

The Role of Green Financial Sector Initiatives in the Low-Carbon Transition

A Theory of Change

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Abstract

Green financial sector initiatives, including financial policies, regulations, and instruments, could play an important role in the low-carbon transition by supporting countries in the implementation of economic policies aimed to decarbonize their economy. Thus, it is fundamental to understand the conditions under which and the extent to which green financial sector initiatives could enable the scaling up of green investments and the achievement of national climate mitigation objectives, while, at the same time, avoiding unintended effects on macroeconomic and financial stability. However, this understanding is currently limited, in particular in the context of emerging markets and developing economies. This paper contributes to filling this knowledge gap by analyzing opportunities and challenges associated with the implementation of green financial sector initiatives. It also considers the specificities of green financial sector initiatives in emerging markets

and developing economies, which are often characterized by budget constraints, debt sustainability concerns, and limited access to finance. The analysis focuses on green macroprudential policies, green monetary policies, and green public co-funding. For each green financial sector initiative, the paper qualitatively investigates the transmission channels through which it affects the availability and cost of capital for high- and low-carbon goods, but also investments, output, and greenhouse gas emissions, considering the design and implementation of the green financial sector initiative. For each green financial sector initiative, the paper further identifies its entry point in the economy and its direct and indirect impacts. Building on these insights, the paper develops a theory of change about the role of green financial sector initiatives in climate mitigation and in the low-carbon transition, identifying the criteria for applicability and conditions to maximize impact.

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The Role of Green Financial Sector Initiatives in the Low-Carbon Transition: A Theory of Change

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1. INTRODUCTION

Deep decarbonization of global economies is needed to achieve the Paris Agreement (PA) climate mitigation ambitions,⁶ and to avoid the harmful consequences of climate change from unabated greenhouse gas (GHG) emissions. Large and widespread socio-economic and financial implications of extreme weather events (IPCC 2021), and of a disorderly low-carbon transition (NGFS 2019, BCSB 2021a), are expected to materialize in the next decades, if climate mitigation is not carried out in a timely fashion.

The financial sector, including private and public financial actors, is expected to play a major role in the low-carbon transition, by scaling up capital directed towards low-carbon activities and by divesting from high-carbon activities (Paris Agreement, Art 2c⁷). However, capital formation is not occurring yet at the pace and amount needed to achieve countries' climate mitigation ambitions, leading to a *green investment gap* (Kreibiehl et al. 2022). Several reasons drive the *green investment gap*.

First, the price of high-carbon goods does not reflect the full impact that they have, via GHG emissions, on the environment and on climate change (i.e., their negative externalities) (Stiglitz 2019, Stern and Stiglitz 2021). This, in turn, limits the incentives for firms to pursue low-carbon investments.

Second, it is still unclear to what extent climate risks are priced by financial markets, as the academic literature on the topic is not conclusive (Monasterolo and de Angelis 2020, Beyene et al. 2021, Bolton and Kazperczyk 2021, Giglio et al. 2021). Recent evidence by the European Central Bank (ECB) for the Euro area indicates that despite increasing awareness, banks have not significantly reduced their exposure to climate-related risks (Emambakhsh et al. 2022).

Third, green projects are characterized by specific time and risk structure. This represents an additional barrier to financing green investment, particularly in emerging markets and developing economies (EMDEs). In EMDEs, low-carbon investments are still less attractive for local and international investors due to pre-existing market conditions. This is despite low-carbon solutions already being competitive in sectors representing around 25% of global emissions and expected to increase to sectors covering 70% of global emissions by 2030 (SystemIQ 2020). Such conditions include the lack of an enabling environment and limited institutional capacity; low business confidence and weak regulatory frameworks (Ragosa and Warren 2019); limited technical capacity, limited policy coherence (given fuel subsidies – see Coady et al. 2017, Parry et al. 2021); lagging

⁶ By ratifying the Paris Agreement, most UN countries agreed to limit global temperature increase to below 2 degrees C with respect to pre-industrial times (UNFCCC 2015). In 2021, at the G20 meeting held in Rome (IT), G20 leaders committed to strengthen the PA temperature targets, limiting global temperature to +1.5 degrees C.

⁷ United Nations Framework Convention on Climate Change (UNFCCC 2015). Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015.

development of capital markets (WBG, 2020; Zheng et al. 2020); and higher debt and equity costs than in the United States or in the European Union (Ameli et al. 2021).

These conditions create adverse incentives, both for firms to invest in low-carbon projects, and for investors to finance such projects. Specifically, firms have low incentives to design and implement low-carbon projects as high-carbon alternatives are still considered as less risky and more economically viable in EMDEs.

In order to foster green investments and create market signals, the need for the introduction of climate policies has been recognized by most scholars and practitioners. There is mounting consensus on the importance to introduce a carbon price and/or a carbon tax on CO₂ emissions (and GHG more in general) to try and internalize the negative externalities of global warming driven in particular by burning fossil fuels (Stiglitz et al. 2017). Such policies would put a price on the adverse socio-economic and environmental impacts of emissions, which are currently not accounted neither in firms' production cost, nor in consumers' prices. However, it has been also recognized that there are political economy issues that limit the feasibility of relying on carbon pricing alone to signal the market and decarbonize the economies. On the one hand, a view is emerging among scholars and practitioners that climate mitigation objectives may require a broader package of climate policies combining carbon pricing with public investments in low-carbon technologies, welfare policies to support firms and labor in switching to low-carbon activities and jobs (Stiglitz 2019; Meckling and Allan 2020; Bergquist 2020). On the other hand, coordination between economic and climate policy, and with financial policies (e.g. monetary) has also been discussed (Monasterolo and Volz 2020).

Nevertheless, the introduction of climate policies is still delayed in many countries. Furthermore, in countries where carbon pricing has already been introduced, the value ranges considerably from less than 1 USD in Poland up to 137 USD/ton of CO₂ in Sweden in 2020 (WB 2021). In contrast, the World Bank's 2017 High-Level Commission recommended a 2020 carbon price corridor of 40 to 80 USD/ton of CO₂, rising to 50 to 100 USD/ton of CO₂ by 2030.

In several EMDEs, fossil fuel extraction, combustion, and trade represent an important component of the economy in terms of employment, GDP, and fiscal revenues (Solano-Rodríguez et al. 2021). Depending on how it is implemented (in terms of timing, magnitude, and presence of accompanying measures), carbon pricing could imply potentially negative short-term effects on GDP growth, fiscal budget, and socio-economic conditions (Rozenberg et al. 2020). Thus, in EMDEs, putting a price on carbon may be challenging from both a political economy and from an economic policy point of view, despite some recent evidence showing considerable co-benefits for the economies and people (Heine and Black 2019).

Climate policy uncertainty has been identified as a barrier for private investments into climate aligned activities (Kreibiehl et al. 2022). Indeed, uncertainty prevents investors from embedding climate change considerations in their risk assessment and management tools, and thus in their

investment decisions (Dunz et al. 2021a). In particular, the credibility of climate policies is crucial for financial institutions to determine climate-related costs and benefits of investments and thus to embed decarbonization scenarios in their risk management tools (Battiston et al. 2021). In turn, this is key to foster the low-carbon transition and mitigate the risk of carbon stranded assets in the financial sector and the economy (Battiston et al. 2017).

Therefore, an adequate climate risk assessment emerges as a key factor for the financial sector to mobilize the required capital in the relatively short time frame available. Poor climate-financial risk assessment gives rise to information asymmetries about firms' development prospects, and limits investment opportunities of low-carbon projects. It is well-established in economic theory that lenders, who are less informed than borrowers about the risk characteristics of the borrower's investment projects, may respond by rationing credit (Greenwald and Stiglitz 1990). In contrast, if investors would properly assess climate-related financial risks for firms,⁸ they would revise the cost of capital for high carbon investments, thereby making low-carbon investments more attractive.

Since the Paris Agreement, central banks and financial regulators have played a relevant role in promoting climate financial risk disclosure and climate-financial risk assessment. Over 100 financial supervisors, including central banks and financial regulators, have joined the Network of Central Banks and Supervisors for Greening the Financial System (NGFS). The NGFS recognizes that climate change represents a new type of risk for finance (NGFS 2019) and recommends investors disclose and assess climate risks, including through climate stress tests. To this aim, the NGFS co-developed climate mitigation scenarios, in collaboration with the process-based Integrated Assessment Models (IAM) community (NGFS 2020, Bertram et al. 2021). Several central banks have already applied the NGFS scenarios in their climate stress tests. Others recommended investors to disclose climate risks on their balance sheets. Nevertheless, despite taking initial steps to consider climate risk, financial institutions in the euro area, are still far from meeting the European Central Bank's (ECB's) expectations (ECB 2021, Arnold 2022).⁹

Green financial sector initiatives (GFSI) could contribute to addressing the market failures related to climate change¹⁰ by signaling to the market and by aligning incentives. By adjusting the availability and the price of capital for low- and high-carbon activities, GFSI could foster the demand for green investments in low-income countries (UNEP 2016), with implications on sectors' performance, investments, output, and eventually on GHG emissions. Depending on their design and implementation, GFSI could support the introduction of fiscal policies for an orderly low-carbon transition, taming the potential negative effects of carbon pricing on macroeconomic and financial stability.

⁸ Depending on their exposure to climate transition risk, see e.g., Battiston et al. (2017).

⁹ The ECB recently assessed the climate-related and environmental risk management approaches of 112 European commercial banks.

¹⁰ Climate change has been defined by N. Stern as the greatest market failure in the Stern Review (Stern 2008).

The most debated GFSI include central banks and financial regulators' intervention, e.g., via a greening of asset purchases and macroprudential regulations (Dikau and Volz 2021). In this regard, the European Commission (EC) has proposed the revision of the micro-prudential banking framework, i.e., the introduction of a Green Supporting Factor (GSF) aimed to lower capital requirements for banks' lending to green investments (Dombrovskis 2018). This proposal attracted criticism for its potential implications on financial stability. A growing consensus in favor of a "dirty" penalizing factor emerged (Thoma and Hilke 2018, Dafermos et al. 2021, Dunz et al. 2021a).

Other GFSI involve the greening of monetary policy (Campiglio et al. 2018, D'Orazio and Popoyan 2019, Schoenmaker 2021), e.g., via the preferential purchase of green bonds (Oustry et al. 2020), or by factoring in climate transition risk (Bressan et al. 2021). Other GFSI focus more on greening financial institutions' lending portfolios by granting green portfolio rewards (TCAF 2021), capitalizing green national development banks (Griffith-Jones and Gallagher 2021), or exploiting synergies between central banks and state-investment banks, e.g., in the European Union (EU) in the case of the ECB and the European Investment Bank (EIB) (Monasterolo and Volz 2020).

While GFSI have been discussed and designed for high-income countries (e.g., in the EU and in the UK), in EMDEs the discussion about GFSI is still at an early stage. In EMDEs, the design and implementation of GFSI would require tailoring to account for market and governance characteristics and supply and demand side channels to avoid unintended effects on socio-economic development and inequality.

Since EMDEs are among the most vulnerable to climate change, an analysis of the potential role and conditions for GFSI implementation is urgently needed. The recent IPCC AR6¹¹ pointed out that the time window left for policy makers to implement the low-carbon transition is narrowing fast. Thus, understanding the conditions under which specific GFSI could enable the scaling up of green investments and achieve national mitigation objectives, while preventing unintended effects on macroeconomic and financial stability, is crucial for EMDEs that face fiscal budget constraints, debt sustainability concerns, and poverty reduction challenges.

This paper contributes to addressing these knowledge gaps, focusing on the impact of GFSI in EMDEs on climate mitigation and on economic decarbonization. It does so by answering two research questions:

1. *Through which channels could individual GFSI affect the decarbonization of the economy?*
2. *Under which conditions (e.g., design, implementation) could specific GFSI lead to an adjustment of financial risk parameters, and drive CO2 emissions reduction in the economy?*

To this end, we identify and discuss a set of GFSI that could be implemented in EMDEs, focusing on green regulatory policies, green monetary policies, and green public co-funding. We then outline

¹¹ See <https://www.ipcc.ch/report/ar6/wg3/>

EMDE-specific conditions and barriers in the financial sector for the low-carbon transition. Then, we investigate the transmission channels through which it propagates into the economy and in the financial sector. For each GFSI, we first identify its entry point (at the level of variables) in the economy and its direct impact. More precisely, we analyze the direct impacts of GFSI on *the cost of capital* for high- and low-carbon activities and *on the quantity of capital* supplied to high- and low-carbon activities. Then, we consider second-order impacts, notably on the *demand* for and the *quantity* of investments in high- and low-carbon activities, and on *relative prices* for high- and low-carbon activities. Furthermore, we track the propagation of these effects through the real economy and their potential impact on GHG emissions reduction and economic decarbonization.

