collateral used by individual financial institutions wishing to borrow funds from the ECB (namely, Eurosystem). Imposing the new limits aims to reduce climate-related financial risks in ECB's credit operations. To begin with, such limits will be applied only to marketable debt instruments issued by nonfinancial companies. The new limits might be extended to additional asset classes in the future once data quality improves. This new collateral framework is expected to be launched before the end of 2024 provided that the necessary technical preconditions are fulfilled. To encourage financial institutions to prepare for this in advance, the ECB plans to conduct tests before its actual implementation date. In addition, the ECB is examining about the possibility of incorporating climate risks into haircuts applied to corporate bonds used as collateral for its lending operations. Central banks use haircuts (i.e., reductions) to the value of collateral based on the degree of riskiness associated with collateralized assets. In any case, all these measures will not lead to a shortage of collateralized assets. The ECB will ensure that ample collateral remains available and thus enable monetary policy to be implemented effectively.

With regards to climate-related disclosure requirements for collateral, the ECB will accept marketable assets and credit claims from issuing companies and debtors that comply with the EU's Corporate Sustainability Reporting Directive (CSRD) as collateral used in ECB's credit operations. The CSRD is expected to be implemented from January 2024 for companies that are already subject to the previous Non-Financial Reporting Directive with the first report to be submitted in 2025. For all other large companies, the implementation date is January 2025, with the first report to be submitted in 2026. For listed small- and medium-enterprises, the implementation date is January 2026 with the first report to be submitted in 2027. To encourage stakeholders to align with the new rules earlier, the ECB will conduct test exercises one year ahead of the actual implementation date. Some assets pledged as collateral within ECB credit operations (such as asset-backed securities and covered bonds) may not

fit into the CSRD disclosure framework. For these assets, the ECB intends to support better and harmonized disclosures of climate-related data.

4.3.4 Introducing Climate Criteria in Risk Assessment and Management

The decision was also made by the ECB in July 2022 to enhance its risk assessment approaches to better reflect climate risks. Based on the assessment that current disclosure standards used by credit rating agencies are not satisfactory, the ECB will urge rating agencies to become more transparent about their approaches of incorporating climate risks into their ratings. The ECB will also encourage credit rating agencies to increase willingness to meet climate-related disclosure requirements through more active communication with the relevant authorities. On this front, the ECB agreed on formulating a set of common minimum standards regarding how national central banks' in-house credit assessment systems should include climate-related risks in their ratings. These standards will enter into force by the end of 2024.

4.4 PBoC's Comprehensive Climate Actions Using Green Monetary and Other Policy Measures

The PBOC has been one of the major authorities within the PRC to take the lead in promoting green finance using various monetary and non-monetary policies and prudential measures. The PBOC is one of the first central banks to conduct the climate stressing exercises that have implications for banks' capital adequacy ratios, as pointed out in Section 3. The government and the central bank are making efforts to achieve the two emission reduction targets (achieving peak carbon by 2030 and carbon neutrality by 2060) set in 2020. In developing green finance, the PBOC is aimed at developing the green financial standard system (the so-called "PRC's version of taxonomy"), strengthening surveillance and information disclosure requirements for financial institutions, providing incentive mechanisms, and promoting green financial products and markets.

4.4.1 PBOC's Green Taxonomy: Green Bond Endorsed Catalogue

One of the most important measures adopted to develop green finance has been the introduction of the PRC's version of green taxonomy. The PBOC, together with the National Development and Reform Commission and the China Securities Regulatory Commission, has been developing the Green Bond Endorsed Catalogue since 2015 by unifying existing domestic standards on green bonds and green projects. The taxonomy is mandatory for all green bond issuers covering companies, financial institutions, and regulatory agencies. The Catalogue is aimed at clarifying projects eligible for green bonds to improve credibility of the green bond market. To make the Catalogue more consistent with the EU taxonomy, it removed "clean use of coal and other fossil energy sources" and adopted EU's "do not significantly harm" principle in the 2021 edition (PBOC 2021a).

The PBOC also collaborates with other central banks and co-chairs with the EU the taxonomy working group established by the International Platform on Sustainable Finance (IPSF) in 2020. The IPSF itself was launched by the European Union in 2019 to deepen international cooperation and, where appropriate, coordination on approaches for the capital markets (such as taxonomies, disclosures, standards, and labels). The founding members were governments in Argentina, Canada, Chile, India, Kenya, Morocco, and the PRC. Later, eleven other economies including Indonesia, Japan, Malaysia, New Zealand, Norway, Singapore, Switzerland also joined the IPSF. In 2021, the taxonomy working group published the report called the Common Ground

Taxonomy-Climate Change Mitigation. The report covered an in-depth comparison exercise, including investigating areas of commonality between the EU and PRC's taxonomies (IPSF 2021).

