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Climate change: policies to manage its macroeconomic and financial effects

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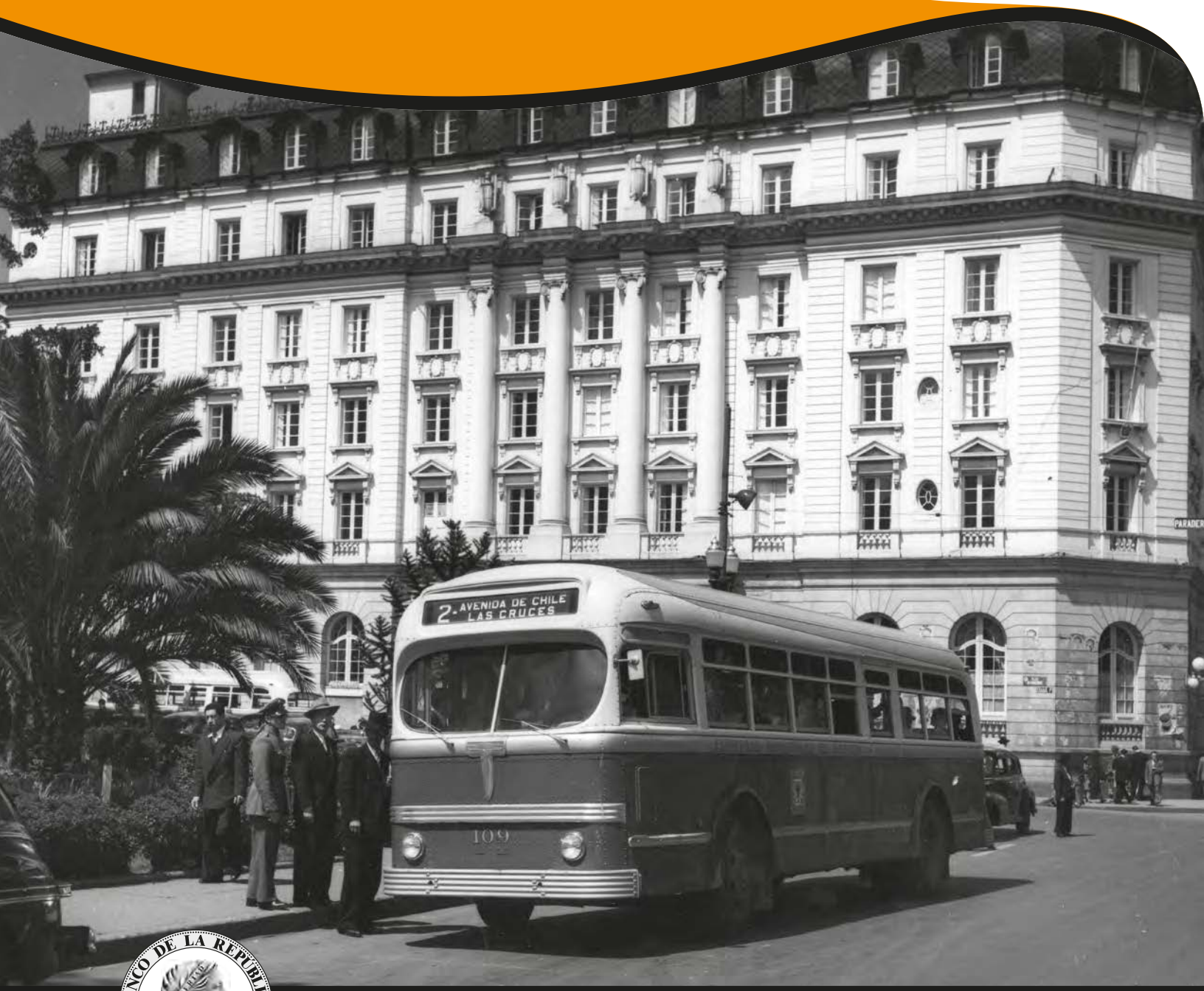

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Climate change: policies to manage its macroeconomic and financial effects

