Central Banking, Climate Change, and Green Finance

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Abstract

Responsibility for financial and macroeconomic stability implicitly or explicitly lies with the central bank, which therefore ought to address climate-related and other environmental risks on a systemic level. Furthermore, central banks, through their regulatory oversight over money, credit and the financial system,

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J. D. Sachs et al. (eds.), *Handbook of Green Finance*, Sustainable Development,
https://doi.org/10.1007/978-981-13-0227-5_17

are in a powerful position to support the development of green finance models and enforce an adequate pricing of environmental and carbon risk by financial institutions. The central topic of this chapter are the public financial governance policies through which central banks, as well as other relevant financial regulatory agencies, can address environmental risk and promote sustainable finance. The chapter first discusses the reasons why central banks should be concerned with aligning finance with sustainable development. Second, the chapter reviews the tools and instruments that can be utilized by central banks and financial regulatory agencies to address environmental risk and promote green finance and sustainable development. Third, the chapter provides a brief review of green public financial governance initiatives.

Keywords
Central banks · Green finance · Green transformation

JEL Classifications
Q5 · E5

Introduction

To achieve the 2030 Agenda for Sustainable Development and the Paris Climate Accord, investment will have to be directed away from carbon- and resource-intensive investments toward sustainable investment. Responsibility for financial and macroeconomic stability implicitly or explicitly rests with the central bank, which therefore ought to address climate-related and other environmental risks on a systemic level. Furthermore, central banks, through their regulatory oversight over money, credit and the financial system, are in a powerful position to support the development of sustainable finance approaches and enforce an adequate pricing of environmental and carbon risk by financial institutions (Volz 2017). Against this backdrop, the chapter discusses the extent to which central banks should incorporate environmental considerations into their operations, and reviews the public financial governance policies through which central banks, as well as other relevant financial regulatory agencies, can promote green finance.

The chapter is organized as follows. The section "Why Central Banks Should Be Concerned with Aligning Finance with Sustainable Growth and Development" discusses the reasons why central banks should be concerned with aligning finance with sustainable development. In doing so, it differentiates between the impact of environmental factors on the conventional goals of central banking, and a potential promotional role of central banks with regard to green finance and sustainability. Subsequently, the section "Tools and Instruments of Central Banks to Address Environmental Risk and Promote Green Finance and Investment" reviews the tools and instruments that can be utilized by central banks and financial regulatory agencies to promote green finance and sustainable development. It also provides some examples of public green financial policies in different policy areas. The final section concludes.

Why Central Banks Should Be Concerned with Aligning Finance with Sustainable Growth and Development

Green central banking can be defined as central banking that takes account of environmental risks, including risks from climate change, which may have a material impact on the short- and long-term stability and development of the financial sector and the macroeconomy. One can distinguish between central banks' responses to environmental externalities affecting central banks' traditional core responsibility of safeguarding macroeconomic and financial stability, and an activist role of central banks in "greening" the economy. Green central banking therefore describes, on the one hand, the process of taking environmental risk and other sustainability-related factors, such as climate change mitigation policy, into account in the design of monetary policy and financial regulation in the pursuit of the traditional goals of price and financial stability. This can be described as the passive aspect of green central banking because in pursuing their established goals, central banks may need to incorporate environmental factors into existing frameworks, for instance into macro-prudential frameworks, without pursuing a "sustainability agenda." On the other hand, central banks may be mandated to actively use the tools at their disposal to promote green investment or discourage brown investment and play a "developmental role" (Dafe and Volz 2015).

The Importance of Environmental Factors for Conventional Goals of Central Banking

The core responsibility of most central banks—often specified in the mandate as the singular or primary objective of monetary policy—is safeguarding low and stable inflation. Sometimes embedded in an inflation-targeting framework, this primary focus of central banks on price stability is based on the theoretical and empirical understanding that low and stable inflation is a necessary precondition for growth or development to take place. Apart from maintaining low and stable inflation, safeguarding financial stability has traditionally been the other important concern for central banks, which throughout history have acted as lenders of last resort. Although there was a trend since the 1990s to assign responsibility for financial stability to dedicated financial regulatory authorities, it has received renewed attention as a crucial central baking objective against the background of the global financial crisis. A further (often secondary) goal of central banking is supporting wider economic policy objectives such as sustainable growth or, in some cases, maximum employment. A strong argument for central banks to take environmental factors into account in the conduct of monetary policy in the pursuit of their core objectives can be derived from how these central goals are affected by climate change and other environmental risks.

Impact on Price Stability

Prices and price variability, which are at the center of attention of most central banks, could be affected through various channels by anthropogenic climate change and an

associated increase in the frequency and severity of extreme weather events. To start with, climate change may have a significant impact on agricultural production, both domestic and abroad, and hence on food prices, which are an important component of consumer price inflation. For instance, climate change-related droughts and floods may have a significant impact on agricultural production and cause supply shocks and hence rising prices and cost-push inflation. For economies in which agricultural production is a central pillar of the economy—which is often the case in developing economies—climate change effects on the agricultural sector may also have a broader impact on aggregate income and employment. While a first concern is how climate change-related hazards may directly affect prices, a second issue of concern is the potential impact of climate change-mitigation policy on inflation. An important issue in this context is the potential impact that climate change mitigation policies may have on energy production and prices (Volz 2017). McKibbin et al. (2017) discuss how different climate change policy regimes—carbon policies such as a carbon tax, a permit trading system, and other regulatory measures—could theoretically affect different monetary policy regimes. In a scenario where the introduction of a carbon tax causes aggregate output to decline and inflation to spike, no response by the central bank would yield a permanently lower output level and no change in the long-term growth rate. In the case of a strict inflation-targeting regime, the central bank would respond to the spike in inflation by raising interest rates, thereby further slowing the economy, but also causing exchange rate appreciation. While both would have a depreciating effect on inflation, the overall decline in output would be worse than in the case without central bank intervention. McKibbin et al. (2017) also discuss implications for other monetary policy regimes, including flexible inflation targeting and price level targeting, and come to the overall conclusion that solely responding to the inflationary component, without taking rising prices and decreasing output resulting from climate policy into account, may lead to unnecessarily large output losses. Monetary policy therefore has to take climate-related effects on food or energy prices into account, as well as consider the impact of climate mitigation policies because of potentially important implications for core inflation.