Building on this evidence, we develop a Theory of Change about the role of GFSI in climate mitigation and economic decarbonization. The Theory of Change plays a main role because it allows for the operationalization of the GFSI, conditioned to the specific green finance policy and instrument transmission channels; the country's initial conditions; economic and financial characteristics; mitigation objectives; and governance. One important remark concerns the policy complementarity of GFSI. The adjustments in cost and availability of capital entailed by GFSI can support and complement climate economic policy packages that make these adjustments persistent. For instance, a country's credible commitment on a NetZero path, by means of phasing out of fossil subsidies and the introduction of fiscal and welfare measures to support firms and workers in affected sectors, implies that higher interest rates, cost of capital and risk scores for high- carbon firms make economic sense and are in line with financial valuation.

The paper is organized as follows. Section 2 provides a literature review of the main GFSI discussed and/or implemented, in light of recent research. Section 3 focuses on the conditions of financial markets in EMDEs and persisting barriers for GFSI implementation. Section 4 discusses the transmission channels through which specific GFSI impact the real economy, the balance sheet of financial institutions, and GHG emissions reduction, covering green macroprudential regulations, green monetary policies and green public co-funding. Section 5 presents the Theory of Change for the operationalization of GFSI to achieve the national climate mitigation targets. Section 6 concludes with recommendations for green finance policy and research.

2. GREEN FINANCE SECTOR INITIATIVES: A REVIEW OF THE STATE OF THE ART

The 2015 Paris Agreement pointed out the relevance of private investments in financing the transition to a low-carbon economy (UNFCCC 2015). Since then, the conditions for scaling up green investments have started to be analyzed, also focusing on the role of climate-aligned policies and financial regulations (UNEP-FI 2018). More recently, at the COP26 conference held in Glasgow in November 2021, every Party – representing almost 200 countries – agreed to the Glasgow Climate Pact. This global agreement aims to accelerate action on climate within this decade and completes

the Paris Rulebook. As part of this rulebook, advanced economies have made progress towards delivering the \$100 billion climate finance goal and are expected to reach it by 2023 at the latest.¹²

In addition, in the wake of COP26, two-thirds of the NGFS members published individual pledges and long-term strategies.¹³ These efforts aim to foster the integration of climate-related and environmental considerations into monetary policy, financial stability monitoring, and prudential supervision. Almost all pledges and strategies involve actions aimed at strengthening micro-prudential and macro-prudential climate-related supervision, by using scenario analysis and climate stress tests (see NGFS 2020 and methodological references in Battiston et al. 2017, Reinders et al., 2021), and by issuing supervisory regulation or guidance.¹⁴ There is a general agreement on the importance of embedding climate-related financial risks in financial risk management (BCBS 2021a).

However, the debate remains about the role of GFSI in climate mitigation and, in particular, about which GFSI would be best suited for delivering emission reductions, considering the opportunities and barriers in their application by type of country and instrument.

In this section, we offer a literature review of GFSI, and discuss their role in fostering economic decarbonization in the low-carbon transition, and in enhancing financial stability.

2.1. Green regulatory policies

Green regulatory policies (GRP) include policies that use macro-prudential regulation to induce a shift towards low-carbon sectors and technologies in the composition of financial institutions' lending and investment portfolios. In the following section, we focus on *policies that affect capital requirements* through changes in the weighting factor used for the computation of risk-weighted assets, as a function of the technological and sectoral characteristics of these assets.

The use of GRP can play an important role in fostering green investment and promoting the low-carbon transition via signaling. However, growing concern emerged that prudential policies introduced in the aftermath of the last financial crisis (i.e., within the Basel III regulatory framework) could negatively affect green investments by setting liquidity requirements that favor short-term investments. This, in turn, could impair banks' financing of green projects, which are characterized by more long-term horizons and are thus currently perceived as riskier (D'Orazio and Popoyan 2019). The current Basel III framework has been criticized for not considering climate change, including only a narrow definition of climate-related financial risks. At the same time, regulatory

¹² See <https://ukcop26.org/cop26-goals/>

¹³ The NGFS currently consists of 87 members and 13 observers among financial institutions. See the list of pledges at https://www.ngfs.net/sites/default/files/ngfs_contribution_to_cop26_contributing_members.pdf

¹⁴ See https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp211103_1~981d1ed885.it.html

capital and liquidity regulations do not explicitly account for the risks stemming from climate change (BCBS 2016).¹⁵

Insufficient supervisory guidance may have negative implications for assessing and managing financial risks, due to the large exposure of investors to high-carbon activities (e.g., fossil fuels, energy-intensive activities). These activities could become carbon stranded assets (Leaton 2011, McGlade and Ekins 2015, van der Ploeg and Rezai 2020, Cahen-Fourot et al. 2021, Welsby et al. 2021) in a disorderly transition to a low-carbon economy, with implications for financial stability, both at the level of individual financial institutions and of the financial system (Battiston et al. 2017). A potential disorderly transition poses serious challenges to price and financial stability (NGFS 2020, BCBS 2021b, ESRB-ECB 2021) and thus matters for central banks and financial regulators with a financial stability mandate (Dikau and Volz 2021). Financial stability gained primary importance for financial supervisors in the last decade, becoming a key objective of monetary and macro-prudential policies (Guerini et al. 2018).

In recent years, several macro- and micro-prudential policies have been discussed with the aim to address climate-related financial risks, including capital, liquidity, and reserve requirements, caps on loan-to-value ratios, and minimum credit floors and maximum credit ceilings, also targeted at specific sectors.¹⁶ Here we focus on the Green Supporting Factor (GSF) and on the ‘Dirty Penalizing Factor’ (DPF), considering their effects on *capital requirements* through changes in the weighting factor used for the computation of risk-weighted assets, as a function of the technological and sectoral characteristics of the assets.

2.1.1. Green Supporting Factor (GSF)

The GSF mechanism affects banks’ ability to grant credit to firms via adjustments in the minimum Capital Adequacy Ratio (CAR)¹⁷ contingent on a bank’s carbon or climate risk profile. The GSF allows banks to commit less capital for loans to “green” activities, which should contribute to accelerating the transition to a sustainable, net-zero economy. In particular, in combination with minimum capital requirements,¹⁸ within a GSF framework, banks are expected to assign lower risk-weights to green projects. Therefore, lending to low-carbon activities, which are currently considered riskier by banks due to limited information about costs and performance, would put less pressure on banks’ balance sheets, thus scaling up financing for low-carbon or green projects.

On the one hand, the GSF can limit the green investment gap by incentivizing banks’ lending to low-carbon activities (Dombrovskis 2018, HLEG 2018). On the other hand, the way the GSF is implemented can undermine its effectiveness and may destabilize the banking sector’s financial

¹⁵ An update of the principles for the effective management and supervision of climate-related financial risks by the BCBS is currently under consultation (BCBS 2021a).

¹⁶ See Campiglio et al. (2018) and D’Orazio and Popoyan (2019) for a review.

¹⁷ The CAR is defined as the ratio between a bank’s capital and the risk-weighted assets.

¹⁸ As under the Basel III regulatory framework.

stability. Indeed, introducing a GSF loosens the regulatory CAR for low-carbon investments (Schoenmaker and van Tilburg 2016). In the absence of a standardized taxonomy of green activities, financial risks associated with green investments can be underestimated.¹⁹

2.1.2. Dirty Penalizing Factor (DPF)

Besides the GSF, a DPF has been discussed as a prudential policy tool to scale up green investments. Differently from the GSF, the DPF requires financial institutions to hold more prudential capital for high-carbon assets, i.e., assets that are exposed to climate transition risk, implying adjustments in their lending portfolio if capital constraints are binding.

While the discussion about the implementation of GSF and DPF is mainly focused on the adaptation of prudential regulatory frameworks, it is crucial to consider their effects on the financial risk assessment of the banking sector, because it affects lending and investment decisions. Banks usually assign a risk profile to firms based on those firms' past performance, on internal models, and economic outlooks. They then set the interest rate accordingly, thereby affecting the cost of capital. However, in the case of climate risk, this reliance on past data could be misleading as climate change and a potential low-carbon transition are new phenomena. Climate risks are characterized by deep uncertainty (Weitzman 2009), non-linearity (Ackerman 2017, Steffen et al. 2018), tipping points (Lenton et al. 2019, Heinze et al. 2021), and endogeneity (Battiston 2019, Battiston et al. 2021). Thus, the analysis of climate transition risks requires moving from a backward-looking to a forward-looking perspective (Monasterolo and Battiston 2020). For this reason, it is crucial to consider how banks form expectations about the effects of climate policies and their implementation (e.g., GSF or DPF) on the future profitability of high and low-carbon firms (Dunz et al. 2021a).

2.2. Green Portfolio Rewards (GPR)

GPR introduce financial rewards (or penalties) to financial institutions as a function of the share of lending to low-carbon activities in their portfolio. GPR aim to foster the achievement of a certain green lending target by commercial banks, by paying them a monetary reward, both for the achievement of the target and for the potential overperformance.

However, three potential shortcomings can be identified at the current state of play. First, if the definition of "green" is ambiguous, it would be even harder to detect greenwashing, i.e., the practice of defining "green" investment projects that do not classify as such. In addition, if there is uncertainty about the impact of the greenness on investment decisions, it will be difficult to compare the green investment performance of banks that benefitted from the policy program regarding their "shares of green". Several commercial banks already engage in Sustainability Linked Loans (SLLs) that allow corporate borrowers to benefit from lower loan rates (by an agreed discount)

¹⁹ Considering high-carbon assets as highly risky does not imply automatically that green assets are safer.

if the green target is met. An example is a decrease in corporate carbon footprint, which is self-declared by the same company that would benefit from the rebate in the cost of capital. In addition, while the carbon footprint of a commercial bank's portfolio can be externally certified, the firm-level information on which it builds is not, giving rise to asymmetric information. Second, in the case of pure rewards, there is no penalty associated with banks that miss the green lending target, thus making the compliance fully voluntary. Third, if no conditionality is introduced for the use of the monetary reward, this could also be invested in high-carbon projects, leading to a rebound at the level of GHG emissions of the economy that could reduce the effectiveness of the policy itself. As such, the implications of GPR on macroeconomic performance and emissions reduction are still to be analyzed.

2.3. Green monetary policies (GMP)

Before the last Great Financial Crisis (GFC) in 2008, central banks' monetary policy was based on the adjustment of the reference interest rate in order to achieve the policy objectives. For most central banks, those objectives include price and financial stability. However, in the liquidity-trap phase that followed the GFC, interest rate adjustment policies proved to be ineffective, and the zero-lower bound (ZLB) became binding. For monetary economists, the GFC represented the period when the common wisdom of monetary policy faced its greatest limitations (King 2014, Turner 2015). Central banks around the world reacted to the GFC by introducing sets of unconventional monetary policy measures. The most debated ones include (Guerini et al. 2018):

- *Balance sheet policies*, focused on using the central banks' balance sheet to influence financial conditions beyond the short-term rate (e.g., Quantitative Easing (QE)).
- *Forward guidance policies*, which pertain to the management of the expectations of the policy rate over the medium run, with the aim to provide stimulus when interest rates have reached the ZLB.
- *Negative interest rate policies*, aimed at incentivizing lending.

Economists tend to disagree about the macroeconomic and financial impacts of these measures, in particular about the impact of QE. Central bankers' research finds that QE is more effective than what results of academic papers show (Fabo et al. 2021). In particular, central banks report larger effects of QE on output and inflation, and their results are more significant, both statistically and economically, than results provided by academic papers.

There is growing consensus on the fact that the QE can support economic growth and inflation via the following channels²⁰:

- *Demand channel*, through which the bond purchase increases demand thus increasing prices and decreasing yields.

²⁰ For a review see: Krishnamurthy and Vissing-Jorgensen 2011, Andrade et al. 2016, Vayanos and Vila 2021, and Woodford 2012.

- *Market stabilization channel*, by which asset purchases provide liquidity when there are deep dislocations in financial markets.
- *Portfolio rebalancing channel*, by which asset purchases reduce the aggregate amount of duration risk to be held by price-sensitive investors, inducing a shift into other, riskier assets in the economy and thereby supporting their value.
- *Signaling channel*, through which asset purchases signal the intention of central banks to keep policy rates lower longer.

In the discussion about central banks and climate change, this new set of monetary policy measures could support the implementation of green monetary policies affecting the criteria of asset eligibility. This, in turn, is expected to induce a shift in the technological and sectoral composition of investments in the economy. Among the most debated green monetary policies, academics and practitioners focused on the role of the green collateral framework (GCF) and green quantitative easing (GQE) (Batten et al. 2016), and they are the focus of this section:

- *Green collateral frameworks*, i.e., changes in the *conditions* under which assets are accepted by the central bank as a function of their technological and sectoral characteristics. This is implemented as the introduction of a cap (maximum) on the share of high-carbon assets or a threshold (minimum) on the share of low-carbon assets that can be held in the portfolio, and through the modulation of the haircut (implying higher haircut for high-carbon assets, and lower haircut for low carbon-assets).
- *Green asset purchase program*, better known as *green QE*, which consists of an asset purchase program with preferential targeting of low-carbon assets.