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Abstract

It is increasingly recognized that climate change generates major macroeconomic and financial risks. There are physical risks associated to the disasters generated by hydro-meteorological events and to gradual but persistent changes in temperatures that have structural impacts on economic activity, productivity and incomes. Additionally, the process of adjustment towards a lower-carbon economy, prompted by changes in climate-related policies, technological disruptions and changes in consumer preferences, generates transition risks. After a brief analysis of the macroeconomic, fiscal and tax policies to manage these risks, this paper concentrates on: (i) how financial policies can help improve transparency and climate-related risk disclosure in financial institutions' balance sheets and assets prices, particularly with appropriate prudential regulation and supervision; and (ii) how those risks could be taken into account in monetary policy and central banks' balance sheets and operations. The paper ends with some reflections on the Covid-19 pandemic and the will for a "green" recovery.

Keywords: climate change, carbon tax, financial policy, monetary policy, central banks.

JEL: E50, G18, H23, Q54.

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Cambio climático: políticas para manejar sus efectos macroeconómicos y financieros

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Resumen

Cada vez se reconoce con mayor claridad que el cambio climático genera importantes riesgos macroeconómicos y financieros. Existen riesgos físicos asociados a los desastres generados por eventos hidrometeorológicos y a cambios graduales pero persistentes en las temperaturas que tienen un impacto estructural en la actividad económica, la productividad y los ingresos. Además, el proceso de ajuste hacia una economía con bajas emisiones de carbono, inducido por cambios en las políticas relacionadas con el clima, cambios tecnológicos y cambios en las preferencias de los consumidores, genera riesgos de transición. Después de un breve análisis de las políticas macroeconómicas, fiscales y fiscales para gestionar estos riesgos, este documento se concentra en: (i) la forma como las políticas financieras pueden ayudar a mejorar la transparencia y la información de los riesgos relacionados con el clima en los balances de las instituciones financieras y los precios de los activos, particularmente con una política de regulación y supervisión prudencial apropiada; y (ii) cómo se podrían tener en cuenta esos riesgos en la política monetaria y en los balances y operaciones de los bancos centrales. El artículo termina con algunas reflexiones sobre la pandemia de Covid-19 y la voluntad de una recuperación "verde".

Palabras claves: cambio climático, impuesto al carbono, política financiera, política monetaria, bancos centrales.

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I. Introduction

Humanity has achieved a remarkable reduction in poverty levels and a significant advance in human development in practically all geographies of the planet. However, production and consumption patterns have been associated with extremely high energy consumption and increasing use of natural resources, with a strong negative impact on the environment and biodiversity. Energy consumption, which is based largely on fossil fuels, has already generated global warming, which already exceeds pre-industrial levels by around 1°C[1].

The current trend will lead to global warming well above the Paris Agreement target of 2°C or preferably 1.5°C above pre-industrial levels (UNFCC, 2015), which is considered critical to avoid the irreversible risks associated with climate warming. However, the long-term nature of this phenomenon, the difficulty in quantifying its impact and its possible tipping points and non-linearities, and the fact that the physical, economic and financial risks related to the climate have only been progressively advancing, has led many economic agents, including governments, to delay action. In the words of Carney (2015, p. 4), "climate change is the Tragedy of the Horizon (…) the catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors – imposing a cost on future generations that the current generation has no direct incentive to fix".

This paper analyzes the macroeconomic and financial effects of climate change and the policies that can help mitigate them. It is divided in five sections, the first of which is this introduction. The second takes a look at the macroeconomic effects. The third considers the alternative macroeconomic, fiscal and tax policies. The fourth looks, in turn, at possible financial policies, and the fifth at monetary policy and other possible central bank actions. The paper ends with some reflections on the Covid-19 pandemic and the will for a "green" recovery.