Impact on Financial Stability

To the extent that environmental damages and climate-related risks affect the stability of banks, insurance firms and other financial actors, they need to be of concern for central banking. Thus far, only few central banks and financial regulators have been concerned with environmental risk, and even fewer have considered it as part of their systemic risk framework, even though risks arising from climate change can constitute a significant systemic risk for the financial sector and economies at large (Volz 2017). However, a broad consensus is emerging that climate change and related mitigation policies will have substantial repercussions on the functioning of economies, and hence financial systems (Bank of England 2015; Carney 2015).

Three different types of risk through which climate change may affect financial systems have been identified: transitional risk, physical risk, and liability risk (Carney 2015). Transitional risk describes the uncertainty associated with policy,

price, and valuation changes that may occur in the process of mitigating climate change and reducing carbon emissions. International goals, such as limiting global warming to two degrees, will require powerful policy initiatives, such as the introduction of carbon taxes or extensive environmental regulation, which will affect the valuation of carbon-intensive businesses and may render assets of coal, gas and oil companies less valuable, with potential systemic repercussions in case these policy changes have not been priced in. Volz (2017) also discusses the development of new technologies in the process of climate change mitigation that may render existing technologies redundant, and the associated revaluation of assets, as a potential source of financial instability, which, if not occurring in a gradual manner, may have systemic implications.

Physical risk describes the risk of natural hazards, such as floods and storms, which may cause direct damages to an economy, as well as indirectly through the disruption of global supply changes. Climate-related damages and risks are understood to be potentially significant and to not only cause disruptions for individual firms or sectors, but to have systemic repercussions for the economy and, therefore, financial stability. Increasing levels of physical risk can be expected to have particularly large repercussions for the insurance sector. As recognized by the Bank of England (2015), climate change-induced and other vital environmental changes therefore have clear implications for central banks because they may negatively affect the stability of financial institutions and systems. Pricing in physical risks is an essential step in avoiding these negative repercussions for the economy, and seems especially crucial for the valuation of long-term investments.

Thirdly, liability risk describes climate or environmental risks that occur from uncertainty surrounding potential financial losses and compensation claims stemming from damages caused by climate change-related natural hazards (Bank of England 2015; Carney 2015). Agents may seek compensation for financial damages from carbon extractors or emitters and environmental polluters, creating repercussions for the insurance sector, and hence for central banks that provide third-party liability insurance (Bank of England 2015).

Overall, a consensus has been emerging in the central banking community that climate change-related natural disasters can create and intensify risks to the stability of the financial system, and that potential disruptions from climate change ought to be analyzed and taken into account by central banks, especially if central banks are responsible for safeguarding financial stability (Bank of England 2015; Carney 2015).

Sustainable Development as a Goal of Central Banking

The second dimension of green central banking—i.e., an active contribution to a greening of the financial system and the economy as a whole by central banks—has been more contentious. As will be discussed in the next section, central banks have numerous powerful tools at their disposal to affect credit allocation and the investment behavior of financial firms. Whether and to what extent a central bank should

use its powers and actively engage in "greening" the financial system and the economy depends on two factors: its legal mandate, and the extent to which it is best placed to correct certain types of market failures, taking into account the ability and suitability of other policy institutions to steer the green transformation (Volz 2017).

Mandated Responsibility

For central banks to assume an active "greening" role requires an explicit legal mandate to pursue environmental and sustainability objectives, given the potentially distributive consequences. In most of today's advanced economies, central banks have a relatively narrow mandate with a primary objective of pursuing price stability and, in some cases, financial stability. As discussed, such narrow mandates arguably require central banks to explore climate and environmental risks with regard to these core goals, but they do not mandate them to go further and to actively promote sustainability and green finance. In many developing and emerging economies, central bank mandates are more comprehensive and include sustainability, as well as social and economic objectives. This is reflected by the fact that central banks in many developing and emerging economies have been comparatively more active in promoting green finance and sustainable development, as will be discussed below. Dikau and Ryan-Collins (2017) take a closer look at the legal mandates and objectives of those central banks in emerging economies that most actively pursue green central banking policies. The legal mandate of Bangladesh Bank, the central bank of Bangladesh, for example, includes supporting economic growth and development as a secondary objective, based on which Bangladesh Bank has stated that it understands the greening of the financial system and the economy to be within its responsibility (Bangladesh Bank 2011). Furthermore, Banco Central do Brasil, the central bank of Brazil, which serves as financial regulator and supervisor, is tasked with promoting balanced development and to serve the collective interest, implying a sustainability objective for the central bank (Brasil 1988). While the mandate of the People's Bank of China includes the primary objective of maintaining price stability and thereby promoting economic growth, it also requires the central bank to implement the orders of the State Council, potentially involving the central bank in far-reaching policy initiatives, such as the promotion of green finance and sustainability (People's Republic of China 2003).

Nonetheless, there are also risks involved with overstretching the mandates of central banks to include sustainability objectives. Volz (2017) highlights problems associated with potentially conflicting objectives of central banks, and dangers regarding the accountability of central banks. He also points to the prevailing central banking paradigm as limiting the extent to which mandates can or should be extended, and existing ones may be interpreted, to include green sustainability objectives.