Within GCF, central banks can green their implementation framework by reviewing the pricing or eligibility criteria for the collaterals that they accept as part of their lending operations. In particular, banks could require the carbon footprint of eligible collateral to be disclosed and can apply additional haircuts related to the carbon intensity of the issuer, when pricing collaterals (Dafermos et al. 2021, Oustry et al. 2020). Greening the collateral framework could ideally work in tandem with Green Targeted and Longer-Term Refinancing Operations (LTROs) (Monnin 2018, Schoemaker 2019), i.e., refinancing operations where the interest rate that banks pay depends on their volume of lending that complies with the European Union (EU) Taxonomy of sustainable investments (van't Klooster and van Tilburg 2020).

Eligibility within the GCF could be based either on sector-based or technology-based targets. Sector-based targets refer to the decrease in CO₂ emissions of a certain activity with regard to the average of the sector (i.e., an indirect impact on emissions' reduction in the economy). In contrast, technology-based targets pertain to the achievement of a certain level of investment in renewable energy technologies (i.e., a direct impact on emissions reduction in the economy). The EU Taxonomy provides a useful starting point in this regard. For instance, cement production plants are EU

Taxonomy aligned if their performance in terms of emission intensity is (approximately) in the top 5 percentile.

GQE can be defined as a monetary policy that rebalances the central bank's balance sheet towards green bonds, i.e., bonds issued by firms in low-carbon sectors.²¹ In the last decade, the bond portfolios of all major central banks have expanded due to prolonged asset purchase programs, which have been deployed to achieve monetary policy objectives when the policy rate hit its lower bound. However, these purchases are carried out by central banks in proportion to the outstanding market shares, thus generating a potential "carbon bias" in central banks' portfolios as high-carbon companies have a larger weight in corporate bond markets, with respect to less carbon-intensive companies (Boneva et al. 2021), since the purchases are "backward-looking" and relate to the carbon-intensive past economy.

Large purchases of bonds issued by large high-carbon companies may signal market participants to assign lower risk profiles to high-carbon bonds' categories. Therefore, in the absence of climate risk considerations, central banks' asset purchases, even if temporary, may steer unintended consequences and promote the current carbon-driven economy. GQE aims to address this climate-related misallocation.

The following similarities and differences between GCF and GQE emerge. Both GCF and GQE share similar eligibility criteria based on sector, technology and carbon intensity of the assets. In order to carry out preferential purchases, the central bank must have sector and technological standards (e.g. taxonomies) to identify what to purchase and what assets to exclude (e.g. in the GCF assets in fossil fuels assets are not accepted and the same assets are not the objects of purchases in the Green QE).

Channels through which the two policies work differ in that while GCF impacts financial institutions' ability to obtain central bank money, GQE impacts more directly securities issuers in the real sector via preferential asset purchase. However, the *implications for central banks' balance sheets* differ. In the case of GQE, the central bank's balance sheet increases as a result of asset purchases from the banks (in return for which, banks obtain liquidity). In the case of the GCF, in contrast, the balance sheet composition of the central bank changes, while the size is essentially unaltered.

One interesting feature of GQE is that a low-carbon allocation can be done without undue market interference (Bressan et al. 2021), within the transmission mechanism of traditional monetary policy (Schoenmaker 2021). Nevertheless, similarly to QE, the GQE is debated. In particular, the main areas of discussion include²²:

²¹ See <https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2500~f7a50c6f69.en.pdf>

²² These considerations also apply to GCF.

- *Risk profile*: within the QE, assets that can be purchased by central banks should respond to a certain risk profile (e.g., being investment grade). However, low-carbon firms often require long-term capital that is, by definition, riskier than the short-term one. Thus, low-carbon assets may not be eligible for central bank purchases, which are based on bonds characterized by low default risk. This, in turn, could raise issues about the quality and climate alignment of central banks' portfolios.
- *Market neutrality principle* of central banks, i.e., the fact that central banks are supposed to purchase assets proportionally to the composition of the economy, in order to avoid market biases (Colesanti and Monin 2020). Thus, in the presence of strong market neutrality, the portfolio rebalancing toward less climate-relevant sectors is virtually impossible (Bressan et al. 2021).
- *Structural conditions*: QE was designed as a cyclical policy to be used in exceptional conditions to foster market recovery, by providing temporary stimulus to lending activity and, thus, to the economy. Turning the GQE into a structural monetary policy instrument may interfere with central banks' objectives and principles of minimal market interference.
- *Mandates*: most central banks' mandates do not explicitly consider sustainability as a *primary* objective. This creates issues for the central banks' legitimacy when deploying their monetary policy tools to support sustainability objectives (Boneva et al. 2021).

Overall, implementing GMP would require consistently integrating climate mitigation objectives into central banks' monetary frameworks to adequately account for the impacts of climate change on macroeconomic and financial outcomes, as well as for the impact of financial outcomes on the low-carbon transition. In this context, a net-zero strategy by 2050, i.e., achieving carbon neutrality of the portfolio by 2050, would help central banks deliver on their mandated goals, safeguard financial stability, and ensure policy coherence.²³

To date, GMP have been applied only to a limited extent. In the euro area, despite the absence of an explicit environmental target in its asset purchase program, the ECB has purchased green bonds under both the Corporate Sector Purchase Program (CSPP), under the public sector purchase program (PSPP), and under the more recent Pandemic Emergency Purchase Program (PEPP). The ECB's purchases have contributed to the establishment of a well-diversified portfolio via market signaling (about the acceptance of green bonds).²⁴ In addition, under specific conditions, they could contribute to decrease the central bank's exposure to climate transition risk. Under a weaker market neutrality principle, the ECB could construct a portfolio of bonds with lower exposure to climate transition risk than the current one (Bressan et al. 2021), without a significant impact on prices. This, in turn, would generate positive spillover effects on market signaling and risk management.

In China, one of the emerging countries with fast-developing climate finance architecture, the People's Bank of China (PBoC) decided to include green financial bonds into the pool of assets

²³ For a detailed discussion for the EU, see Dikau and Volz 2021.

²⁴ See https://www.ecb.europa.eu/pub/economic-bulletin/focus/2018/html/ecb.ebbox201807_01.en.html

eligible as collateral for its Medium-Term Lending Facility. The reform increased the greenium, i.e., the spread between green and non-green bonds, by 46 basis points (Macaire and Naef 2021).

These seminal natural experiments highlight the potential of GMP. However, empirical evidence is still scarce, notably about the actual impact of these policies on GHG emissions reduction in the economy, and on the economic performance of green sectors. Also, a common framework integrating the implementation of GCF and GQE has not been developed yet.

2.4. Public co-funding and co-funding of green investments

The creation of green national development banks, and the increase of the capitalization of existing national development banks with a green mandate, has been advocated to address the urgent need to mobilize finance and to address the threat of climate change (Griffith-Jones and Ocampo 2016). The rationale for development banks' intervention in the low-carbon transition stands in recognition of credit rationing and green market failures. Low-carbon investments are usually long-term while having no long track record of past performance. Thus, they are considered as riskier by traditional financial institutions, resulting in higher cost of capital for firms willing to invest. The transition to a low-carbon economy requires long-term, large investments (e.g., in infrastructure and technology), i.e., "patient finance" which may not be available if the local credit market is not properly capitalized. National development banks (NDBs) could help address the "Tragedy of the horizons" recognized by Mark Carney (2015) – i.e., the short-termism of private finance vs. the long-term dimension of climate impacts.

In addition, in EMDEs, access to capital for smaller firms is scarce and expensive. Thus, where private finance is unwilling to fund activities with uncertain returns but positive externalities, such as low-carbon investments, NDBs could play the role of a Green Entrepreneurial State (Mazzucato 2015). In this context, national development banks could help to attract, and to de-risk, international private finance by providing *counter-cyclical finance* to foster the green structural transformation. National development banks could finance green investments that can deliver public goods, and that the private is not able or willing to. In addition, national development banks could contribute to deepen financial markets. This is the case of low-carbon guarantees that would de-risk low-carbon investments, thus making them more appealing for financial institutions with capital requirements, e.g., banks and insurance firms (see for example the role of blended finance in Zheng et al. 2020).

Here we discuss two ways in which NDBs can pursue a green investment strategy. First, NDBs can increase (decrease) the funding of low-carbon (high-carbon) activities through the provision of *soft loans*, i.e., loans associated with lower -than-the-market interest rates that would decrease the cost of capital for green investments. This, in turn, would make it cheaper for firms to invest in low-carbon projects.

Second, NDBs can provide *credit guarantees* for low-carbon investments, in order to de-risk commercial banks' lending to firms that invest in low-carbon projects.

Both options can be implemented via several channels, including through the capitalization of a dedicated green development bank, through an increase of the share of green sector investments in the portfolio of existing NDBs, or through green on-lending via commercial banks.

Nevertheless, NDBs need tailored metrics to support the selection of projects to consider climate and environmental as well as other development goals. The introduction of analytical tools for public development banks was recently advocated in order to inform the selection of operations that would contribute to sustainable development (Marodon 2018). Such tools would integrate climate and environmental sustainability criteria on top of the current, purely financial ones. Thus, a precondition for the adjustment in investment portfolios of NDBs stands in the implementation of standardized climate financial risk disclosure and climate financial risk assessment. On the one hand, the identification of eligible low-carbon projects should follow standardized taxonomies of sustainable investments, to allow comparability and replicability. In this regard, science-based taxonomies can provide a relevant starting point, to be then tailored to the economic characteristics and climate mitigation goals of the beneficiary countries. On the other hand, the decrease in the share and value of high-carbon funding should also be informed by standardized taxonomies of carbon stranded assets, that consider the contribution of individual economic activities to emissions, as well as their exposure to climate transition risk.

3. FINANCIAL MARKETS AND POLICY: CHALLENGES AND CONDITIONS FOR GFSI IMPLEMENTATION

To be successful, GFSI need to be tailored to prevailing financial market conditions. EMDEs have particular characteristics and face specific barriers that can determine the success or failure of GFSI.

3.1. Financial market characteristics and barriers in EMDEs

EMDEs play a crucial role in addressing climate change and reaching sustainable development goals, since most of the increase in global emissions in the coming decades is expected to derive from EMDEs (IEA 2021). However, EMDEs currently account for only 20% of global investment in clean energy. Annual clean energy investment must increase from USD 150 billion in 2020 to over USD 1 trillion by 2030, to meet net-zero emissions targets by 2050 (OECD 2021a). According to IEA (2021), more than 90% of EMDE investment needs are in countries with underdeveloped banking and capital markets.

The ability to access low-cost domestic sources of capital to finance the low-carbon transition in EMDEs depends on the characteristics of their financial system, i.e., on the ability to issue debt and equity instruments, to access bank credits, and liquid capital markets. Therefore, it is crucial to

understand the main financing needs and barriers, the role of the banking system and capital markets, and the relevance of the state and market in the context of the low-carbon transition in EMDEs.

Financial systems in EMDEs tend to be less developed than financial systems in advanced countries²⁵ and EMDEs' financial markets differ in terms of concentration (e.g., the financial system development indicator, wide differences in development level across EMDEs exist). Financial development has been often considered in the literature in terms of concentration. While there is the view that countries with more developed equity markets have less concentrated financial systems, the assessment of concentration differs in terms of scope, measurement approaches and geography, as well as on development models (e.g. the debate about Anglo-Saxon financial systems versus the German and Japanese models²⁶). In contrast, most EMDEs have in common that the financial system is usually characterized by a large role of banks (typically accounting for 85-90 percent of financial system assets) and bank loans remain the most important source of external financing for firms in EMDEs.

While specifically sovereign and private debt markets are growing, EMDE financial markets are still substantially smaller than their advanced economy counterparts.

EMDEs tend to be confronted with greater volatility in real exchange rates, interest rates, and private capital flows (Frankel 2010). Furthermore, energy prices can have a strong impact on production and consumption and can influence how capital is allocated across different segments of the energy sector²⁷ (OECD 2021). EMDEs recovering from the pandemic now face headwinds from rising energy prices, led also by the conflict in Ukraine. Of particular concern is the impact of rising energy prices on the inflation outlook in EMDEs, which already faced the effects of increasing international energy prices on domestic consumer and producer prices. The degree to which countries will be affected by the Ukrainian conflict depends on their energy import dependence and on the proximity to the conflict. Therefore, the instability of energy prices may further impair the attracting of capital for low-carbon investments into EMDEs and increase uncertainty in financial markets.