II. Macroeconomic effects of climate change

Climate change generates widely known *physical risks*, particularly disasters associated with hydro-meteorological events such as hurricanes, tornadoes, cyclones and monsoons, floods, avalanches, and, conversely, desertification and increasing aridity. These impacts are wide-ranging, since they will affect all agents and sectors of the economies in all geographies of the planet –although in an uneven way (NGFS, 2019a). These major events, as well as gradual but persistent changes in temperatures have structural impacts on economic activity, consumer preferences and the well-being of the population. In addition to them, the process of adjustment towards a lower-carbon economy prompted by changes in climate-related policies, technological disruptions and changes in consumer preferences, generates what in the literature are called *transition risks*. There are, thus, multiple mechanisms of transmission of climate change on the macroeconomy and the financial sector, both on the supply and

[1] According to IPCC (2018, p. 6), the "observed global mean surface temperature for the decade 2006–2015 was 0.87°C higher than the average over the 1850–1900 period (…) Estimated anthropogenic global warming is currently increasing at 0.2°C per decade due to past and ongoing emissions".

demand side (NGFS, 2019b)[2]. We will analyze in this section the macroeconomic dimensions of the physical and transition risks, and in section IV their financial dimensions.

1. Transmission mechanisms on the macroeconomy and sectorial effects

Agriculture, the livestock sector and fishing are particularly sensitive to changes in the climate, and so climate change can become a serious threat to them. Extreme weather events cause crop failures, destroy facilities and infrastructure and disrupt supply chains. Gradual warming and more volatile precipitation patterns may cause the intensification of soil degradation and desertification; loss of productivity and suitability of certain crops and even the risk of loss of genetic resources; and the increase and displacement of pests, among others. In the livestock sector, changes in temperature and precipitation are decisive in production and in the quality of different types of pasture and forage, as well as in the ability of livestock to feed and gain weight, therefore affecting the production of meat and milk. In fishing, warming of the seas, their acidification and overexploitation have substantially reduced biodiversity and put the survival of many species at risk. The latter is also the case for many terrestrial species as a result of the increasing loss of forests and jungles.

For all these reasons, climate change-related events may cause agricultural supply shocks (both temporary and structural) and hence have an impact on food prices, which are an important component of consumer prices. For developing economies in which these primary sectors are central pillar of the economic activity, and food constitutes a large share of the consumption basket, climate change effects may also have a broad impact on aggregate income and employment.

Other productive sectors that can also be negatively affected by natural phenomena (physical risks) are transportation, coastal real estate, public utilities, etc. Some can also be hit by policy decisions and technological developments (transition risks), such as oil and coal, and those highly intensive in their use, such as steel, aluminum, cement, glass, chemicals, plastics, paper, etc. In contrast, other sector can take advantage of new opportunities, such as unconventional renewable energy, electric vehicle production, and the information industries, among others.

Extreme weather events can also destroy physical infrastructure and productive capacity, generate shortages of resources and products, and cause more frequent disruptions in production processes, trade and supply chains, both domestic and international. This generates the need to divert investment towards the adaptation to climate change –and to the possible reconstruction of damaged infrastructure, buildings and machinery.

Firms could face a more complex environment, with higher operating costs; legal liabilities, and regulatory and reputational risks; and changes in the behavior of their clients (buyers and suppliers) and in the demand for their products towards more environmentally friendly ones. There would also be more uncertain conditions for investment, due to possible distortions in market signals, uncertainty about potential growth and evolution of future demand, anticipated depreciations of existing assets as a result of changes in policies and regulations, lower profitability of existing assets, and higher expenses in adaptation and mitigation, as

[2] NGFS (2019b, pp. 6-10) analyzes the mechanisms of transmission of climate change to the macroeconomy and its effects on financial stability, and provides a survey of methodologies, models and quantitative estimates.

well as the development of alternative technologies. These problems could be exacerbated by policy decisions necessary to face climate change, such as carbon taxes (see section III), which could increase the transition risks (see section II.2.b and IV.2).

For their part, households, especially the most vulnerable, could face an impact on the relative prices of food, fuel, transport and basic public utilities such as energy and water, which would affect their consumption capacity. Their properties could also be more exposed to physical risks that would affect their value, possibly inducing them to increase their precautionary savings. Additionally, the multiple physical phenomena associated with climate change, such as heat stress, will have an impact on people's health, which would be reflected in higher rates of morbidity and mortality and, consequently, would have implications for labor productivity.

It is also possible to anticipate structural effects and volatility in the relative prices and traded volumes of many commodities that have an important role in international trade (hydrocarbons and minerals, food and other) that could alter the terms of trade and real exchange rates of many emerging and developing countries, in quantities that are difficult to forecast. Taxes, regulations and restrictions on imports and exports resulting from transition policies might also influence trade patterns (section III). Real exchange rates of many countries might also be affected by lower labor productivity. Supply chains could be more frequently hit by geophysical changes and weather events.