The Market Failure Argument

Achieving the global climate targets will not only require the financial sector to play a central role in financing sustainable and green investment, but also in restricting funding for environmentally harmful activities. In the absence of public intervention,

banks and other financial institutions may allocate their resources to environmentally and socially undesirable activities, such as carbon-intensive or polluting ventures, in order to maximize their private returns. This discrepancy between environmental and social returns, and private returns represents a market failure or imperfection that may call for efficiency-enhancing government intervention. That free markets do not necessarily yield Pareto-efficient allocations has been investigated by Greenwald and Stiglitz (1986), based on the understanding that if information is incomplete or asymmetric, or when markets are incomplete, outcomes may not be efficient and can be improved through the intervention of the government. With regard to the allocation of credit, Stiglitz (1994) discusses an efficiency-enhancing role of credit policies based on the assumption that the private returns of commercial bank lending are not necessarily congruent with social returns. He argues that in order to overcome these discrepancies between private and social returns, directed credit, restricted lending to some activities, and promoting investment in others may be justified. With regard to sustainable growth and green finance, externalities that cause an environmentally suboptimal allocation of credit by commercial banks and other market participants may call for a more active, market-correcting role of central banks.

Nonetheless, intervention by the central bank conceptually constitutes a second-best solution to the problem of market imperfection. The preferable first-best solution would be the removal of the market failure. For instance, a carbon pricing mechanism internalizing the social costs of carbon emissions would constitute a preferred, first-best, market failure-correcting policy that may prevent or disincentivize environmentally undesirable investment; the problem, however, is that such first-best policies may not always be politically feasible, or may take a long time to establish (Volz 2017). In the case where the optimality conditions of fixing market failure cannot be satisfied, the intervention of the central bank through environmental financial regulation or the interference into the allocation of resources can be interpreted as a second-best solution based on the theory of the second-best by Lipsey and Lancaster (1956) (Volz 2017). In practice, second-best policies could be implemented by mandating central banks to address such externalities by affecting the creation and allocation of credit.

Central banks and other financial regulatory authorities can influence investment decisions and the allocation of resources and credit through a number of different policy implementation instruments, which are discussed in greater detail below. Their regulatory oversight over money, credit, and the financial system puts central banks in a uniquely powerful position that enables them to incentivize or direct resources away from carbon-intensive sectors toward green investment. Especially in developing countries, central banks typically have a strong institutional standing that enables them to shape policy outcomes in ways that other public institutions such as environmental ministries are unlikely to achieve. However, given their power, the points made about central banks' mandate and accountability discussed above are very important.

Historically, credit allocation policies and various other instruments of financial repression have been widely used and have led in many cases to substantial

distortions of financial systems, with often unwanted repercussions for savings and prices; in many cases, the consequence was the underdevelopment of financial markets. While the historic success or failure of credit allocation and financial repression policies is subject to ongoing debate, such instruments stand in strong contrast to the widely accepted notion of the neutrality of monetary policy, and central banks in general, toward different investment classes, sectors, or types of firms. Allocating financial resources toward or away from certain sectors and companies implies favoring certain segments of the economy over others and appears to be incompatible with the modern understanding of central bank independence. Nonetheless, many central banks in emerging and developing economies have resorted to these policies as viable, second-best solutions to promote sustainable development and green investment. The notion of the neutrality of monetary policy has come under intense scrutiny more recently, not least in the context of discussions about the distributional consequences of the negative interest and quantitative easing policies adopted by major central banks.

Another kind of market failure involves missing or incomplete financial markets that impede the trading of different forms of credit, assets, or risks (Volz 2017). While central banks most certainly have a role to play in financial market development and in establishing primary and secondary markets for securities, as well as money and exchange market segments where none exist (Gray and Talbot 2007), they may also be in a position to aid development of new green markets by, for instance, creating a regulatory environment that promotes green bonds issuances and trading in secondary markets.

Tools and Instruments of Central Banks to Address Environmental Risk and Promote Green Finance and Investment

Central banks and financial regulatory agencies can employ numerous policy instruments to achieve sustainability targets (Volz 2017). This section distinguishes five different policy areas, including micro-prudential regulation, macro-prudential regulation, financial market development, credit allocation, and central bank soft power and guidelines. For each of the five policy areas, a number of different policy implementation tools and instruments are discussed and then illustrated through examples of central banks that have employed the discussed tools. It is apparent that especially central banks in developing and emerging economies, and in Asia in particular, have been at the forefront of using a broad range of instruments to address environmental risk and encourage green investment (Volz 2016, 2018; Dikau and Ryan-Collins 2017). Central banks in advanced economies have only recently begun to address the implications of climate change for monetary and financial stability, with a leading role by the Bank of England, which has played a central role in raising awareness of the implications of climate change risks amongst central banks (Bank of England 2015; Carney 2015). A more comprehensive overview of the steps central banks around the world have taken to align the financial system with sustainability targets is provided in Appendix 1.

Green Micro-Prudential Regulation

Many instruments of financial regulation can be calibrated to encourage or require financial institutions to consider climate and environmental risks in their operations with regard to the loan origination process or financial stability concerns. Central banks and other financial regulatory authorities can require banks and other financial institutions to adopt Environmental & Social (E&S) risk management standards, to assess and disclose climate-related risks, or to adjust reserve holdings.