Access to debt for financing energy investments is often constrained in EMDEs. Renewables usually compete for the same pool of bank capital as fossil fuel alternatives. However, as renewable energy projects in EMDEs still tend to have a shorter track record, the banking sector is often more hesitant to provide credit to low-carbon energy projects. A reason is the lack of capacity and expertise to properly evaluate the risks and opportunities of low-carbon projects. Another issue is that

²⁵ It should be noted that EMDEs are heterogenous and vary widely in their financial market characteristics. This paper thus focuses on general features that most EMDEs have in common.

²⁶ For instance, Glattfelder and Battiston (2009) showed that equity markets in Anglo-Saxon countries are locally less concentrated, presenting more numerous equity owners at individual firm level, but globally more concentrated, i.e. those owners are in fact the same for all firms.

²⁷ In this context, subsidies to fossil fuels contribute to attract more capital toward high-carbon investments.

renewable energy projects are often regarded as less ‘bankable’ as compared to traditional investment projects.²⁸ India is an example where long-tenure debt for renewable power projects is available; however, in most EMDEs tight financial regulation or weak governance frameworks constrain bank lending. In recent years, lending is also more constrained as an increase in stressed thermal power assets has put pressure on bank capital (IEA 2021).

Finally, formal credit markets are usually only available for a fraction of Small and Medium Enterprises (SMEs) in EMDEs, while most have issues getting access to finance. The cost of finance for SMEs can far exceed that for larger companies, and the smaller size of transactions and lack of credit ratings makes lending to small-scale borrowers more challenging.²⁹ National development banks play a crucial role in mobilizing key investment for the transformation to a low-carbon and inclusive economy. However, there is growing consensus that smaller, more decentralized banks, are also needed in EMDEs to target constrained SME lending. They tend to be able to accommodate the specific needs of their customers better and can, as such, reduce information asymmetries. Overall, a diversified banking system, with large and small banks, as well as private and public development banks could offer benefits of diversification (reducing systemic risk and financial instability), providing cheaper and appropriate financial services to the real economy (Griffith-Jones et al. 2016).

3.2. Policy environment to enable the role of financial markets in the low-carbon transition

The low-carbon transition involves a shift in the allocation of EMDE spending toward capital-intensive clean technologies. This is particularly challenging in EMDEs where capital has been traditionally constrained. Thus, keeping financing costs low will be critical to the speed and affordability of this transition (OECD 2021a). Enhanced provision of private debt and equity could play an important role in channeling capital to EMDEs to finance the low-carbon transition. If well designed, financial instruments can attract higher domestic and foreign private capital levels in low-carbon activities at competitive rates.

The need for greater private financial sector involvement is exacerbated by the macro-financial consequences of COVID-19 and the ongoing war in Ukraine. The COVID-19 pandemic hit the economy worldwide, requiring a huge amount of resources to avoid major disruptions and changing investment decisions and public policy priorities. The COVID-19 pandemic hit EMDEs very heterogeneously, but the economic downturn generally led to an increase in debt levels, lower remittances, domestic investments, FDI and capital outflows. In Africa, average public debt ratios rose to 70% of gross domestic product (GDP) in 2020, with at least seven African countries reaching

²⁸ For instance, the average duration of a loan in Southeast Asia is just over six years, while 60% of loans in West Africa are short term, which makes it difficult to finance assets that have rather long operating lifetimes (IEA, 2021).

²⁹ In Brazil and Peru the interest rate spread tops 12%, while in a number of EMDEs, small-scale finance involves a premium that is higher than that in advanced economies (around 1.2%) (IEA, 2021).

levels over 100%. In Asia, the rise in unemployment and underemployment risks leading to a significant income loss. In Latin America and Caribbean (LAC), the number of people living below the poverty line increased by 22 million, now comprising 33.7% of the population, while public debt ratios reached 79.0% of GDP in 2021 (OECD, 2021b).

Given tight public budgets, it would be relevant for EMDEs to undertake initiatives to attract private capital for financing the necessary shift to a low-carbon economy. However, many policies and market practices still encourage emissions-intensive investment, production and consumption. Therefore, EMDEs need to gradually eliminate distortions, incentivize energy transition solutions and introduce new policies, e.g., well-designed carbon pricing, Emissions Trading Schemes (ETS) and adequate finance measures. Those policies could enhance the competitiveness of renewable-based solutions against fossil fuels, promoting investments in low-carbon activities. In addition, ensuring a proper mix of market-based instruments, including easing access to climate finance, would play an important role in the transition (IEA 2021).

In this context, adopting GSFI can support the increase of low-carbon investments and build an enabling environment for private investments. On the one hand, GSFI could support the financing of low-carbon activities, shifting investments to green technology and projects. On the other hand, they could contribute to accelerate the conditions for a more standardized climate financial risk disclosure and to foster policy coherence and credibility, which can contribute to attract investment from the capital market.

More specifically, GPR can represent a strong incentive for banks to channel their credit lines towards low-carbon projects, and other monetary and regulatory policies (e.g., GQE, GCF, GSP, DPF) can further create the conditions for the banking sector in EMDEs to support the high needs of funds required for the low-carbon transition. In particular, central banks could redefine the asset purchase programs taking into account the potential impacts of climate-related risks and implement green financial regulations. Neglecting those aspects can increase the climate-related risks induced by the central banks' financing activities, impairing the recovery and posing further issues to sustainable development. Soft-loans and credit guarantees could also play an important and supporting role in the structuring of bankable projects and in the financing of low-carbon investments. In particular, NDBs could promote the low-carbon transition by granting soft loans to finance low-carbon projects, and by providing credit guarantees to mitigate the risks to provide credit for low-carbon projects.

3.3. GSFI implementing conditions: Challenges and opportunities

In this section, we discuss the main challenges associated to the implementation of GSFI and the opportunities to overcome them, which result in a set of enabling conditions.

3.3.1 The importance of standardized classifications of low/high-carbon activities

The lack of a standardized and science-based classifications of low/high-carbon activities has been recognized by as a barrier for scaling up investments at the global level (Monasterolo 2020). In 2020, the European Commission (EC) introduced the EU Taxonomy of sustainable activities, providing companies, investors, and policy makers with science-based criteria to define economic activities as environmentally sustainable, while providing a mapping to established international classification of economic activities (e.g. ISIC, NACE, NAICS).³⁰ Other taxonomies of green economies are being developed in a number of jurisdictions (e.g., Chile, Colombia), despite the scope may be narrower.

However, the EU Taxonomy does not identify “high-carbon” activities, i.e., activities that could become carbon stranded assets, nor allows to identify their climate financial risk relevance (Monasterolo 2020). The lack of standardized, science-based classification of high-carbon economic activities based on their exposure to climate transition risk prevents to differentiate high- and low-carbon assets and thus is an important obstacle for the implementation of GFSI, including monetary policies that work via asset eligibility, prudential policies that work via adjustments in capital or reserves requirement, and NDBs’ selection of projects to be supported.

To fill this gap, a more comprehensive perspective on the classification of economic activities is provided by the Climate Policy Relevant Sectors (CPRS) classification, which has been developed by academic research (Battiston et al. 2017) to assess economic activities’ exposure to climate transition risk. The CPRS provide a standardized and actionable classification of activities (at the NACE Rev2, 4-digit level) whose revenues could be affected positively or negatively in a disorderly low-carbon transition, going beyond carbon accounting and its limitations, by considering the energy technology profile (e.g., based on fossil fuel or renewable energy) of the activity.

The CPRS classification considers the economic and financial risk stemming from the (mis)alignment to the climate and decarbonization targets of firms and sectors (recorded at the NACE 4-digit level in the EU, or the NAICS in the USA) that can affect their output and performance, based on the following criteria:

- The direct/indirect/induced contribution to GHG emissions (e.g., Scope 1, 2, 3).
- The energy technology profile of the activity (e.g., what type of fossil fuels or renewable energies is produced or used).
- The business model and revenues structure of the firm (i.e., their input substitutability).
- The relevance of the activity for climate policy implementation (i.e., their costs sensitivity to climate policy change, based e.g., on the EU carbon leakage directive 2003/87/EC).

³⁰ See https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

By mapping activities depending on their climate transition risk, and by matching firms' climate-relevant non-financial information into the financial information about the financial instrument of the firm (e.g., equity holdings, bonds, loans), the CPRS allows the quantification of transition risk exposure of the portfolios of investors' portfolios, and the computation of scenario-adjusted risk measures.

The CPRS methodology is replicable and comparable across portfolios and jurisdictions, and is available at different levels of disaggregation, depending on the level of disaggregation of information about the energy technology profile of the activity that is relevant for the transition (i.e., the type of energy or electricity that the activity uses, for instance, electricity production out of coal). At their most aggregate level, we obtain CPRS-main, which include CPRS1-fossil fuels, CPRS2-utility, CPRS3-energy efficiency, CPRS4-housing, CPRS5-transport, CPRS6-agriculture.

The CPRS classification is open access³¹ and is recognized as a best practice from European financial authorities,³² which applied them to assess investors' portfolios exposure to climate transition risk. It has recently been updated into the CPRS-granular, considering firms' revenues from energy technologies, and mapped into the IAM variables used by the NGFS scenarios. Finally, the CPRS is it is also fully compatible with the EU Taxonomy for the share of green of activities of firms, thus allowing for the consideration of firms with multiple business lines (e.g., energy and utility companies).

The importance of using standardized, science-based taxonomies for "green" and "high-carbon" activities is particularly relevant for central banks. Indeed, it would allow them to (i) compare their current portfolios exposures to those under low-carbon investment strategies; (ii) assess the impact of greening financial portfolios in terms of the composition of the real economy, prices and distributive effects; (iii) assign risk weights to assets, depending on whether they are high or low-carbon; and (iv) calculate the investment risk profile in a forward-looking way, across climate mitigation scenarios (e.g. the NGFS ones), thus affecting the eligibility criteria.

3.3.2 Enabling conditions for the implementation of GFSI

We can identify the following set of general enabling conditions that would foster the effectiveness of all GFSI.

³¹ The CPRS classification can be downloaded at: <https://www.finexus.uzh.ch/en/projects/CPRS.html>

³² These include the European Banking Authority, The European Insurance and Occupational Pension Authority, the European Securities and Markets Authority, the European Central Bank, the Swiss National Bank and the Austrian National Bank. In the context of EMDEs, CPRS have been already applied by the Caribbean Development Bank to its project portfolio in the Caribbean region, by Monasterolo et al. (2018) to the energy infrastructure projects of the China Development Bank and Import-Export Bank of China outside the Chinese borders, and by Roncoroni et al. (2021) in the climate stress test of Mexico.

1. *Climate financial risk disclosure, with regard to transition risk exposure*, is crucial to inform climate financial risk assessment, climate scenario-adjusted financial valuation of financial contracts and investment projects. In addition, the adjustment of financial valuation of contracts conditioned to climate scenarios (e.g., the NGFS ones), and *the assessment of climate-related risks and opportunities* for investors, contributes to a smooth implementation and governance of the GFSI. This condition rests on the use of a standardized and science-based classification of both low- and high-carbon activities, in order to identify those that can gain from a transition and those exposed to transition risk. In particular, it is key that this classification is applicable to all jurisdictions and contracts, in order to avoid greenwashing and improve market pricing of climate transition risk. In this regard, the CPRS classification (Battiston et al. 2017) can be already applied at the level of country economy and of investors' portfolios, including central banks' ones.

2. *Green conditionality* is key for several aspects of GFSI. The implementation of green conditionality can be informed by the application of the classifications and taxonomies used for climate financial risk disclosure discussed in 1.
 - i. Within monetary policy programs aimed to signal the market and channel investments towards low-carbon activities sectors, the eligibility criteria for collateral (GCF) and for asset purchases (GQE)
 - ii. The design of financial regulations, e.g., GSF and DPF, that make low-carbon investments more attractive for banks rests on the condition that banks
 - iii. The selection of projects to be funded or supported (e.g., via guarantees) by GNDB.It should be noted that GCF and GQE, alone, do not lead necessarily to higher levels of low-carbon investments unless some conditionality is explicitly associated to the policy implementation. For instance, the extent to which the QE implemented in the euro area has channeled liquidity from commercial banks into the real economy is still debated (Kojien et al. 2021).

3. *Investors' climate sentiments* need to be considered in the GFSI implementation. This notion refers to investors' expectations about the impact of GFSI on firms' performance and how this would lead to adjustments in climate financial risk perception (e.g., differentiating interest rates for high and low-carbon firms). In turn this has an impact on the realization of national climate mitigation objectives and thus on a successful low-carbon transition (Battiston et al. 2021). For instance, if banks trust the GFSI implementation, they could anticipate them by revising their lending conditions, i.e., by decreasing (increasing) the risk pricing and thus cost of capital associated to low- (high-carbon) loans, already in advance. The change in lending conditions would directly affect firms' profitability and investment decisions, by improving them for low-carbon firms and worsening them for high-carbon firms. In contrast, if banks do not embed climate risk in their lending contracts, the policy itself might not achieve its goals (Dunz et al. 2021a). Climate sentiments point to the fact that climate risk is endogenous, i.e., the climate risk materialization depends on how financial actors perceive green prudential, monetary, and public co-funding policies, they

could enable or hinder the transition, with implications on asset price volatility and financial stability (Battiston et al. 2021).