It is foreseeable, then, that climate change will have a significant impact on the potential growth of the world economy, although its effects will not be homogeneous in all geographies or sectors. As one of the best studies on the subject points out, quantifying the potential magnitude of these risks and the distribution of financial losses is complex "because of the radical uncertainty associated with an environmental, physical, social and economic phenomenon that is constantly changing and involves complex dynamics and chain reactions. Traditional backward-looking risk assessments (that merely extrapolate historical trends) and existing climate-economic models cannot anticipate accurately enough the form that climate-related risks will take" (Bolton et al, 2020, p. iii). In turn, "Climate-related physical and transition risks involve interacting, nonlinear and fundamentally unpredictable environmental, social, economic and geopolitical dynamics that are irreversibly transformed by the growing concentration of greenhouse gases in the atmosphere (…) Exceeding climate tipping points could lead to catastrophic and irreversible impacts" (Bolton et al, 2020, p. 1).

2. Quantitative estimates of the impact of climate-related risks on the economy

The Central Banks and Supervisors Network for Greening the Financial System (NGFS, 2019b, section 2; 2020c) has prepared a synthesis of modeling approaches, methodologies, aggregate and sectoral estimates, of the impact of climate on the economy and on financial stability. Although the transmission mechanisms indicated above are clear, the radical uncertainty of this phenomenon and its forward-looking nature explain why the range of estimation results is very wide and depends on the assumptions made in aspects such as climate change scenario, future path of climate policies, timing of reaction, discount rates, the rate of progress in carbon-neutral technologies, the feedback loops effects, the level of adaptation and adaptive capacity and nonlinearities or uncertainties related to the nature of climate risks.

a. Physical risks

As indicated in the beginning of this section, physical risks are those that arise from climate-related hazards. They generate economic costs resulting from the increasing severity and frequency of extreme climate-related weather events, as well as from longer term progressive shifts of the climate (such as changes in precipitation, extreme weather variability) that reduce productivity, disrupt global supply chain, etc. Later, in section. IV, this issue will be revisited from a financial stability perspective.

NGFS (2020c) estimates that in the Hot house world scenario[3], impacts from physical risk (progressively cumulative) result in up to a 25% GDP loss by 2100. NGFS (2019b, p. 7) had reported a number of researches on the subject, among which the one made by the OECD (2015) is located at a midpoint with respect to other studies. It calculates the losses in world GDP by 2100 in up to 12% if timely mitigating measures are not taken. Other works mentioned include Burke et al. (2015), that calculates falls of over 20% of the world GDP by 2100 relative to a scenario without changes in the climate. At the other extreme, Nordhaus (2017) estimates falls of 2.1% if the average world temperature increases by 3°C, and 8.5% if warming rises to 6°C. The NGFS points out, however, that the first generation IAM models that served as the basis for this last calculation generate a possible underestimation of economic losses. Finally, they quote the estimate of Hsiang et al. (2017) for the USA, with expected GDP losses that increase quadratically as a function of the increase in temperature, with ranges between -0.1 and 1.7% of GDP with warming of 1.5°C, between 1.5 and 5.6% of GDP with 4°C warming, and worse at higher temperatures. The most affected economic activity is agriculture (9 to 12% yield losses for each °C).

Regarding geographic impacts, it is anticipated that climate change will affect tropical countries more harshly, many of which correspond to those with the lowest incomes and levels of human development. According to IMF (2017, pp. 126, 128), "in countries with high average temperatures, an increase in temperature dampens economic activity, whereas it has the opposite effect in much colder climates. The threshold temperature is estimated to be about 13°C to 15°C. (…) Emerging market economies and particularly low-income developing countries tend to have much hotter climates, and a rise in temperature significantly lowers per capita GDP growth. For the median emerging market economy, a 1°C increase from a temperature of 22°C lowers growth in the same year by 0.9 percentage points. For the median low-income developing country, with a temperature of 25°C, the effect of a 1°C increase in temperature is even larger: growth falls by 1.2 percentage points. And even though countries projected to be significantly affected by an increase in temperature produced only about one-fifth of global GDP in 2016, they are home to close to 60 percent of current global population and more than 75 percent of the projected global population at the end of the century".