Disclosure Requirements

Effective disclosure requirements for banks and other financial institutions of climate change-related risks can play a central role in ensuring that the impact of climate change, climate policies, and natural hazards are correctly priced in by financial institutions. The Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) discusses disclosure requirements as a central element of forming a response to climate and environmental risk based on the understanding that a lack of information of risk exposure of financial institutions entails consequences for financial stability, because the misallocation or mispricing of assets may cause abrupt price corrections in financial markets at a later stage (TCFD 2016). Mandatory disclosure requirements for all financial institutions could be a regulatory instrument to achieve this goal. Furthermore, Volz (2017) points out that improving transparency with regard to climate-related risks and the appropriate pricing of these risks are pre-conditional for green macro-prudential regulation, which is discussed below.

E&S Risk Management Standards

Similar to disclosure requirements, financial regulation that endorses mandatory E&S risk management standards requires financial institutions to incorporate E&S risk factors into their governance frameworks. With the aim of enforcing climate-related risk management beyond disclosure, green E&S risk management standards may also establish environmental and social rules for banks' lending practices by requiring the assessment of these risks, as well as taking potentially harmful environmental effects of new financial services and products into account. Furthermore, mandatory green risk management standards could oblige banks to include an assessment of E&S risks in the loan origination process as a criterion based on which loans are extended. This is likely to also have allocative consequences by reducing the flow of finance to polluting and energy intensive firms and enhancing the financing of greener projects.

Reserve Requirements

Reserve requirements determine the minimum amount of reserves that must be held by commercial banks. They could be calibrated to create incentives, leading to the promotion of green assets, or to make brown lending less attractive. Differential reserve requirements that are linked to the compositions of banks' portfolio allowing lower (higher) required reserve rates for portfolios skewed towards greener, less

carbon-intensive assets (brown, carbon-intensive assets) can potentially influence the allocation of credit and promote green investments. Another approach discussed in the literature is the acceptance of carbon certificates as part of commercial banks' legal reserves in order to enhance the market for carbon certificates, and by distributing carbon certificates that are exchangeable for loan concessions to low-carbon projects, creating an incentive to further enhance green investment (Rozenberg et al. 2013).

Green Financial Regulation in Practice

Green financial regulatory measures have been employed in a number of countries thus far, including Bangladesh, Brazil and the People's Republic of China (PRC). In the PRC, first environmental regulatory policies by the People's Bank of China (PBC) date back to the 1980s (Zadek and Chenghui 2014). The Green Credit Policy that was launched jointly by the PBC, the Ministry of Environmental Protection, and the China Banking Regulatory Commission in 2007 has been one of the most comprehensive regulatory green policies to date, addressing the banking system, insurances, and securities markets. Furthermore, in 2006 the PBC created a database for credit consisting of information on credit, fines, and environmental compliance of firms as a source of information on which to base restrictions of credit to blacklisted companies and sectors.

Differential reserve requirements have been employed by Banque du Liban, the central bank of Lebanon, with the goal of influencing the allocation of credit in favor of investment in renewable energy and energy efficiency. Commercial banks are incentivized to increase the share of green lending projects of their loan portfolio by allowing "greener" banks to hold lower reserves (Banque du Liban 2010). Commercial banks that extend loans to finance projects that entail energy savings potential are subject to lower reserve requirements. In practice, the Lebanese Centre for Energy Conservation, a governmental agency, verifies whether the underlying investments would contribute to greening the energy sector and declares the bank loans that finance them eligible for receiving the preferential reserve requirement treatment.

Green Macro-Prudential Regulation

Macro-prudential regulation aims to mitigate systemic risk that threatens the stability of the financial system as a whole. It is applied to close the gap between macroeconomic policy and micro-prudential regulation and can play a central role in incorporating climate and environmental risks into regulatory frameworks. The application of many macro-prudential policy tools to identify and mitigate environmental risks may also have allocative consequences for credit (Schoenmaker and Tilburg 2016).

Climate-Related Stress Testing

Climate-related stress tests can fulfill the task of assessing the potential impact that natural hazards may have on the economy, the health of individual financial

institutions, and the financial system as a whole. Apart from enabling the evaluation of the resilience of the financial system to adverse shocks, climate-related stress tests would also be necessary to calibrate green macro-prudential policy instruments and to allow for the incorporation of the identified vulnerabilities into capital buffers, risk weights, and caps.

Counter-Cyclical Capital Buffers

Counter-cyclical capital buffers are employed to mitigate the financial cycle, and can be calibrated with regard to environmental risks to ease the potential effect of the pricing-in of a so-called "carbon bubble" that describes the expected sudden re-pricing of carbon-intensive assets due to stricter emission targets and environmental policy. In practice, higher capital-requirements for carbon-intensive credit growth could be applied (Schoenmaker and Tilburg 2016).

Differentiated Capital Requirements

Through capital requirements, financial regulators require financial institutions to hold a certain percentage of capital for risk-weighted assets, which is usually expressed in the Capital to Risk (Weighted) Assets Ratio. Capital requirements could theoretically differentiate asset classes based on sustainability criteria and assign higher risk weights to carbon-intensive assets, in anticipation of future negative and sudden price developments. Schoenmaker and Tilburg (2016) stress differential capital requirements as a central policy tool enabling the correct pricing of carbon risks. Furthermore, this instrument may also have important allocative consequences for credit by incentivizing the disinvestment from carbon-intensive assets and dependent sectors.

Loan-to-Value and Loan-to-Income Caps

Limiting the extension of credit by banks to certain industries and the investment in specified asset classes can also be used as an allocative tool to limit the flow of resources to sectors or companies that exceed specified carbon-emission targets.

Large Exposure Restrictions

Exposure restrictions by counter-party, sector, or geographic area is a macro-prudential policy tool employed to limit the exposure of financial institutions to assets entailing high risks or, with regard to green finance, a high-carbon intensity. While the primary aim might therefore be to protect financial institutions against a carbon bubble, Schoenmaker and Tilburg (2016) argue that this instrument could also be employed for the fine-tuning of lending restrictions and the allocation of credit.