4. *Foster climate policy coherence and credibility*, which plays a key role in the investors' climate sentiments (see condition 3). In the context of the low-carbon transition, policy coherence is still low both in low- and high-income countries. In the latter, fossil fuels subsidies and renewable energy subsidies often coexist. Overall, climate policy introduction (e.g., a carbon tax) is still delayed. Contradictory signals prevent investors to adapt their business for the low-carbon transition, failing to internalize the costs and co-benefits of climate policies in their risk assessment and management. As highlighted by the NGFS *“Operationalizing climate neutrality in the context of policy coherence is critically important to ensure that the actions of central banks are not perpetuating a high-carbon status quo in financial markets that delays a transition in the real economy”*. The question of policy coherence is particularly relevant for monetary policy because of the significant size of central banks' balance sheets and the increased impact on the economy and financial markets. Here it will be vital to ensure that a climate-neutral calibration of instruments does not impair central banks' ability to exercise their primary functions and to avoid potential conflicts associated with a 'supportive role' of central banks (NGFS 2021).
5. *Accounting for the interdependence across financial institutions and financial markets*. In the aftermath of the 2008 financial crisis, many financial supervisors recognized the failure of traditional stress-testing for banks (Haldane 2009) and the importance of modeling the financial system as a network (Bardoscia et al. 2021). This view is widely recognized today and reflected in the policy actions and discourse of financial authorities globally (see e.g., Yellen (2013) for a US and Noland and Park (2015) for an Asian perspective). Indeed, network effects of various kinds had a key role in the 2007–2008 financial crisis, the impact of which persists after more than a decade. For instance, according to the Bank for International Settlements (BIS), the largest part of losses suffered by financial institutions during the financial crisis was not due to actual counterparties' defaults, but to the mark-to-market reevaluation of obligations following the deterioration of counterparties' creditworthiness.³³ In other words, they were due to *network effects*. In addition, in the aftermath of 2008, it has become widely accepted that micro-prudential regulations can have undesirable macro-level repercussions, due to network effects and procyclical effects (Adrian and Shin 2010) and that macro-prudential regulation should be pursued instead (Borio et al. 2014). In the context of the low-carbon transition, recent balance-sheet climate stress tests have analyzed how financial interconnectedness can lead to a reverberation of losses across financial institutions with implications for systemic risk (Battiston et al. 2017). This holds in particular, if financial actors fail to adequately embed climate scenarios in their

³³ The Basel Committee on Banking Supervision states that “roughly two-thirds of losses attributed to counterparty credit risk were due to Credit Valuation Adjustment (CVA) losses and only about one-third were due to actual defaults”; see BCBS (2011).

risk management tools. In contrast, financial actors that anticipate the climate policy introduction and adjust their risk assessment earlier, could gain from the transition in terms of financial performance.

6. *Policy complementarity.* Beyond the timely introduction of a carbon price set at an appropriate value per ton of CO₂, its alignment with other green fiscal policies (e.g., removal of fossil fuel subsidies, public investments in low-carbon infrastructures, support to firms and worker in the transition), as well as monetary, and macroprudential policies, would strengthen policy coherence and leverage impact investments in the low-carbon transition. A climate finance governance that promotes complementarity of climate fiscal and financial policies, within the institutions' mandates, could contribute (i) to exploit mutually reinforcing effects of policies and (ii) taming potential trade-offs on macroeconomic performance, financial stability, and inequality. Recent research showed promising results about the interplay of policy complementarity and supportive financial markets in fostering the low-carbon transition³⁴ and counteracting the macro-financial impacts of compounding risks (Dunz et al. 2021b). Further research about the conditions for climate finance policy complementarity to work in EMDEs could be beneficial to inform the GFSI implementation.
7. *Financial stability.* Financial shocks can propagate through trade and bank credit network (Bernanke et al. 1999, Delli Gatti et al. 2010, Battiston et al. 2012), and financial interconnectedness contributes to risk amplification (Billio et al. 2012, Battiston et al. 2016, Roukny et al. 2018). Thus, in order to fully understand the impacts of GFSI we need to take into consideration financial propagation mechanisms and track which sectors/firms are going to be sequentially affected in the economy, and in which direction (i.e., the potential winners and losers). According to the financial accelerator theory (Bernanke et al. 1999), endogenous developments in credit markets contribute to amplify and propagate shocks to the real economy. These propagation processes will eventually determine the macro-economic response to GFSI. However, the impact of individual GFSI will crucially depend on the macro-economic context. While it is true that EMDEs have usually a lower degree of financial complexity and deepening, they are exposed to turmoil that could occur in more established financial markets (Yilmaz and Godin, 2020). For instance, foreign financial actors that experience balance sheet stress could decide to divest from bonds of low-income countries' firms and sovereigns, which are usually associated with higher risk and thus used for diversification purpose, with implications on the bonds' prices and yields.

³⁴ See https://greenfin.at/wp-content/uploads/2022/03/Vismara_A2.6-1.pdf

4. GFSI TRANSMISSION CHANNELS AND IMPACTS: REAL ECONOMY, FINANCE, AND GHG EMISSIONS

GFSI work via a financial intermediary (usually commercial banks, or national development banks). Hence, it is crucial to analyze the transmission channels to the economy via the financial sector, in order to capture the potential effects on mitigation, on macroeconomic and financial stability. For each GFSI presented above (section 2), we identify the key transmission channels to the variables of the real economy (e.g., energy prices, investments, technological change), financial parameters (e.g., cost of capital, availability of capital), and GHG emissions reduction. In addition, for each GFSI, we identify the potential direct, indirect, and cascading impacts to the economy and finance, and the key variables that can generate spillovers.

In our analysis, we consider the *characteristics of climate change* (i.e., forward-looking, deep uncertainty, non-linearity) and *the functioning of financial markets and financial policies* (i.e., institutions, instruments, and governance).

4.1. GFSI's transmission channels to the economy and finance

4.1.1. Green Supporting Factor (GSF)

Figure 1 presents the transmission channels from the GSF to real economic and financial actors (banks). The GSF affects banks' capital requirements via decreasing risk weights of low-carbon or green activities.

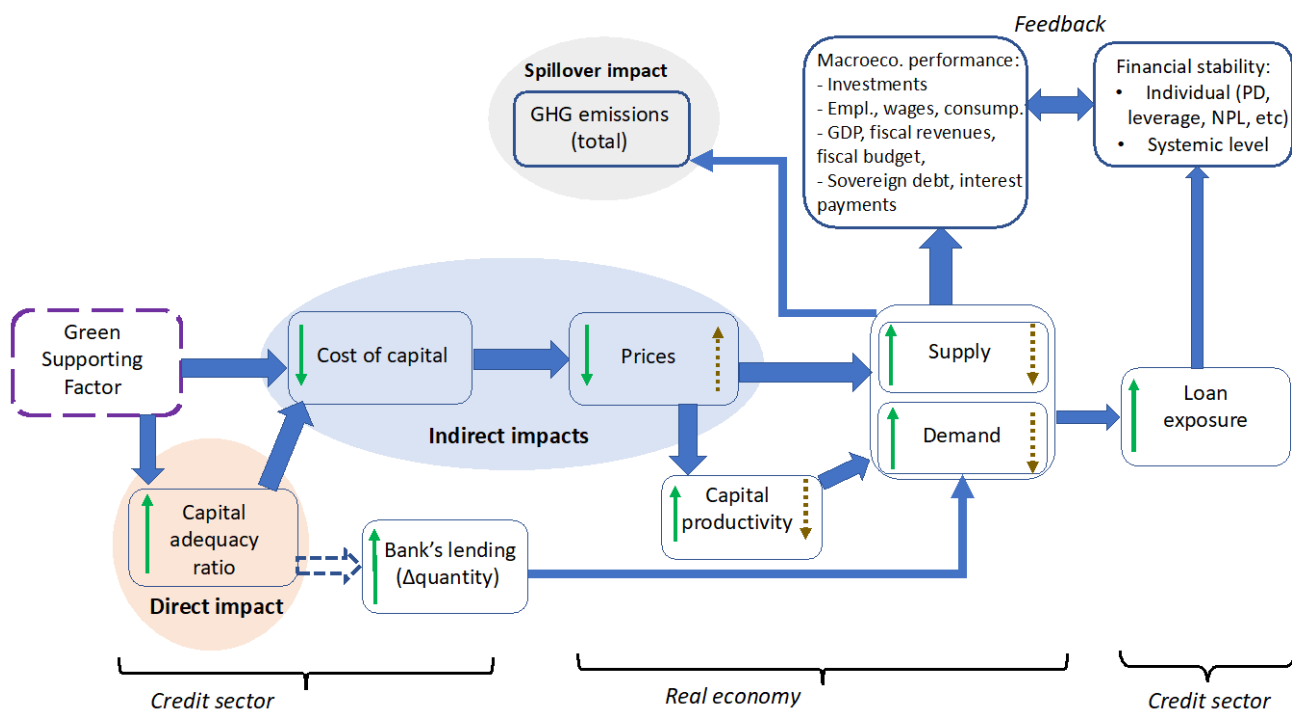


Figure 1: Macro-financial transmission channels of the Green Supporting Factor. The purple box indicates the policy. Up-facing arrows: positive trend. Downfacing arrows: negative trend. Green arrows: policy impacts on low-carbon firms. Pink area: direct impacts. Blue area: indirect impacts. Grey area: spillover impacts. Dotted arrows: potential effects on the high-carbon sector.

The GSF lowers the risk weights for loans to low-carbon firms that enter the denominator of the CAR (direct impact). The resulting higher CAR would lead to higher lending capacity for the banking sector and thus to new (green) business opportunities. Indeed, banks' setting of lower interest rates for low-carbon firms lead to new investments in low-carbon firms while capital costs and prices would decrease (indirect impacts). Being more price competitive, the demand and profits of low-carbon firms go up, resulting in higher investment needs of low-carbon firms and, thus, in their supply. This would lead to a decrease of the green investment gap and to a higher exposure of the banking sector to green loans, mitigating the risk of carbon stranded assets in banks' balance sheets. At the same time, new low-carbon investments would stimulate low-carbon capital productivity gains, reducing the prices of low-carbon capital goods even further, and making high-carbon goods less attractive.

The higher demand and supply of low-carbon investments could foster the overall economic activity and reduce unemployment. However, the effect on GHG emissions reduction may be ambiguous. On the one hand, the higher investments in low-carbon companies could lead to an additional reduction of GHG emissions (positive spillover effect). On the other hand, the increase in economic activity could also benefit high-carbon activities (e.g., via the production of components for solar PV) and thus counterbalance GHG emissions reduction (negative spillover effect).

4.1.2. Dirty Penalizing Factor (DPF)

Figure 2 shows the transmission channels through which the DPF affects the banking sector and the real economy, via higher risk weights assigned to high-carbon activities.

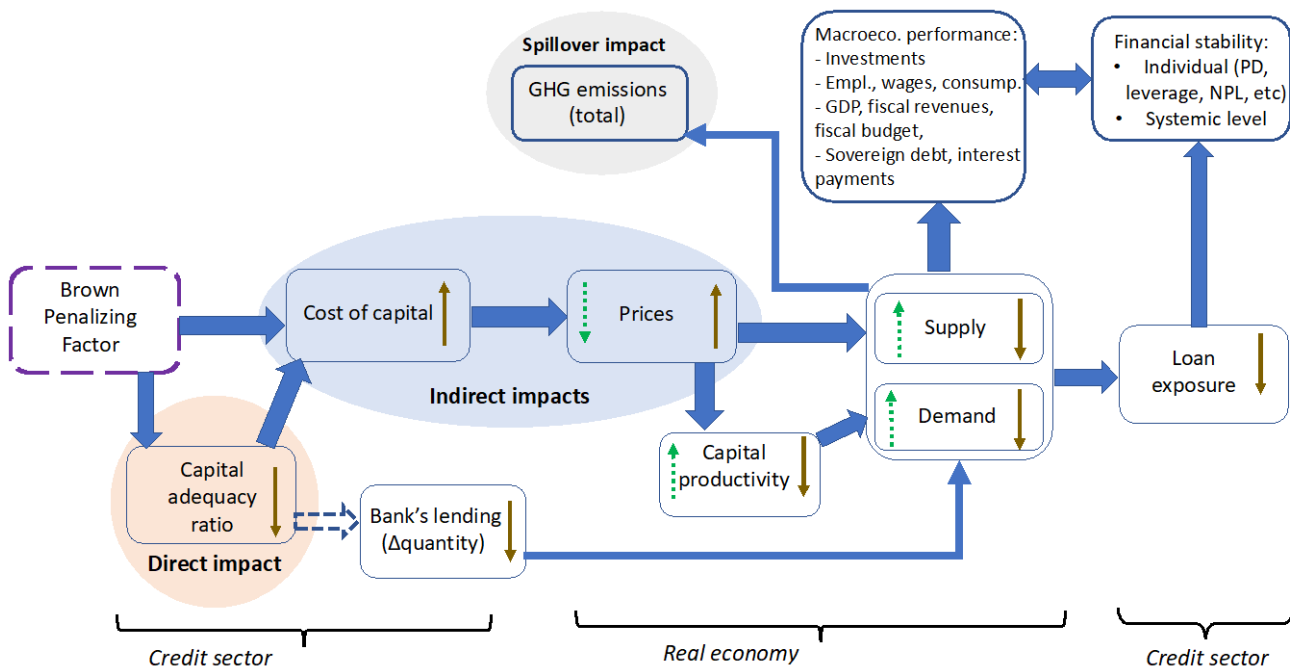


Figure 2: Macro-financial transmission channels of the 'Dirty Penalizing Factor'. The purple box indicates the policy. Up-facing arrows: positive trend. Downfacing arrows: negative trend. Brown arrows: policy impacts on high-carbon firms. Pink area: direct impacts. Blue area: indirect impacts. Grey area: spillover impacts. Dotted arrows: potential effects on the low-carbon sector.