Along these lines, the 2019 Human Development Report (UNDP, 2019) points out that developing countries and poor communities have less capacity to adapt to climate change and extreme weather events than richer countries. Therefore, climate change can widen existing socioeconomic inequalities. These heterogeneous social and regional impacts can

[3] "Hot house world assumes that only currently implemented policies are preserved. Nationally Determined Contributions are not met. Emissions grow until 2080 leading to 3°C+ of warming and severe physical risks (NGFS, 2020c, p 6)

generate different political manifestations, as well as complex migratory flows and even conflicts, both within countries and internationally.

b. Transition risks

Transition risks are related to the process of adjustment towards a lower-carbon economy prompted by changes in climate-related policies (taxes, subsidies, regulations), technological disruptions (e.g., in the alternative renewable energy sector) and changes in consumer preferences (e.g., transport demand, diets). They are thus associated to the transformation of the modes of current production and consumption to reduce greenhouse gas (GHG) emissions and mitigate climate change. They have macroeconomic effects, analyzed here, as well as financial stability implications, discussed in section IV.

NGFS (2020c, p. 8) presents a range of estimates on the impacts of transition risks. They vary between -4% of the GDP by the end of the century in an orderly scenario (where climate policies are introduced early)[4] and -9% of GDP in a hot house world scenario. The report adds that: "some studies from the wider literature suggest that the impacts could be smaller, or even positive, given the rapid reduction in the cost and increased deployment of new technologies. Still, all users of energy and emitters of carbon will be affected, with major fossil fuel exporting regions most at risk".

NGFS (2019b) presents a synthesis of the estimates of various previous studies on the transition risks. In brief: "the studies suggest that the economic costs of meeting the requirements to give a likely chance of limiting global warming to 2˚C would be between 1 and 4% of global aggregate consumption levels in 2030. The impact of the transition on GDP depends heavily on the assumptions underlying the analysis, but models generally agree that the speed and timing of the transition is crucial for macroeconomic costs: if it is *orderly and starts early,* costs can be minimized, because it allows for an orderly transition of the existing capital stock and infrastructure. According to Furman et.al. (2015) a one-decade delay in addressing climate change would result in a 40% increase in the net present value cost of doing so" (NGFS, 2019b, p. 10).

Transition risks can also have heterogeneous regional effects, since it is clearly foreseeable that climate change will have stronger impacts on countries and regions that are more dependent on hydrocarbon and coal exports, which are usually also dependent on these sectors for public sector revenues (taxes, royalties, and profits of state-owned enterprises).

A concrete example is the study by Huxman et al (2019) on South Africa, which is one of the main coal exporting countries in the world and whose public finances are also highly dependent on income from that sector. They estimate that the net present value for this country of the cost of a global transition to a low-carbon transition economy, for the accumulated period 2013-2035, is $120 billion[5], approximately a third of its 2019 GDP. Another notable result is that, although the public sector's share in those losses are only 16%, with investors facing the rest, the latter can become contingent liabilities for the national

[4] In NGFS's (2020c, p 6) orderly scenario, net zero CO_2 emissions are achieved before 2070, giving a 67% chance of limiting global warming to below 2°C, thanks to the significant amount of investment undertaken to make the transition to a carbon-neutral economy.

[5] The sign $ is made to represent US dollars throughout this paper.

government. Thus, when potential bailouts to investors, support to workers who lose their jobs and assistance to struggling municipalities are taken into account, the transition risks borne by the national government could triple.

3. Transmission mechanisms on central bank policies: a first approach

Finally, a brief reference to climate change transmission mechanisms on central bank policies should be added (an issue that would be analyzed in more detail in section V). From the previous analysis, prices and price variability could be affected through various channels by climate change, including through the increase in the frequency and severity of extreme weather events. Climate change can also lead to supply-side shocks that may cause strong trade-offs for central banks between stabilizing inflation and stabilizing output fluctuations.