Identification of Systemically Important Financial Institutions and Capital Surcharges

Applying capital surcharges for institutions with high large exposure to carbon-intensive assets could alter the identification of Systemically Important Financial Institutions (SIFIs) and ensure that climate-risks are appropriately accounted for in order to reduce systemic risk.

Green Macro-Prudential Regulation in Practice

The Banco Central do Brasil has been among the first central banks to address climate-related environmental, as well as social, risks on a systemic level, through the issuance of binding amendments to its macro-prudential regulatory framework. In 2011, the Banco Central do Brasil extended its requirements on the Internal Process of Capital Adequacy Assessment, which originates from Pillar 2 of the Basel II accords and requires commercial banks to take the exposure to environmental damages and risks into account (Banco Central do Brasil 2011). These capital requirements aimed at pricing-in environmental risks are part of the Banco Central do Brasil's broader green banking regulatory approach, through which it requires banks to evaluate and consider E&S in their lending practices, to stress-test against the exposure to environmental risks, and to furthermore issue annual reports outlining their risk assessment methods and exposure to social and environmental damages (Banco Central do Brasil 2017).

Green Financial Market Development

The development of green security markets and green lending is another area in which central banks could play an assisting role. In many of today's advanced economies, the evolution of financial markets precedes the establishment of central banks. However, central banks in developing countries can play a central role in supporting the development of financial markets, and encourage active trading in bond markets to encourage other actors to participate (Gray and Talbot 2007). With regard to green bonds, policy-directed development banks such as the European Investment Bank of Germany's KfW have so far played this market-developing role in many countries by issuing the first green bonds, thereby aiding the creation of green bond markets. Central banks and other financial agencies can create an enabling environment for the issuance and trading of such green securities.

Information Disclosure Requirements

Through the introduction of effective procedures for the disclosure of environmental and sustainability-related information on bonds and other assets, central banks and regulatory agencies can strengthen the identification and acceptance of green assets.

Green Bond Guidelines

In order to encourage the issuance of green bonds, central banks can issue green bond guidelines and define criteria according to which the financing of projects and firms qualifies as green bonds, what the use of the proceeds from the bond issuance can be, and disclosure standards. Establishing and enforcing criteria for green bond labels can be a further step in promoting green bond issuance.

Green Financial Market Development in Practice

A central bank that has played an active role in encouraging the development of green bond markets and innovative market institutions is the PBC. The Green

Finance Task Force, an international cooperative group initiated by the PBC, in cooperation with UNEP Inquiry, with the aim of developing an action plan for the promotion of green finance in PRC, recommended that the PBC, together with China's banking and securities regulatory agencies, should issue industry guidelines for green bonds (PBC and UNEP Inquiry 2015). The PBC issued the first official green bond guidelines in December 2015 to encourage unified standards for the issuance of green bonds (PBC 2016).

Green Credit Allocation

Even though many of the policy instruments discussed above have potentially allocative consequences, there are also dedicated credit allocation instruments. These are not widely in use today by central banks in advanced economies, but remain fairly popular in many developing and emerging economies. For central banks that employ credit allocation policies today with regard to green finance, most notably Bank Bangladesh and the Reserve Bank of India (RBI), green investment has often been added as an additional priority sector to existing and longstanding credit allocation policy schemes that otherwise pursue developmental objectives (Dikau and Ryan-Collins 2017). Fry (1995), who makes a strong case against financial repression and credit allocation policies, lists subsidized loan rates for priority sectors, differential rediscount rates, direct budgetary subsidies, credit floors and ceilings, and the proliferation of development banks as the central allocative policy instruments, many of which can also be applied to promote green investment and sustainable development.

Targeted Refinancing Lines

Green targeted refinancing lines by central banks offer refinancing for commercial banks at preferential terms for specified green asset classes, thereby compensating or overcompensating financial institutions for lending at lower-than-market interest rates to low-carbon or otherwise sustainable projects. However, this policy tool is only relevant in economies with relatively underdeveloped secondary security markets, and hence a lack of market-based refinancing options for banks that necessitates central banks to offer refinancing lines, some of which can be offered at preferred terms.

Minimum and Maximum Credit Quotas

Mandatory or minimum or maximum credit quotas or floors are fixed lending requirements that are set by the central bank and require commercial banks to allocate a percentage of their loan portfolio to specified classes of assets, industries, or geographical areas. Green minimum credit quotas, for example, require banks to at least lend a specified quota to green investments, while maximum credit ceilings could can be utilized to restrict lending to carbon-intensive industries. In contrast to all policy instruments discussed so far, the operating channel of credit quotas is not the creation of incentives for financial institutions to channel their resources to

preferred causes, but a mandatory "hard" quota, which may potentially create severe market distortions.

Preferred Interest Rates for Priority Sectors

Credit interest rate ceilings for priority sectors, asset classes, and firms are the central instruments of financial repression policy. The administrative setting of interest rates by the central bank of commercial banks' lending rate with the aim of promoting green investment and curbing unsustainable lending is another heavy interventionist central banking tool that is not aimed at creating incentives, but targets setting lower rates for preferred sectors, or higher rates for less preferred ones, in order to reduce funding.

Central Bank Assistance to Development Banks

As specialized financial institutions, development banks can play an important assisting role in financing the green transformation by providing long-term investment (Stern 2016; UNEP Inquiry 2016). The failure of private financial institutions to provide the required financial resources for substantial investments into greening the economy has been interpreted as justification for the presence of development banks. The latter may play a risk-reducing and pioneering role by implementing green finance standards or by developing innovative financial products such as green bonds, thereby encouraging private institutions to engage in green lending and long-term finance activities. Historically, central banks have often played a supportive role for development banks by subscribing to the initial equity, or by buying and creating markets for bonds issued by development banks (Brimmer 1971). However, concerns have been raised that refinancing of public development banks by central banks may amount to monetary financing, which may cause inflation and undermine central bank independence.