The DPF affects the real economy and banking sector through the same transmission channels that characterize the GSF (see section 3.1.1). However, the direct and indirect impacts differ. The DPF increases the risk weights of high-carbon activities, resulting in lower CAR and, thus, into lower banks' ability to lend to firms, and into higher interest rates. In turn, higher interest rates driven by DPF would negatively affect new investments. In this context, if banks react to the DPF by reducing their lending and by increasing the interest rate for high-carbon companies, lower demand for high-carbon investments could follow, leading to lower investment in high-carbon sectors, and, thus, to lower supply of high-carbon goods (indirect impacts). This mechanism would contribute to lower banks' exposure to high-carbon companies, and reduce climate transition risk, mitigating the implications on banks' financial stability. In addition, lower investment in high-carbon companies would also involve high-carbon capital productivity losses, which further increase the prices of high-carbon capital goods and make low-carbon investment more attractive.

As in the case of the GSF, the DPF could lead to higher low-carbon investments and economic activity, and to lower unemployment. The lower attractiveness of high-carbon firms could foster investments in low-carbon firms, potentially leading to a reduction of GHG emissions. Nevertheless, as for the GSF, the overall effect on GHG emissions reduction may be ambiguous and depend on relative strengths of the macroeconomic effects with potential rebound effects for high- or low-carbon investments.

4.1.3. Green Portfolio Rewards (GPR)

Figure 3 shows the transmission channels from the GPR to the financial sector and real economy, via changes in banks' liquidity, in the quantity of green lending, and in the cost of capital for high and low-carbon firms, directly affecting the green investment gap.

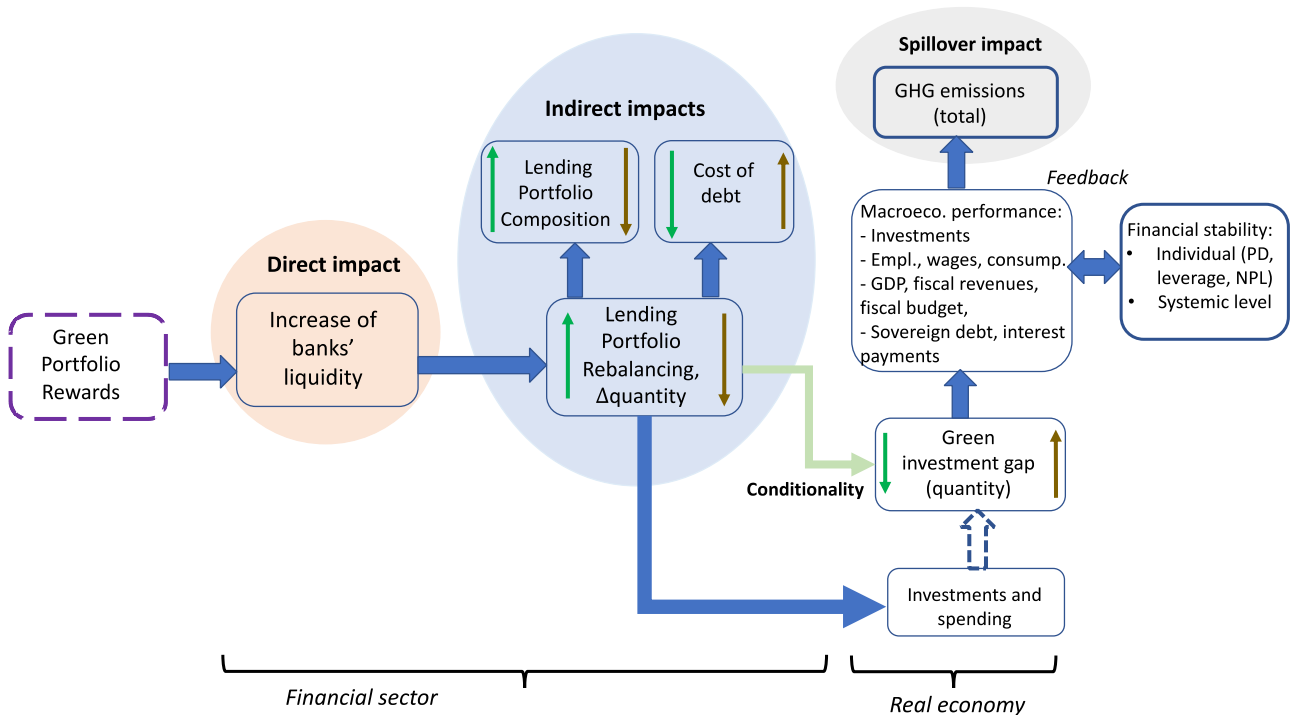


Figure 3: Macro-financial transmission channels of green portfolio rewards. The purple box indicates the policy. Up-facing arrows: Positive trend. Downfacing arrows: negative trend. Green arrows: policy impacts on low-carbon firms. Brown arrows: policy impacts on high-carbon firms. Thick green arrow: conditionality. Pink area: direct impacts. Blue area: indirect impacts. Grey area: spillover impacts.

The GPR directly affects banks by increasing their liquidity via rewards linked to the financing of green projects. The higher banks' liquidity can be used to increase lending to low-carbon companies, fostered by the green rewards that the banks could obtain. This could lead to a rebalancing of banks' lending portfolio towards green projects, while the share of high-carbon projects might be reduced. The lower investments in high-carbon companies could lead to a substitution effect and foster green investments. This, in turn, could contribute to narrow the green investment gap, and to a reduction of GHG emissions (spillover effect). Overall, the GPR could thus induce better financing conditions for green projects (indirect impact).

The GPR could generate an incentive for banks to finance green investments, in absence of a coordinated policy framework that supports green investments, and in absence of an orderly introduction of green fiscal policies. However, it may not be effective in decreasing GHG emissions if rewards are paid unconditionally. Indeed, banks could use rewards from the GPR to finance high-carbon activities. To avoid such negative impacts on GHG emissions reduction, rewards of GPR should be made conditional on low-carbon investment financing.

4.1.4. Green Collateral Framework (GCF)

Figure 4 shows the transmission channels from the GCF to the financial sector and real economy, via changes of the eligibility criteria of high and low-carbon assets, which directly affect the central bank money lending to the banking sector.

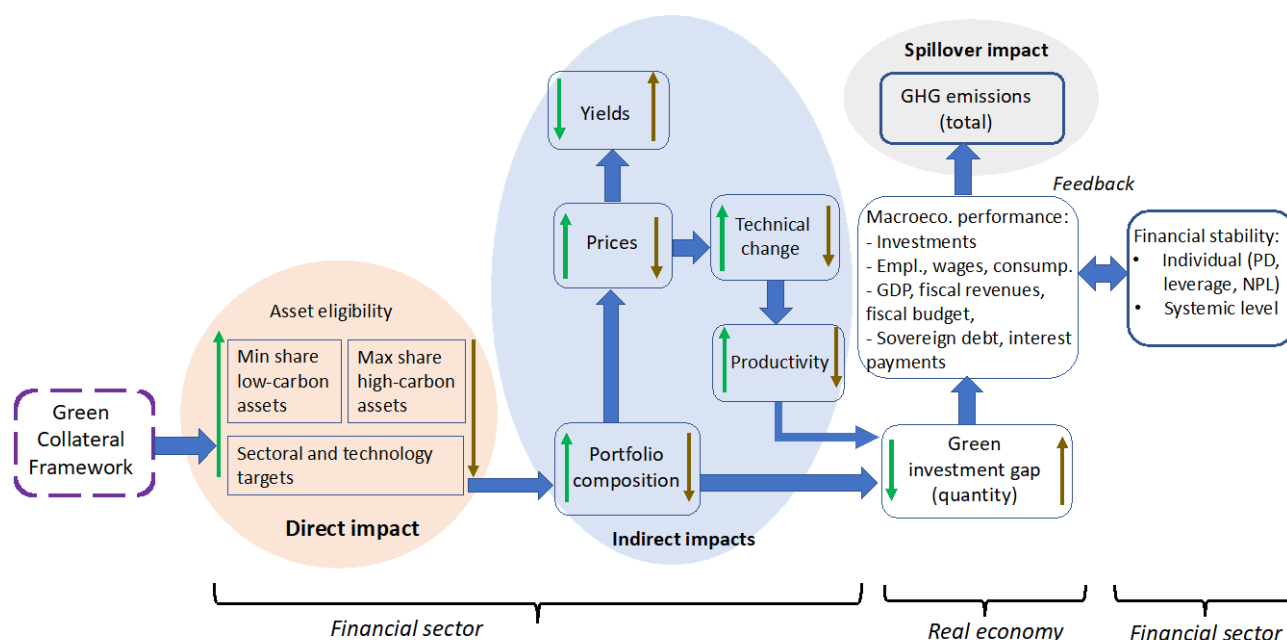


Figure 4: Macro-financial transmission channels of the green collateral framework. The purple box indicates the policy. Up-facing arrows: Positive trend. Downfacing arrows: negative trend. Green arrows: policy impacts on low-carbon firms. Brown arrows: policy impacts on high-carbon firms. Pink area: direct impacts. Blue area: indirect impacts. Grey area: spillover impacts.

Major central banks supply reserves to commercial banks mainly through Main Refinancing Operations (MROs) and Long-Term Refinancing Operations (LTROs). These operations ensure the smooth functioning of the banking system. Central banks lend to the banking sector and obtain assets as collaterals, such as sovereign or corporate bonds. The use of collaterals allows central banks to protect themselves from financial losses, e.g., when banks are unable to pay back received loans. Financial assets that are accepted as a collateral are defined as *eligible assets*.

Within the GCF, eligible assets that banks can use to borrow from central banks must include certain shares of low and high-carbon assets. In particular, the GCF sets a minimum share of low-carbon assets and a maximum share of high-carbon assets that can be used as collateral by banks (direct impact). Banks react to the change in the eligibility criteria of low and high-carbon assets by changing the composition of their portfolio, increasing the amount of low-carbon assets, and reducing high-carbon assets. This result can be achieved following criteria that set sector-based and technology-based targets. Higher (lower) demand of low-(high-) carbon assets increases (decreases) asset prices, while decreasing (increasing) their yields. Thus, GCF could improve financing conditions for low-carbon companies (indirect impacts), which in turn would contribute to foster green investment and reduces the green investment gap. Implications for macroeconomic performance and financial stability, and GHG emissions reduction would unfold (spillover effects).

4.1.5. Green Quantitative Easing (GQE)

Figure 5 presents the transmission channels from the GQE to the financial sector and real economy, via changes of the eligibility criteria of high and low-carbon assets, the expansion of central banks' balance sheet and the increase in banks' liquidity.