4.4.2 Promoting Environment-Related Disclosure for Financial Institutions and Green Finance Evaluation Program

To improve climate-related information disclosure, the PBOC released the first Guidelines on Environmental Information for Financial Institutions in July 2021 (PBOC 2021b). The financial institutions included commercial banks, asset management companies, trust companies, and insurance companies. Financial institutions are required to report on their environmental objectives, strategic plans, actions undertaken, and major outcomes during the year under investigation. While many of the disclosure content required is similar to the TCFD guidelines, financial institutions are required to disclose more detailed information beyond these guidelines.

On the environment-related governance structures, financial institutions are expected to disclose Information about green finance committees established at the board level and the executive level. Also, financial institutions need to describe their environment-related strategic goals, analysis, and judgment on environment-related risks and opportunities, as well as their management and monitoring of environment-related issues. The management positions or internal organizations and their main responsibilities also need to be explained. This section is similar to the *Governance pillar* of the TCFD guideline. The section on environmental risks and opportunities, which appears to be similar to the *Strategy pillar* of the TCFD guideline, should cover the actual and potential impact of risks and opportunities on the business and strategies, including the short-, medium- and long-term perspectives as well as measures undertaken to deal with environmental impacts and their effects. Quantitative climate scenario analysis and climate stress test are expected to be performed. In a separate section on the environment-related policies and systems, financial institutions are expected to disclose new measures implemented during the reporting year and the actual implementation of government's environmental policies, regulations, and standards. Regarding the section concerning the environmental risk management process, financial institutions are expected to disclose processes of identifying and evaluating environment-related risks and processes of managing and controlling environment-related risks. This section appears to be similar to the *Risk Management pillar* of the TCFD guidelines. Regarding data sorting and verification, the guideline expects financial institutions to improve the timeliness and accuracy of environment-related statistical data disclosure by establishing data quality management systems and emergency measures to cope with possible data security incidents or accidents. This section appears to be partially similar to the *Indicators&Targets pillar* of the TCFD guideline.

In addition to the TCFD-like disclosure, the PBOC expects financial institutions to disclose detailed information about financial products and impacts. For example, the section on the environment-related products and services innovation should cover a description related to innovative green finance products and services offered by the financial institution—including product name, scope of delivery, financing terms, environmental and social benefits of the financial institution's green product innovation. In addition, the section on the environmental impacts of the investment and financing activities includes descriptions of the overall investment and financing situation and its impacts on the environment; the implementation effect of green investment and financing policies; and the green supply chain and its impact on the environment. The PBOC plans to set a schedule for financial institutions to meet these disclosure

requirements in the near future as a part of the process of improving the green financial standards system.

To enforce the information disclosure, the PBoC introduced the Green Finance Evaluation Program in July 2021 on banks' holdings of green bonds. The Program was applied to more than 20 major Chinese banks, including state-owned banks and policy banks (such as the China Development Bank, the Agricultural Development Bank of China, and the Export–Import Bank of China). The ratings of each bank are assessed based on the quantitative assessment (whose weight is given 80%) and qualitative assessment (20%). The quantitative measures comprise the share of green bond holdings in their total assets; the year-on-year change in the total amount of green bonds holdings; and, the share of green bond business risks. The qualitative assessment is judged based on the quality of daily management practices and risk control policies. These ratings are used by the PBOC to determine incentives and disciplinary measures applied to each bank. This July 2021 decision was an addition of green bonds to the PBOC's existing Evaluation Program covering green loans, which was initiated in 2018 towards the major banks. Given that the size of the green bond market is rapidly growing in the country, the central bank decided to include both green loans and green bonds in the quarterly assessment of banks' contribution to the national and local green financing policies.

4.4.3 Providing Incentives for Financial Institutions to Promote Green Finance

The PBOC provided several incentives for financial institutions to promote green finance. For example, it included green financial bonds into the pool of eligible collateral used for monetary policy credit operations. Namely, these bonds were added to the eligible collateral list applicable to its Medium-Term Lending Facility (MLF) in 2018. The MLF was launched in 2014 with maturities up to one year.