Green Credit Allocation in Practice

Bangladesh Bank has introduced several policy initiatives to guide credit toward green sectors and to encourage banks to extend loans for renewable energy projects. Among the green credit allocation programs of Bank Bangladesh, targeted refinancing lines have been the most prominent policy tool. They were first utilized in 2009 when Bangladesh Bank established a revolving refinancing scheme, amounting to BDT 2 billion, through which commercial banks were compensated at reduced interest rates for loans extended for sustainable investment projects (Bangladesh Bank 2017). Subsequently, Bangladesh Bank has developed further green refinancing lines, such as in 2015, when it earmarked a USD 200 million refinancing window for refinancing green loans, with the specific aim of supporting investment improving water and energy usage (UNEP Inquiry et al. 2015) and in 2016, through the creation of a Green Transformation Fund, another green refinancing window worth USD 200 million targeting loans financing the import of environmentally friendly machinery in order to improve sustainability in the leather and textiles sector (Bangladesh Bank 2017).

The RBI's Priority Sector Lending (PSL) program, which has its origins in 1949, is another example of a heavily interventionist approach to credit allocation. The PSL forces commercial banks to allocate 40% of adjusted net bank credit or credit equivalent amount of off-balance sheet exposure, whichever is higher, to sectors and causes specified by the central bank—traditionally agriculture, infrastructure, education, and SMEs. Following an internal review by the RBI, the PSL was extended in 2015 to include lending for social infrastructure and renewable energy projects as two new categories qualifying to be listed under commercial banks' PSL requirements.

Other Supportive Green Central Bank Initiatives

Through their central position in the financial system and the powers vested in them, central banks have a great deal of convening or soft power (Volz 2017). By promoting a discussion of climate change-related risks and environmental issues, the central bank can drive the sustainability agenda in the financial sector. The expertise and special status of central banks, as a result of their unique relation to the government and the financial sector, allow central banks to influence the discussion on green finance in informal ways.

Green Finance Guidelines and Frameworks

Central banks are in a good position to create or endorse industry-led, non-mandatory green finance guidelines, which may set out guidelines for the issuance of green bonds, E&S risk management practices, or general criteria for green lending. In many emerging and developing economies where green credit guidelines exist, these tend to be either voluntary industry-led green finance guidelines or, in most cases, central bank-led that often serve as a foundation for the creation of mandatory green credit regulation at a later stage (Dikau and Ryan-Collins 2017).

Soft Power

Central banks can also influence the reception, knowledge, and practice of green finance through their convening role and soft power, by including environmental issues and climate change on their wider agenda and by signaling the importance of these issues to market participants. The generally well-respected research departments of central banks are furthermore uniquely positioned to research topics around green finance and the impact of climate risks on the financial system. The research focus and output of central banks usually have a significant impact on raising awareness of their issues and directing broader macroeconomic research. Another area where central banks can contribute to the knowledge of green finance and threat of environmental risks are capacity-building workshops and seminars for bankers and investors, thereby addressing a potential lack of expertise on green financial issues, which has been identified as holding back the prevalence of E&S risk management practices. Finally, the participation of central banks in international bodies and networks, such as the Financial Stability Board and its TCFD, which

discuss standards and methods of policy engagement, also play an important role in finding internationally coherent approaches to greening the financial system.

Supportive Green Central Bank Initiatives in Practice

The Bank of England's engagement with climate change is exemplar for a central bank's use of soft power to raise awareness of climate and environmental risks for the financial sector. With his much-noticed speech in 2015 on "Breaking the Tragedy of the Horizon—Climate change and financial stability" (Carney 2015), the Governor of the Bank of England brought global attention to the potential systemic ramifications of climate change-related risks for the financial system, and especially the insurance sector, thereby also motivating further research at the Bank of England's research department on climate change and green finance (Bank of England 2015; Batten et al. 2016), as well as the organization of workshops and conferences on the issue. The Bank of England also engages with a number of international initiatives, including the TCFD, as well as taking part in the Sustainable Investment Forum, and by co-chairing the G20 Green Finance Study Group (which was recently renamed G20 Sustainable Finance Study Group), which was established together with the PBC during PRC's G20 presidency.

Non-mandatory green finance guidelines, principles, or roadmaps that focus on sustainable banking have so far been issued by 17 members of the International Finance Corporation (IFC)'s Sustainable Banking Network, a knowledge-sharing network for financial regulators and banking associations aimed at enhancing E&S risk management practices and green lending of financial institutions (the 17 members include financial authorities and banking associations from Bangladesh, Brazil, Cambodia, the PRC, Colombia, Ecuador, Indonesia, Kenya, Mexico, Mongolia, Morocco, Nigeria, Pakistan, Peru, South Africa, Turkey and Viet Nam). Furthermore, in December 2017, central banks and financial supervisors, among them the Bank of England, the Banque de France, De Nederlandsche Bank, the Deutsche Bundesbank, the European Central Bank the Banco de España, the National Bank of Belgium, the Oesterreichische Nationalbank and the PBC, jointly created the Network for Greening the Financial System as a voluntary information and best practice sharing framework with the aim of mainstreaming green finance and more sustainable growth. This network potentially represents one of the most powerful initiatives to date, bringing the largest and most influential monetary and regulatory institutions together under the declared joint goal of supporting the transition toward more sustainable economies.