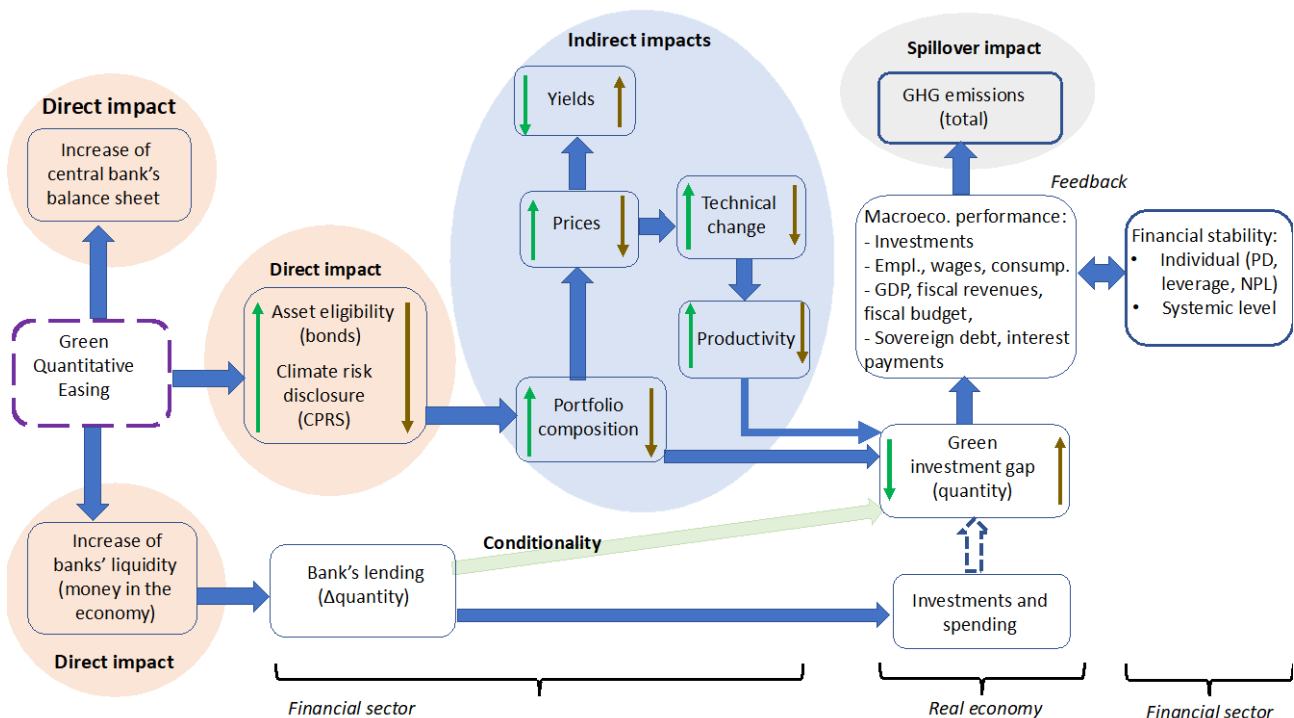


Figure 5: Macro-financial transmission channels of green quantitative easing. The purple box indicates the policy. Up-facing arrows: Positive trend. Downfacing arrows: negative trend. Green arrows: policy impacts on low-carbon firms. Brown arrows: policy impacts on high-carbon firms. Thick green arrow: conditionality. Pink area: direct impacts. Blue area: indirect impacts. Grey area: spillover impacts.

The GQE is characterized by three direct impacts. First, it contributes to expand the central bank's balance sheet by creating new banks' reserves in exchange of the assets purchased by the central bank. Second, it contributes to change the eligibility criteria of banks' assets that can be purchased by the central banks. Third, it leads to an increase in banks' liquidity, thus increasing the amount of money in the economy. These three direct impacts could give rise to different transmission channels, and into adjustments of financial and real economy variables. Here we focus on the effects of the second and third direct impacts, thus leaving aside the consequences of the expansion of the central bank's balance sheet.

With reference to the change in eligibility criteria, the transmission channels are similar to those described in section 2.1. In particular, banks react to the change in the eligibility criteria of low-carbon and high-carbon assets by changing the composition of their portfolio, by increasing the amount of low-carbon assets and by reducing the quantity of high-carbon assets. The resulting higher (lower) demand of low (high) carbon assets increases (decreases) asset prices and decreases (increases) their yields, improving financing conditions for low-carbon companies (indirect impacts). This channel could contribute to foster low-carbon investment and reduce the green investment gap, if banks adjust investment spending (dotted arrows), thus affecting macroeconomic performances, and potentially reducing GHG emissions (spillover effects).

Within the third direct impact, the green QE leads to an increase in banks' liquidity. By purchasing assets from banks, central banks create new reserves, increasing the supply of money. An increase in banks' liquidity and money in the economy can foster banks' lending and financial activity, thus stimulating investments and spending, with positive effects on macroeconomic performance.

However, it is important to highlight that in absence of a clear conditionality on the use of the banks' liquidity created out of the GQE, banks could also increase investments and lending to high-carbon activities, thus partially vanishing the effects described above in relation to the second direct impact, i.e., the eligibility criteria. This is the meaning of the dotted arrow from "investment and spending" to "green investment gap".

Furthermore, the transmission channels from GQE to macroeconomic performance and financial stability can be affected by the way in which the low-carbon transition is carried out, i.e., either through an orderly or a disorderly introduction of climate policies and regulations. An orderly transition would allow a smooth adjustment in energy technology profile of the economy, i.e., a decrease in high-carbon and increase in low-carbon activities, as a result of pricing the negative externalities of pollution (e.g., in the case of a carbon tax), and of investors' financial valuation of firms' assets. This, in turn, would affect investors' risk assessment and portfolio allocation, supporting the scaling up of green investments and the divestment by high carbon activities that could lead to stranded assets.

4.1.6. Soft loans and credit guarantee

Figure 6 includes the transmission channels from the soft loans and credit guarantees to the financial sector and real economy, encompassing the increase of NDBs' balance sheet and projects' eligibility.

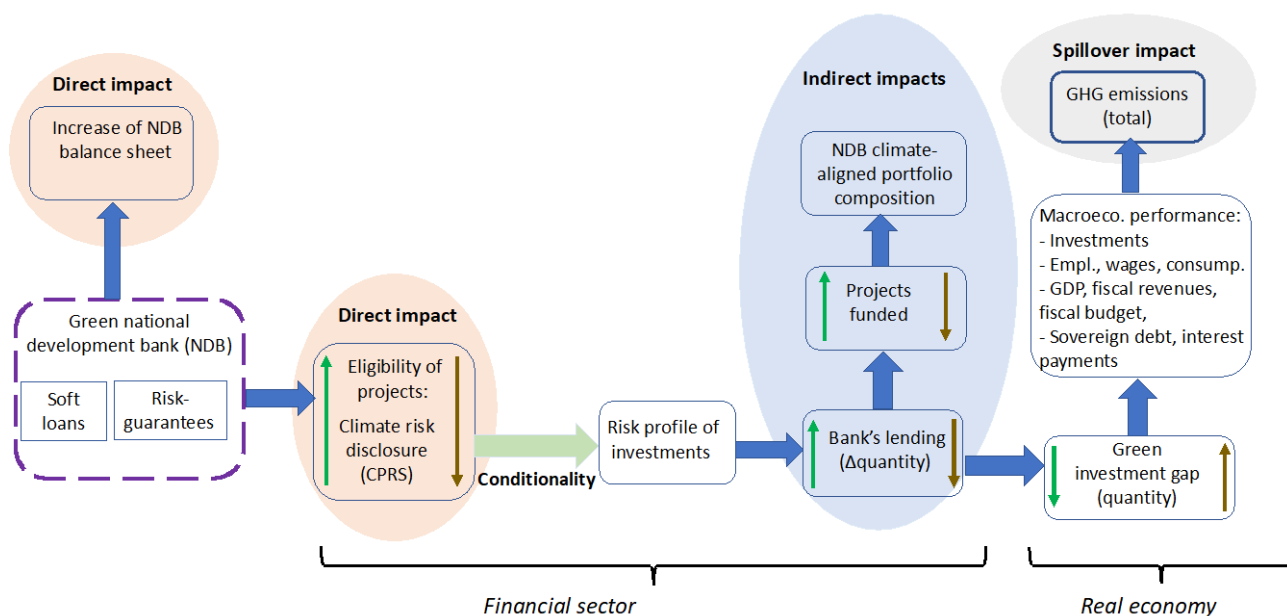


Figure 6: Macro-financial transmission channels of green development banking via soft loans and credit guarantees. The purple box indicates the policy. Up-facing arrows: Positive trend. Downfacing arrows: negative trend. Green arrows: policy impacts on low-carbon firms. Brown arrows: policy impacts on high-carbon firms. Thick green arrow: conditionality. Pink area: direct impacts. Blue area: indirect impacts. Grey area: spillover impacts. Green arrow: conditionality.

NDBs can influence the low-carbon transition by *granting soft loans* to finance low-carbon projects, and by *providing credit guarantees* to mitigate the risks of the lending institutions that finance low-carbon projects (direct impacts). Both instruments contribute to foster investments in low-carbon activities.

The main difference between the soft loans and the credit guarantees is that the soft loans represent direct lending to low-carbon projects, while the guarantees indirectly affect the decision of lenders to grant loans to low-carbon projects, by providing guarantees in case of possible losses. Soft loans have a direct impact on lowering the cost of capital for new green investments, on macroeconomic performance (e.g., new green jobs) and thus on GHG emissions. In contrast, the impact of guarantees on lowering the cost of capital for green investments, on macroeconomic performance and GHG emission reduction is indirect and depends on the lending conditions, which are eventually decided by banks.

Either the creation of a Green National Development Bank (GNDB), an individual loan/guarantee program of an existing GNDB or of other public finance providers, could support the funding of low-carbon companies and reduce investment in high-carbon companies.

The increase of low-carbon investment driven by soft loans and risk guarantees has a positive effect on narrowing the green investment gap and on improving macroeconomic performance, because higher low-carbon investment leads also to higher workforce needed, increasing employment in low-carbon activities. However, the overall effect on GHG emissions reduction can be ambiguous. On the one hand, the higher investments in low-carbon activities could also lead to a reduction of GHG emissions (positive spillover effect). On the other hand, the increase in economic activity could benefit high carbon activities (e.g., production of components for solar PV), and increase GHG emissions (negative spillover effect).

5. A THEORY OF CHANGE (TOC) FOR THE ROLE FOR GREEN FINANCIAL SECTOR INITIATIVES IN CLIMATE MITIGATION AND DECARBONIZATION

We build on the insights of the previous section to develop a Theory of Change (ToC) aimed to operationalize GFSI for climate mitigation and decarbonization objectives, with a focus on EMDEs. As illustrated in Figure 7 the ToC is structured into (i) challenges, (ii) opportunities, (iii) enabling conditions, (iv) outcomes, (v) impacts, and (vi) expected impacts.

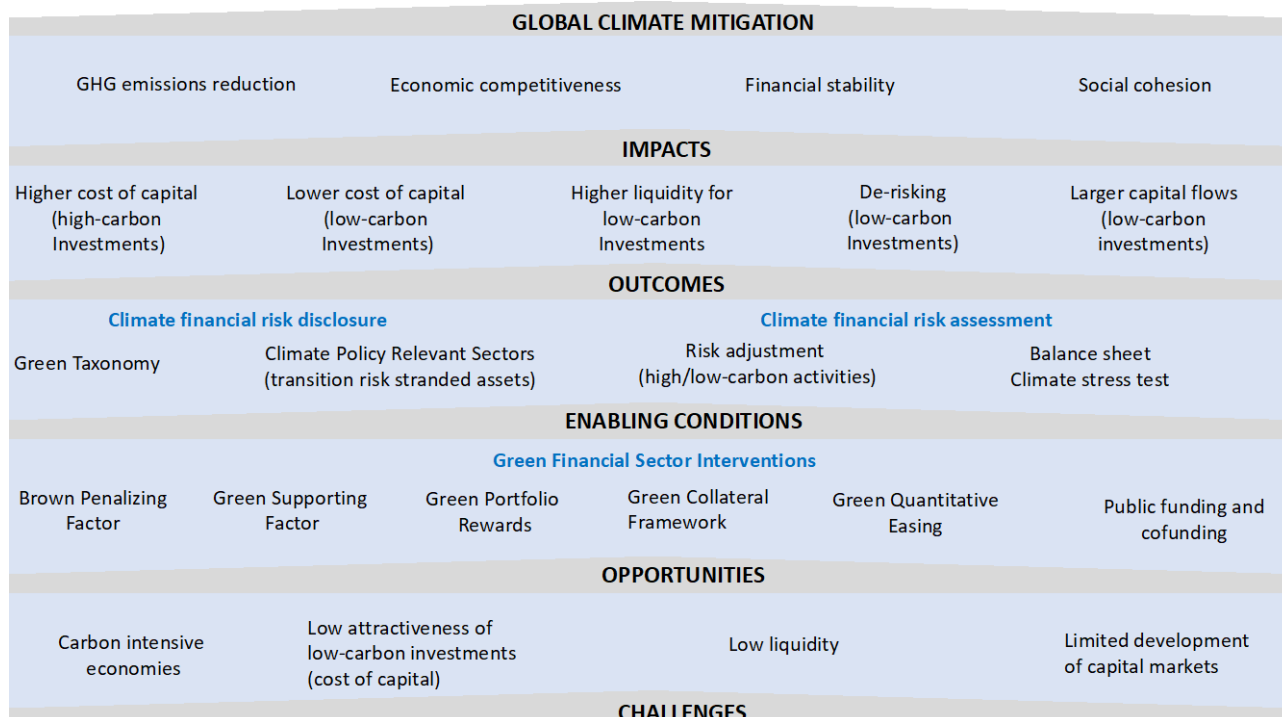


Figure 7: Diagram illustrating the Theory of Change (ToC) of GFSI for climate mitigation, and its building blocks.