In this regard, many authors also consider that there is a clear risk that climate change will generate stagflation (Villeroy de Galhau, 2019). According to Brainard (2019), these types of supply shocks pose more complex dilemmas for monetary policy than demand shocks and the policy response is very different in the face of a transitory shock than in the face of a more persistent one. She concludes that "to the extent that climate change and the associated policy responses affect productivity and long-run economic growth, there may be implications for the long-run neutral level of the real interest rate, which is a key consideration in monetary policy", and "Just on its own, the large amount of uncertainty regarding climate-related events and policies could hold back investment and economic activity" (Brainard, 2019, pp. 3-4).

4. Some preliminary take-aways

In conclusion, as Stern (2007) has stated, climate change is "the greatest market failure the world has seen". As explained by Krogstrup and Oman (2019, pp. 14-16), "a set of market and governance failures prevent the required transition from taking place in time via the market (…) market prices do not reflect the social cost of carbon and hence over-emit greenhouse gases, or underprovide mitigation (…) market failures include different variants of: common pool and free rider problems, time inconsistency or impatience that leads to short-termism (due to two major sources of risk: uncertainty around their ability to deliver carbon abatement, and uncertainty around the future value of avoided emissions). Market failures interact with government failures: common pool and free-rider problems (since the benefits of carbon abatement mostly accrue to citizens of other jurisdictions or countries), collective action and capture by powerful interest groups".

To face this problem, it is imperative to massively transform the structure of world economic activity and consumption patterns to allow development with low GHG emissions, increase global capacity to adapt to the effects of climate change, and promote climate resilience. But, as stated by Bolton et.al. (2020, p. 5), "changing our production and consumption patterns and our lifestyles to transition to a low-carbon economy is a tough collective action problem. There is still considerable uncertainty on the effects of climate change and on the most urgent priorities. There will be winners and losers from climate change mitigation, exacerbating free rider problems. And, perhaps even more problematically, there are large time lags before climate damages become apparent and irreversible (especially to climate change sceptics):

the most damaging effects will be felt beyond the traditional time horizons of policymakers and other economic and financial decision-makers. This is what Mark Carney (2015) referred to as 'the tragedy of the horizon'".

In the next section we discuss some macroeconomic, fiscal and tax policy alternatives, leaving for sections IV and V those related to financial and monetary policy and other actions within the reach of central banks and financial regulators.

III. Alternative macroeconomic, fiscal and tax policies

Article 2 of the Paris Agreement (UNFCCC, 2015) calls on signatory countries to increase "the ability to adapt to the adverse impacts of climate change and foster climate resilience", and make "finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development"

For this purpose, it is necessary to explicitly incorporate the objective of mitigating the impact of climate change in the framework of public policy, particularly macroeconomic, fiscal, tax and financial policies. Regulations that discourage undesirable actions and uses of resources and that transmit signals that encourage others are fundamental and must be complemented by large-scale investments, both public and private. Coordination between a large number of state entities with different institutional mandates, and with a large number of stakeholders from the financial markets, the real sectors and civil society, represents a highly complex challenge.

1. Tax and fiscal policies and investments in renewable energy

So far, much of the effort has been focused on investments in renewable non-conventional energies –solar and wind, in particular. These actions are of the utmost importance and substantial private and public investments should be directed to them. But a massive transformation of the productive apparatus and consumption patterns is required, including through the wide adoption of new technologies, profound adjustments in land use, and changes in consumer behavior induced by radical adjustments in the costs of GHG, and particularly CO_2 emissions, complemented by large investments in sustainable infrastructure, construction, R&D and productive capital, among others (Krogstrup and Oman, 2019).

There is a wide agreement in the literature in that the theoretical "first-best" response to climate change comprises a path of taxes on GHG emissions (particularly if it is internationally coordinated) combined with subsidies to R&D in new "green" technologies. The complexity of the subject makes a case for also using a much broader set of tools, such as regulations, spending and investment policies and public guarantees. Financial policy tools can play a complementary role to enable the change in the underlying financial asset structure that is needed to transform the productive structure of the economy (Krogstrup and Oman, 2019; Bolton et al, 2020; IMF, 2019; World Bank, 2019).