Conclusions

Climate and other environmental risks have increasingly become an important topic for central banks and financial regulators. It is now largely accepted that environmental risks can have material impact on financial and macroeconomic stability, and an increasing number of central banks have started to develop micro- and macroprudential frameworks that incorporate risks related to climate change and the

environment. At a recent meeting of financial supervisors, Bank of England Governor Mark Carney highlighted: "Once climate change becomes a clear and present danger to financial stability, it may already be too late [. . .]. Our responsibility is to work in a way that puts the financial system as a whole in a position so it can adjust in a smooth and effective and orderly fashion as climate policies adapt" (Hook 2018). Carney (2018) also reiterated that "[t]he catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors" in the financial sector, and that central banks should therefore use their unique position and oversight over financial markets to point out these risks and make sure that they are sufficiently addressed by financial institutions.

This chapter has also highlighted the potential developmental role of central banks and has reasoned why central banks, especially those in developing economies, may be mandated by governments to use various instruments at their disposal to promote green or discourage brown lending and investment. However, it needs to be emphasized that in many cases, central banks may *not* be the public institutions that will be best positioned to correct market failures that lead to overinvestment in socially undesirable activities. The reader should, therefore, not conclude from this chapter that the authors want central banks to become responsible for fixing all environmental problems. Nevertheless, in cases where first-best policies are impossible to implement, targeted policy interventions by central banks or other financial regulators may indeed need to be considered and introduced.

Appendix 1: Sustainable Finance Policies

	Brazil
2008	Banco Central do Brasil: Starting in 2008, resolutions issued on environmental regulation, restricting lending to firms that operate in vulnerable geographic areas such as the Amazonas region (Resolution 3,545/2008, Resolution 3,813 Resolution 3,896/2010 and Resolution 4,008/2011)
2009	Brazilian Banking Association: Voluntary green finance guidelines adopted by commercial and state-owned banks
2011	Banco Central do Brasil: Resolution 3,988 incorporates risk of exposure to environmental damages into "Internal Process of Capital Adequacy Assessment" (ICAAP) requirements
2014	Banco Central do Brasil: Guidelines on "Social and Environmental Responsibility for Financial Institutions" discusses and defines E&S risk exposure
	Bangladesh
2008	Bangladesh Bank: Circular on "Mainstreaming Corporate Social Responsibility in Banks and Financial Institutions in Bangladesh"
2011	Bangladesh Bank: "Policy Guidelines for Green Banking" and "Guidelines on Environmental Risk Management"
2015	Bangladesh Bank: Mandatory Green Finance Credit Targets l
2016	Bangladesh Bank: "Integrated Risk Management Guidelines for Financial Institutions"
2017	Bangladesh Bank: Guidelines on Environmental & Social Risk Management for Banks and Financial Institutions

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	Canada
2014	Toronto Stock Exchange and CPA Canada: "A Primer for Environmental and Social Disclosure Ontario" Ministry of Finance: Regulation 235/14, amending the Pension Benefits Act and requiring pension plan administrators to disclose whether and if E&S risk factors are incorporated
2017	Green Ontario Fund created as government agency that invests proceeds from Ontario's carbon market into the reduction of greenhouse gas emissions
	People's Republic of China
2007	China Banking Regulatory Commission (CBRC), People's Bank of China (PBOC), and Ministry of Environmental Protection (MEP): Green Credit Policy ("Opinions on Enforcing Policies and Regulations on Environmental Protection to Prevent Credit Risk") MEP and China Insurance Regulatory Commission (CIRC): Green Insurance Policy ("Guiding Opinions on Environmental Pollution Liability Insurance")
2008	China Securities Regulatory Commission (CSRC) and MEP: Green Securities Policy ("Guidance Opinions on Strengthening the Oversight of Public Companies") Shanghai Stock Exchange: Shanghai CSR Notice and Shanghai Environmental Disclosure Guidelines
2009	Shenzhen Stock Exchange: Social Responsibility Instructions to Listed Companies
2012	CBRC: Green Credit Guidelines
2013	MEP and CIRC: "Guiding Opinions on Implementing the Pilot Programs of Compulsory Environmental Pollution Liability"
2014	CBRC: Green Credit Monitoring & Evaluation mechanism and Key Performance Indicators Checklist PBOC: Green Finance Task Force MEP and CIRC: "Guiding Opinions on Pilot Scheme for Compulsory Environmental Pollution Liability Insurance"
2015	PBOC: Green Financial Bond Directive and Green Bond-Endorsed Project Catalogue for Bonds Issued by Financial Institutions and Corporations PBOC: Green Finance Committee
2016	PBOC: Guidelines for Establishing the Green Financial System NDRC and Shanghai Stock Exchange: Green Bond Guidelines China Bond Green and Climate-Aligned Bond Index
2017	State Council: Establishment of five green finance pilot zones in Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang MEP and CSRC: Environmental Disclosure for Listed Companies CSRC: Guidelines for Green Bond Issuance by Listed Companies MEP and CIRC: Draft Guideline on Environmental Pollution Liability Insurance Shanghai's Lujiazui Financial City: Lujiazui Standard of Green Finance
2018	CSRC and MEP: Mandatory ESG disclosures for listed companies and bond issuers by 2020
	Hong Kong, China
2016	Securities and Futures Commission: Principles of Responsible Ownership Financial Services Development Council: Report on "Hong Kong as a Regional Green Finance Hub"
2018	Hong Kong Quality Assurance Agency: Green Finance Certification Scheme