As a pioneer in central bank-sponsored green credit operations, moreover, the PBOC introduced the Carbon Emission Reduction Facility, aimed at promoting financial institutions to increase finance to green and low-carbon projects and activities in November 2021. The facility focuses on supporting the development of three key areas for carbon emissions reduction (i.e., clean energy; energy conservation, and environmental protection; and carbon emissions reduction technologies) in a steady, orderly, targeted, and direct manner. Another facility, called the Special Central Bank Lending to Support the Clear and Efficient Use of Coal, was also introduced simultaneously to ensure energy supply security and promote orderly carbon emission reduction. This facility is designed to provide support for the large-scale clean production of coal, the application of clean combustion technologies, and another five areas. These two facilities reflect the strategy of developing clean energy while continuously supporting the clean and efficient use of coal and coal-fired power. Under the two facilities, commercial banks are allowed to finance eligible projects and activities at the loan prime rate (currently, 3.65% for the one-year rate and 4.3% for the five-year rate) determined by the PBOC as policy rates. Conditional on qualified loans extended by commercial banks, moreover, the PBOC provides 60% of such loans with a one-year lending rate of 1.75% to those commercial banks (which can be rolled over twice).

To be qualified for these central bank's lending schemes, the PBOC required financial institutions to disclose information concerning these loans, including the amount of carbon emission reduction loans and the volume of carbon emission reduction arising from such loans. The data must be examined and verified by third-party professional institutions to avoid green-washing behavior. The measure is expected to

enhance the efforts to improve the information disclosure discussed above. More than 200 financial institutions in pilot zones have been tentatively compiling reports based on such environmental information disclosure.

4.4.4 Central Bank Cooperation to Promote Green Finance

The PBOC and the MAS announced an establishment of a Green Finance Taskforce in November 2021 to strengthen bilateral cooperation in green finance and at the same time facilitate mobilization of private capital for the region's sustainable development needs. The Taskforce was established to collaborate on setting standards and standardizing definitions of green finance. The Taskforce also plans to collaborate on providing green and transition financing solutions, promote data collection and technology needed for increasing green financing flows, and enhance green investment opportunities in their regions. This initiative is part of the broader cooperation in green finance and capital market linkages between the two economies—including the exchange-traded funds product link through the Shenzhen Stock Exchange and the Singapore Exchange, as well as the launch of a low carbon index family by the Shenzhen and Shanghai Stock Exchanges and the Singapore Exchange (which intends to serve as a benchmark for green funds in the PRC, the Association of the Southeast Asian Nations (ASEAN), and other Asian economies managed by fund managers).

4.5 BOJ's Approach to Climate Change through a Lending Scheme

The BOJ regards climate change as one of its main challenges in conducting business operations and organizational management. Since 2021, the BOJ has been actively working on measures to help financial institutions to cope with climate risks.

4.5.1 BOJ's Climate-Related Lending Scheme

In December 2021, the BOJ adopted the one-year low-cost financing program (0% interest rate) called the Funds-Supplying Operations to Support Financing for Climate Change Responses. The facility is to provide funds for financial institutions within their outstanding amount of climate-related investments or loans. Financial institutions are required to disclose information in line with the TCFD guidelines, as well as targets and actual results for their climate-related investments or loans. The maturity is one year and can be rolled over unlimitedly until the end of March 2031. The 0% interest rate on reserve balances held by financial institutions is applied up to twice as much as the amount outstanding of funds provided by the BOJ to the financial institution (thus, the negative interest rate is exempted for this amount).

Meanwhile, the BOJ stated in July 2021 that climate change could have an extremely large impact on economic activities, prices, and financial conditions in the medium to long term. While supporting the private sector's efforts on climate change from a central bank perspective will contribute to stabilizing the macroeconomy in the long run, the BOJW stressed the need to keep its market neutrality and avoid direct involvement in micro-level resource allocation (BOJ 2021).