Challenges. Challenges for a low-carbon transition include the initial high-carbon composition of the economy, the low attractiveness of low-carbon investments (e.g., due to higher costs of capital, lack of available renewable energy technologies that can be readily deployed at the country level), low firms' liquidity, limited capital flows (e.g., due to country's business environment and governance), and low development of capital markets (which is a common condition to several low-income countries).

Opportunities. The above-mentioned challenges can be addressed with tailored GFSI, which act here as *potential solutions*. For instance, both a DPF and a GSF could help to decrease the current carbon intensity of the economy, and its climate transition risk exposure. In contrast, the GSF and the green monetary policies considered can increase the attractiveness of low-carbon investments by affecting the cost of capital and relative prices. Green monetary policies could contribute to increase liquidity in the system posing the conditions for higher banks' lending (in theory). Finally, public funding and co-funding could support capital market development and de-risk investments in low-carbon technologies and economic activities. In this regard, it would be important to learn from past experiences of Public Private Partnerships (PPP) that involve national or multilateral development banks (such as EIB) in order to (i) prevent governments to take too large project risks, which could impair their sovereign financial solvability, and (ii) allow governments to access gains of successful projects.

Enabling conditions. Two enabling conditions play a crucial role for moving from solutions to *outcomes*. On the one hand, standardized *climate financial risk disclosure* should be introduced by all financial actors that implement the GFSI. By learning from international best practices, this could consist of the implementation of a green taxonomy (e.g., on the example of the EU Taxonomy) and of a classification of economic activities' exposure to climate transition risk (e.g., the CPRS). On the other hand, financial institutions that implement the GFSI should adopt standardized *climate financial risk assessment methods* such as climate stress testing of balance sheets (see e.g., Battiston et al. 2017, Roncoroni et al. 2021, Allen et al. 2020, Reinders et al. 2021, Alogoskoufis et al. 2021).

An example of how to carry out a *standardized* climate financial risk assessment is provided by the CLIMAFIN methodology for climate stress test developed by Battiston et al. (2019), which builds on Battiston et al. (2017) and is further developed in Roncoroni et al. (2021). The methodology consists of the following steps:

- *Classifying economic activities into CPRS* and mapping them into the sectors and variables of the Integrated Assessment Models that provide climate mitigation scenarios. Those can then be mapped to investors' portfolios of financial contracts.
- *Adjusting the financial valuation* of firms' financial contracts and securities conditioned to forward looking climate mitigation scenarios (e.g., those provided by the NGFS).
- *Adjusting financial risk metrics* (e.g., Probability of Default (PD), Expected Shortfall (ES)) conditioned to climate scenarios, considering the non-linear dependency between change in risk metrics and the probability of occurrence of disorderly transition scenarios and thus the tail risk

associated (Battiston and Monasterolo 2020). In this regard, it is important to consider that the valuation adjustment for bonds and loans, which usually represent the largest part of financial exposures, is more complex than for equity holdings, and requires tailored approaches.

- *Assessing the largest losses conditioned to the climate scenarios*, considering reverberation of losses due to financial interconnectedness, through a balance sheet climate stress test. To this aim, national central banks could benefit from existing research and NGFS policy applications of climate stress tests, through tailored trainings and capacity building activities.

Outcomes. The implementation of specific GFSI – depending on the challenges identified at the country level – would lead to adjustments in the sector and technology composition of the economy, i.e., in a decrease in high-carbon and an increase in low-carbon investments. Other relevant implications would imply more liquidity available for banks and firms willing to invest in low-carbon activities, and the de-risking of low-carbon investments and to larger capital flows, by attracting green foreign direct investments (FDI) and investments from international financial institutions.

Impacts. The socio-economic and mitigation *impacts* would include:

- (i) GHG emissions reduction for the country, allowing it to narrow its emissions gap and to achieve ambitious climate mitigation targets.
- (ii) Smoothing the short-term negative economic impacts (e.g., unemployment, lower fiscal revenues, distributive effects).
- (iii) Strengthening financial stability in order to mitigate risks of a disorderly transition and its implications on asset prices volatility and stranded asset.
- (iv) Promoting social cohesion, by taming large distributive effects for poorer cohorts of the population, who are generally most exposed to climate physical risks (which will increase in case of failed mitigation) and have little ability to cope with them.

Thus, the ToC provides an operative framework for delivering the transformational change in climate finance needed to achieve ambitious climate mitigation objectives in EMDES, in the short time available.

Figure 8 illustrates the ToC implementation framework composed of four steps, i.e., (i) the identification of a country's decarbonization goals and relevant GFSI, (ii) the analysis of the transmission channels to the economy and finance, considering the country-specific socio-economic and financial characteristics, (iii) the identification of the conditions and challenges for GFSI introduction, and (iv) the design of the governance framework for successful implementation. Note that, in principle, the ToC and its implementing framework can be tailored and applied to any country.

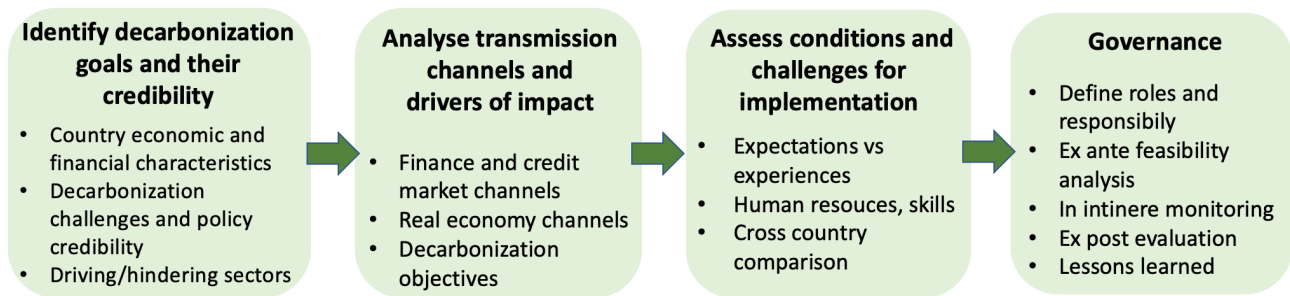


Figure 8: ToC implementing framework in four interconnected steps.

Step 1. The first step of a ToC is to identify the country’s decarbonization goals and their policy credibility. This includes a comparison of its Nationally Determined Contributions (NDCs) and most recent climate pledges with climate economic policies already implemented or foreseen, an analysis of the economic sectors that would play a main role in this process (either because exposed to climate transition risks, or relevant for the production of renewable energy and electricity and low-carbon assets). Indeed, the adjustments in cost and availability of capital entailed by GFSI can work best if GFSI complement climate economic policy packages that make such adjustment persistent over time. In the absence of a country’s credible commitment on a NetZero path, GFSI could lose effectiveness, because eventually interest rates, cost of capital and risk scores for low carbon firms would revert to the levels of the high-carbon ones.

Step 2. Second, the identification of the country-based decarbonization challenges, and financial characteristics, should guide the selection of the relevant GFSI and their implementation. Country-specific challenges may include potential trade-offs between phasing out highly climate-relevant activities (e.g., coal and metals extraction) and respective socio-economic implications (e.g. employment, fiscal revenues, GDP). For instance, in countries where fossil fuels extraction and value chain play a large role in the economy, it would be preferable to implement first a GSF, and/or a GQE (if the corporate bond market is functioning) than a DPF.

With regards to financial stability objectives, the degree of preparedness of financial institutions, as well as the degree of deepening and interconnectedness of the financial market matter and should be considered. The degree of financial complexity in EDMs is generally limited, and the banking sector is usually subject to central bank’s supervision (e.g., in Malaysia). Furthermore, in some low-income and even in emerging countries, such as Morocco, the degree of banks’ financial interconnectedness is very limited. In this context, both GSF and GCF and GQE could play an important role, given a previous introduction of a green taxonomy, and a green conditionality on the use of proceeds.

Step 3. Third, the implementing conditions are crucial for the success of the selected GFSI. In countries where central banks have limited space of action (e.g., due to their narrow mandate), limited human capital and limited supervisory power, GCF or GQE could be challenging to implement. In contrast, in countries with a limited degree of financial deepening and poorly

regulated capital markets, implementing GSF or DPF could be little effective with regards to the scaling up of green investments in the short term. Challenges for individual financial stability could emerge, potentially requiring central banks' intervention. In addition, all the GFSI that work via the credit channel would be little effective in countries where firms are generally small (or micro), have limited or no credit record and thus face severe limitations in access to credit. Thus, increasing the capitalization of NDBs, and greening public development banks, could be a preferable solution.

Step 4. Governance would guide the implementation of the ToC via a set of GFSI that involve fiscal, monetary and macroprudential interventions. Good governance would improve the effectiveness of GFSI substantially. Importantly, the TOC allows to regard the GFSI beyond the logic of local interventions and project funding, and to create an enabling environment for climate finance. Therefore, the governance dimension is important here. First, the comparative analysis of GFSI transmission channels, including their direct, indirect and spillover impacts for economic decarbonization, helps to understand the conditions for policy implementation and impact on mitigation. Second, it provides the tools to understand where synergies across GFSI could emerge, in order to leverage on complementarities and maximize impact. Finally, it contributes to inform their design, programming, and implementation in the context of international climate finance, and their tailoring at country level, considering countries' climate challenges, and socio-economic and financial characteristics.

6. CONCLUSION

In this analysis we have developed a ToC for the role of GFSI in the decarbonization of the economy and in the low-carbon transition, with a focus on EMDEs. First, we identified and analyzed the most debated GFSI, their specific transmission channels to the banking sector and to the real economy (with a focus on high-carbon and low-carbon activities). Then, we discussed the implementation challenges for emerging markets and developing economies. Finally, we developed a ToC for the operationalization of GFSI in order to enable beneficiary countries' GHG emissions reduction plans and climate mitigation pathways.

The qualitative analysis indicates that specific GFSI work via three main channels, i.e., *the price/interest rate channel*, *the quantity channel* (lending to the real economy) and *investors' portfolio rebalancing*. Depending on the challenges identified at the country level, the GFSI would lead to an adjustment in the sector and technology composition of the economy (decrease in high-carbon, increase in low-carbon ones), higher liquidity available for banks and firms willing to invest in low-carbon activities, and de-risking of low-carbon investments and larger capital flows, by attracting green FDI.

However, potential rebound effects for GHG emissions could emerge as a result of the larger liquidity, and of the consequent potential larger lending to the real economy, if no green conditionality and climate risk assessment is accompanied with the GFSI. Indeed, large positive

spillover effects on demand for investments in the economy generated by the liquidity and capital availability of the GFSI could also benefit high-carbon activities and lead to unintended higher GHG emission intensity in the economy.

Those indirect effects pose several challenges when aiming to quantify the impact of GFSI on macroeconomic variables and GHG emission reductions. In particular, the quantification of the impact of each GFSI on GHG emissions depends on the conditions of GFSI implementation, which in turn might vary across time and space. Then, access to and availability of affordable finance represent important obstacles in several countries. Moreover, there are substantial uncertainties about the value of key parameters such as the elasticity of the investment demand to interest rate.³⁵ Finally, there is a large number of confounding factors and policies whose effects need to be disentangled. More broadly, our analysis shows that transmission channels can be extremely complex and involve several feedback loops.

Our results highlight that because of those indirect feedback loops the quantification of GFSIs and of their transmission channels is important to better understand the full GHG emission impacts. Yet, challenges remain given the level of uncertainty associated (e.g., due to the presence of feedback effects) and the limited availability of the required data/models for the quantification. In this context, climate financial risk disclosure and risk assessment is a precondition for a successful application and tailoring of the ToC and the effective implementation of the GFSI at the country level, to reduce the risk of greenwashing and allow for the sustainable development of green finance markets.

Finally, the policy complementarity of GFSI needs to be highlighted. GFSI can support GHG emission reductions only if the country engages on a decarbonization path by means of economic policies. A country's credible commitment on a NetZero path, by means of phasing out fossil fuel subsidies and measures to support firms and workers in affected sectors, implies that a higher cost of capital for high carbon firms make economic sense and is in line with financial valuation. Thus, the adjustments in cost and availability of capital entailed by GFSIs can work best if they complement climate economic policy packages that ensure persistence over the years of the transition. In contrast, in the absence of a country's credible commitment on a NetZero path, GFSI could lose effectiveness, because eventually interest rates, cost of capital and risk scores for low carbon firms would revert to the levels of the high-carbon ones.

³⁵ See in this respect the concluding section of the 2DII report on "Assessing the impact potential of financial products supporting the energy transition", available at <https://2degrees-investing.org/wp-content/uploads/2021/11/Impact-Potential-Green-Finance-Products.pdf>

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