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	France
2001	French National Assembly: Passes the New Economics Regulation law and introduces the reporting requirements on ESG issues as part of a broader framework on "ethical" aspect of financial practices
2010	French National Assembly: Passes the "Grenelle II" law, outlining the national commitment in favour of the environment, as well as environmental reporting requirements for asset managers
2015	French National Assembly: Passes Law on Energy Transition for Green Growth (ETGG), outlining procedures for the assessment of climate-related risks and addressing the role of the financial sector in the green transition
2017	Banque de France: Launches Network for Greening the Financial System (NGFS) for the sharing of experiences of the supervisory dimensions of climate- related and environmental risks and green finance
	India
2007	Corporate Social Responsibility, Sustainable Development and Non-Financial Reporting—Role of Banks
2011	Ministry of Corporate Affairs: National Voluntary Guidelines on Social, Environmental and Economic Responsibilities of Business
2012	Securities and Exchange Board of India (SEBI): Annual Business Responsibility Reporting
2014	SEBI: Infrastructure Investment Trusts (InvIT) Regulations
2015	Reserve Bank of India: Priority Sector Lending—Targets and Classification Indian Banks Association: National Voluntary Guidelines for Responsible Financing
2016	SEBI: Guidelines for the Issuance and Listing of Green Bonds
2017	SEBI: Disclosure Requirements for Issuance and Listing of Green Bonds
	Indonesia
2012	Bank Indonesia: Green Lending Model Guidelines for Mini Hydro Power Plant Projects Government Regulation on Social and Environmental Responsibility of Limited Liability Companies
2014	Otoritas Jasa Keuangan (OJK) / Financial Services Authority: Roadmap for Sustainable Finance in Indonesia 2015–2019
2015	IFC, USAID, OJK: Clean Energy Handbook for Financial Service Institutions
2017	OJK: Framework and regulation for green bond issuance in Indonesia OJK: Regulation on the Application of Sustainable Finance for Financial Services Companies, Issuers and Publicly Listed Companies
	Japan
2012	Ministry of the Environment: Principles for financial action towards a sustainable society
2014	Financial Services Agency: Japan Stewardship Code
2015	Tokyo Stock Exchange: Corporate Governance Code and Infrastructure Fund Market
2017	Ministry of the Environment: Green Bond Guidelines
	Kenya
2015	Kenya Bankers Association (KBA): Sustainable Finance Initiative (SFI) Guiding Principles
2017	KBA, Central Bank of Kenya, Capital Markets Authority and the National Treasury: Green Bond Programme
	Republic of Korea
2008	Government launches Republic of Korea's Green Growth Strategy and provides a strategic policy framework

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2009	Ministry of Strategy and Finance and Financial Services Commission: Announce a certification system to verify green projects and companies' eligibility for funds under government's plans to promote investment into green industries
2013	Export-Import Bank of Korea: First financial institution in Asia to issue green bonds
2017	Korea Development Bank: Issuance of green bonds worth 300 million USD, using proceeds to finance or refinance investments in renewable energy projects, low carbon emission technology and green transportation
	Mongolia
2014	Bank of Mongolia & Mongolia Banking Association: Mongolia Sustainable Finance Principles and Sector Guidelines
	Netherlands
2014	De Nederlandsche Bank: Central Bank mandate updated to include "sustainable prosperity" and "financial stability," as well as equipping the DNB with new macroprudential instruments and tools to fullfil the task
2017	Dutch Pensions Federation: Declaration to create an environmental, social and governance (ESG) covenant for pension funds
	De Nederlandsche Bank: Organises workshop on "Central Banking and Green Finance"
2018	De Nederlandsche Bank: Organises International Climate Risk Conference for Supervisors
	Philippines
2008	Government of Philippines: National Disaster Risk Reduction and Management Law
2011	Securities and Exchange Commission: Corporate Governance Guidelines for Companies Corporate Responsibility Act updated
2015	Government of Philippines: Joint Catastrophe Risk Insurance Facility for Governments (Local Government Units Pool)
	Singapore
2010	Singapore Stock Exchange (SGX): "Guide to Sustainability Reporting for Listed Companies"
2015	Association of Banks in Singapore: Guidelines on Responsible Financing
2017	Monetary Authority of Singapore: Green Bond Grant Scheme
	South Africa
2011	Institute of Directors in Southern Africa: "Code for Responsible Investing in South Africa (CRISA)"
2015	Banking Association South Africa: Principles for Managing Environmental and Social Risk
2017	Johannesburg Stock Exchange: Green Bond listing requirements and creation of Green Bond Segment
	Thailand
2008	Stock Exchange Thailand and Securities and Exchange Commission of Thailand: Guidelines for Sustainability Reporting
2014	Stock Exchange Thailand: CSR Reporting Requirements Securities and Exchange Commission of Thailand: Sustainability Development Roadmap for Listed Companies
	Turkey
2014	Banks Association of Turkey: Sustainability Guidelines for the Banking Sector
2015	Borsa İstanbul: ESG Reporting Guide
	United Kingdom
2012	London Stock Exchange: Mandatory Disclosure of Carbon Emissions for Listed Companies

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2015	Bank of England: Governor Mark Carney highlights the Bank's view on climate change
	Prudential Regulation Authority (PRA): Report on the impact of climate change on the UK insurance sector
2016	Bank of England: Publishes further research on climate change and central banks and organizes workshops and conferences on the subject of climate risks and financial stability; co-chairs the G20 Green Finance Study Group
	Viet Nam
2015	State Bank of Vietnam (SBV): Directive on Promoting Green Credit Growth and Managing Environmental and Social Risks in Credit Extension SBV: Action Plan of Banking Sector to Implement the National Green Growth Strategy until 2020
2016	SBV: Circular on lending transactions of credit institutions and/or foreign bank branches with customers
2017	SBV: Renewed commitment to implementing the Green Growth program and the program of preventing climate change

Source: Compiled by authors, drawing on Volz (2018)

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