4.5.2 BOJ's Disclosure in Line with the TCFD Guidelines

In 2022, the BOJ disclosed information in line with the TCFD guidelines (BOJ 2022). With regards to the *Governance pillar*, the Policy Board meeting approved the strategy on climate change in 2021 and conducted an interim review of the Medium-Term Strategic Plan (Fiscal 2019–2023) to address climate change in conducting business operations and organizational management in line with the Strategy comprising five areas. These five areas are described in the *Strategy pillar*, which are comprised of monetary policy, financial system, research, international finance, and communication). The BOJ also collaborates closely with all major international organizations including the NGFS. Furthermore, the central bank makes investments in the Asian Bond Fund launched by the Executives' Meeting of the East Asia-Pacific Central Banks (EMEAP) to support emerging economies' bond market. In 2021, the BOJ decided to purchase foreign currency-denominated green bonds issued by the EMEAP member governments and other foreign institutions to further deepen local currency-denominated green bond markets in the region. It should be noted that the BOJ's holding of foreign currency assets is limited and amounts to only about $66 billion. Japan's foreign reserves of about $1.1 trillion are managed by the Ministry of Finance. The BOJ set up the Climate Coordination Hub to promote information sharing and coordination internally between various departments on detailed measures and address issues related to climate change. Every fiscal year, the central bank conducts performance reviews of related initiatives taken by each department.

With regard to the *Risk Management pillar*, the BOJ pointed out that some progress has been made in the five areas set out in its Strategy on Climate Change. The monetary policy aims at using the Funds Supplying Operations to Support Financing for Climate Change Responses mentioned above. In terms of the financial system, the central bank has been engaging with financial institutions through its on-site examinations and off-site monitoring of climate-related financial risks and of their engagement with corporate counterparties on decarbonization. The pilot climate scenario analysis was conducted with the Financial Services Agency in 2022, as described in Section 3. The BOJ has been making efforts to reduce GHG emissions and promote energy saving in its Head Office and branches. The central bank is also strengthening its business continuity plan to cope with an increasing flood risk.

With regards to the *Indicators&Targets pillar*, the BOJ has begun to disclose data on direct (Scope 1) and indirect (Scope 2) carbon dioxide (CO2) emissions stemming from its business operations every fiscal year. These efforts have resulted in the decrease in CO2 emissions in recent years.

4.6 MAS's Climate Actions through Foreign Reserve Management

Singapore has the largest sustainable finance market in the ASEAN. The MAS intends to contribute to developing climate-resilient financial center in the country.

4.6.1 MAS's Disclosure Based on TCFD Guidelines

The MAS began to publish its sustainability report in 2021. The latest 2022 report was released in line with TCFD guidelines (MAS 2022a). In the section related to the *Governance pillar*, the MAS established the Green Finance Steering Committee (chaired by Managing Director) to discuss strategies to develop a climate-resilient financial sector. Before tabling this Committee, the relevant initiatives are made at the Management Financial Supervision Committee and the Management Financial Stability

Committee, where both are chaired by a deputy managing director. The former holds a meeting on a weekly basis to make decisions on policies related to the supervision and regulation of the financial sector, while the latter holds a meeting on a quarterly basis to identify and assess risks to the financial system and discuss macroprudential policy. Since 2019, the MAS has convened the Green Finance Industry Taskforce comprising representatives from financial institutions, companies, financial industry associations, etc. The Taskforce aims at accelerating the sustainable finance market mainly through four major areas: (i) the development of a taxonomy; (ii) the improvement of disclosures; (iii) the promotion of green finance solutions; and (iv) the enhancement of environmental risk management practices by financial institutions.

With regard to the section related to the *Strategy pillar*, the MAS has integrated environmental risks into its supervisory framework and processes at the individual financial institution and system-wide levels. The MAS also actively promotes international collaboration with various organizations to facilitate the sharing of best practices and promote globally compatible frameworks. The NGFS is currently chaired by MAS's managing director. The MAS also collaborates with the BIS Innovation Hub Singapore Centre on Project Viridis, aiming to help financial sector supervisors to have a deeper understanding of banks' exposures to green and non-green assets.

With regards to the *Risk Management pillar*, the MAS issued the Guidelines on Environmental Risk Management to Financial Institutions in 2020 (which became effective in June 2022). Before implementing the Guidelines, the MAS conducted thematic reviews of financial institutions' environmental risk management practices in 2021. Engagement was also conducted with selected banks, insurers, and asset managers through surveys and dialogue. In May 2022, the MAS published information papers on the environmental risk practices of banks, insurers, and asset managers.

The MAS collaborated with the Green Finance Industry Taskforce and Association of Banks in Singapore to develop a standardized Environmental Risk Questionnaire for financial institutions to obtain common major risk data from corporate client counterparties before making financing and investment decisions. The MAS also worked closely with Singapore Exchange (SGX) to finalize a roadmap on mandatory climate-related financial disclosures in line with the TCFD guidelines. By 2025, mandatory climate reporting is expected to cover 60% of SGX-listed entities by number, and 78% by total market capitalization.