Regarding the first best option, there is a broad consensus in the literature that the primary and fundamental action of public policy is to internalize the externalities associated with the social cost of GHG emissions. For this purpose, the elimination of fossil fuel subsidies and

the adoption of carbon taxes (i.e., on CO_2 emissions) are absolutely essential. According to Turner (2020), "the ideal policy (…) would be a globally agreed carbon price, which would encourage producers in all countries to adopt low- or zero-carbon technologies. Absent this ideal, there are now growing calls (…) for a second-best solution –domestic carbon prices imposed in particular countries plus 'border carbon adjustments,' meaning carbon-related tariffs on imports from countries that do not impose an equivalent carbon price on their producers".

However, the current level of such taxes is very low in most countries and a large number have not yet implemented them, which makes the world average estimated by the IMF (2019, p. ix and 3), of $2/ton of CO_2 is clearly below the minimum considered socially optimal. The IMF (2019, p. 3) has advocated for international coordination in the prompt setting of a global minimum level[6] –at the very least among the main GHG emitter countries so that it would provide reassurance against losses in competitiveness and address free-rider issues—, and gradually increased it to levels of $75/ton in 2030. Of the countries referenced in IMF (2019), only Sweden ($127) and Switzerland ($96) have set levels above this value, and close to it are Norway ($59) and Finland ($65). Emerging economies include South Africa ($10/ton), Chile and Colombia ($5/ton), and Mexico ($1-3/ton).

It is evident that adjustments at a high level could have distributional consequences, both within and across countries, and will face controversial political discussions. Voters and particular groups often oppose carbon pricing because it increases their costs for energy and their cost of living. The IMF (2019, p. viii) estimates, however, "that the revenue from such a tax (1.5% of GDP in 2030, on average, for the G20 countries) could be redistributed, for example, to assist low-income households, support disproportionately affected workers or communities (for example, coal-mining areas), cut other taxes, fund investment in clean energy infrastructure or United Nations Sustainable Development Goals, reduce fiscal deficits, or pay an equal dividend to the whole population".

In addition to carbon taxes[7], other (less efficient) pricing policies may be cap-and-trade schemes, targeted subsidies (for R&D on innovative alternative technologies), rebates and tax breaks. However, as it is widely recognized in the literature, despite its convenience and importance, the contribution of carbon pricing and of internalization of externalities in general has limits and may be insufficient to generate the necessary structural transformations require to reach the Paris Agreement goals. It must be complemented, therefore, with sustainable investments by governments at all levels in infrastructure based on non-conventional renewable energies (power generation, public transport networks, carbon capture and storage, etc.), efficiency retrofits for buildings, prevention and adaptation works

[6] The IMF (2019, pp. 11-13) makes an illustrative carbon tax exercise of $25/ton for emerging economies and $50/ton for more developed G20 countries and concludes that at those levels the current voluntary commitments of the signatory countries of the Paris Agreement would be reached. However, their calculations show that these levels would not allow meeting the goal of keeping the global temperature increase below 1.5°-2°C and that it is, therefore, necessary to increase their "ambition".

[7] IMF (2019, p ix) considers that "if carbon taxation is not feasible, emission trading systems (auctioning or allocating emission permits that are then traded) would be equally effective if applied to as wide a range of economic activities. If neither of these mitigation strategies is available on the necessary scale, "feebates" (systems of fees and rebates on products or activities with above or below-average emission intensity) or regulations (for example, standards for emission rates and energy efficiency) could generate two thirds of the CO_2 reduction opportunities of carbon taxation".

with resilience to the adverse effects of climate change, etc., as well as support for R&D in nascent technologies with uncertain and long-term returns, among many others.

Related programs in emerging and less developed economies could include compensation or payments for environmental services such as assisted restoration of natural forest, land-related sequestration (e.g. conservation of standing forests and afforestation), regeneration and conservation of biodiversity, conversion of extensive livestock farming into silvopastoral modalities, and the massive adoption of irrigation by drip, among many others. There is ample empirical evidence that these types of investments are cost-effective and helps to moderate the negative effects of climate change, in addition to helping to achieve greater social acceptance of carbon taxes. But they will undoubtedly put significant pressure on public finances.