4.6.2 MAS's Climate Target on Investment Portfolio

With regards to the *Indicators&Targets pillar*, the MAS has launched a 2030 environmental sustainability roadmap including Scope 1, Scope 2, and Scope 3 short- and medium-term emissions in FY2025 and FY2030. The 2030 roadmap seeks to promote energy efficiency measures in the MAS building and keep pace with technological advancements.

With regards to investment portfolios mostly arising from foreign reserves, the MAS measures the carbon intensity of its equities and corporate bonds portfolio based on Scope 1 and Scope 2 emissions. The carbon profile of the equities and corporate bonds portfolios are reported using Weighted Average Carbon Intensity (WACI). This measures carbon intensity (i.e., the CO2 equivalent emissions per unit of revenues) for each of the corporate counterparties in the portfolio, weighted by the relative size of the investments in the respective portfolios. The MAS aims to reduce the WACI of the equity portfolio by up to 50% t by FY2030 compared to the base year of FY2018. The WACI for the corporate bond portfolio as at end-March 2022 was 76% lower

compared to the benchmark. These efforts have helped to reduce portfolio exposure to securities issued by companies in carbon-intensive sectors.

5. CONCLUSIONS

This paper provided an overview of climate-related approaches and practices undertaken by central banks and financial regulators that have become more visible in recent years. As climate change has major implications on inflation, economic growth, financial system stability, central banks and financial regulators have increasingly recognized that they can no longer ignore climate change and other environmental issues. In general, central banks are responsible for achieving price stability under the monetary policy mandate and financial stability under the macroprudential policy mandate. Therefore, it is possible for central banks to consider climate risks within their existing mandates. Moreover, the global financial markets have been facing the problems of mispricing due to the presence of low carbon prices. If these issues are unaddressed, the transition process towards a low-carbon economy will remain too slow to achieve carbon neutrality. While governments play the most important role in pursuing climate policy, central banks could contribute to governments' efforts within their existing mandates.

Central banks cope with financial stability mainly through macroprudential policy, including financial supervision and monitoring, while price stability is dealt with through monetary policy. There is a growing consensus globally that central banks and financial regulators should treat climate risks as one of the major financial risks. Meanwhile, a consensus has not yet emerged as to whether central banks should incorporate climate risks in their price stability mandate and thus in the monetary policy framework. The ECB is so far one of the most environmentally ambitious central banks in the world as its comprehensive climate agenda covers macroeconomic modeling, detailed monetary policy instruments, financial risk assessment including stress tests and data collection, as well as policies to promote green finance. Some central banks appear to place more emphasis on climate-related financial risks and prudential perspectives to cope with financial institutions rather than relating climate risks to price stability and monetary policy.

There are several policy options that central banks might consider—financial stability, macro-climate modeling, non-monetary policy asset purchase, monetary policy asset purchases, and monetary policy-related credit operations. Climate scenario analysis and/or climate stress test are central to maintaining financial stability against climate risks and increasingly adopted by central banks and financial regulators, including the ECB, the BOE, the PBOC, the BOJ, and the MAS. Moreover, there are growing discussions on how to include climate risks with respect to the capital adequacy requirements regulation for banks in the Basel framework as micro- and macroprudential tools.

Central banks are also encouraged to lead by example through disclosing the impact of climate risks on their central banks' own balance sheets, setting a GHG emission reduction target on their operations, and adjusting the composition of various domestic and foreign assets held by central banks for non-monetary and monetary policy objectives. Adopting climate criteria for asset management held for non-monetary objectives is being increasingly adopted by many central banks worldwide. Meanwhile, asset purchases held for monetary objectives are not yet very common. Currently, the ECB has been incorporating climate criteria into the reinvestment corporate bond framework through a tilting approach from October 2022. With regard to credit

operations, the PBOC and the BOJ are incorporating climate criteria into their long-term credit operations for financial institutions. Adopting the climate criteria into the collateral framework has been performed by the PBOC for some time while the ECB plans to do so in 2024.

Overall, central banks and financial regulators face data gaps and modeling complexities and thus continue to face challenges in supervising financial institutions' banks and making financial systems more environmentally resilient. Nonetheless, the growing recognition of the need to collect reliable data, including Scope 3 emission data of corporate counterparties, and developing modeling and surveillance methodologies among central banks and financial regulators, will likely lead to more dialogues and collective actions in the world.

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