2. Other policy actions

Obviously, public efforts must be complemented by private sector investments, given the enormous magnitude of the challenge. According to the International Energy Agency (IEA, 2015, p. 4), "the full implementation of (Paris COP21) climate pledges will require the energy sector to invest $13.5 trillion in energy efficiency and low-carbon technologies from 2015 to 2030, representing almost 40% of total energy sector investment".[8] However, the IMF (2019) and other analysts consider that current national pledges fall far short of those needed to meet the Paris Agreement targets (they would lead to an average global temperature increase of around 2.7°C by 2100), and must be increased, with the additional investments required.

Therefore, the rapid and massive mobilization of mainstream finance would be essential to support the transition toward a sustainable economy and out of stranded sectors and assets. The transition to a low-carbon economy requires shifting trillions from brown to green activities. Several reports estimate that more than $100 trillion[9] will be needed to make infrastructure consistent with the 2°C scenario. It should also be underscored that, although there are costs, there are also immense new opportunities in several sectors and activities.

Following the Paris Agreement, a growing momentum in the private sector has opened up a new phase in the development of green finance. However, given that the horizon of materialization of climate risk is narrowing, the need to change scale is becoming more pressing. Inaction, or action that comes late, would come at a significant economic cost through higher physical damages and risks. Earlier action would also allow more time for new technologies to enter the market and for private investments to respond to price signals, leading to lower transition costs. Private efforts could also be supported with some fiscal tools, such as public-private partnerships, public guarantees, and concessional loans from development banks. Financial and monetary policy options will be discussed in the following sections.

On the other hand, changes in habits that contribute to modifying consumption patterns will also be required. The voluntary actions of all individual members of society will be decisive in this regard. But surely these could be insufficient as long as the greater challenge of solving

[8] According to IEA (2015), about two-thirds would be needed to improve energy efficiency in the transport, buildings and industry sectors, and the remaining to de-carbonize the power sector.
[9] https://www.climatebonds.net/

collective action problems is not resolved. For this, it will be necessary to review social contracts, and respect by all citizens for the environment and biodiversity. Political debates would have to reflect the necessary changes in production and consumption patterns, and the need for strong coordination between different levels of government and with the private sector and civil society –as they have started to take place in several places.

At the international level, all countries should contribute, but following "the principle of common but differentiated responsibilities and respective capacities, in the light of different national circumstances", as well recognized by Article 2 of the Paris Agreement (UNFCCC, 2015). New and innovative ideas on how to break political deadlocks on who should bear the burden of climate mitigation policies –both within and between nations— are imperative (Krogstrum and Oman, 2019, p. 9). An overhaul of global governance and the search for agreements in international organizations is urgent, including the recognition of the needs for technology transfers, increased official development assistance, and increased financial resources for developing countries to undertake their mitigation and adaptation policies. Finally, international debates and action should include the participation of local governments, civil society and the private sector. The application of the principle of "common but differentiated responsibilities" should be a framework for all these debates and actions.

Finally, it is also essential to develop national accounting that measure in an appropriate way the contribution of natural capital and ecosystem services, and the economic costs of ecological degradation –tough recognizing that these concepts are difficult to define precisely" (Bolton et al, 2020, pp. 61-64). As the OECD (2011, p. 9) has indicated, "green growth is about fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies".

IV. Financial policy

As stated in the Paris Agreement (UNFCCC, 2015, article 2, c), in order to strengthen the global response to the threat of climate change, it is essential to make "finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development". Financial policies play a key role to help mobilize mainstream finance to achieve the needed large scale transformation in the productive structure of the economy and the concomitant change in the underlying financial assets structure, by leveraging market mechanisms to achieve greater efficiency in the allocation of resources and costs of mitigating climate change. The dimension of the challenge has been already made clear in the previous sections.

Macroprudential, financial regulation and supervision, governance and financial market development policies are considered under the general heading of financial policies. Some of them aim to correct the lack of accounting for climate-related risks for financial institutions, to support mitigation by changing the demand for green and carbon-intensive investments, and to ensure proper pricing, accounting and assessment of climate risk in financial institutions. Others aim to internalize externalities and co-benefits at the level of society. In turn, monetary policy instruments, which will be reviewed in section V, include

the financial stability framework, policies related to the central bank balance sheet –such as collateral policy, asset purchases, and commercial banks' access to central bank facilities— and, in some countries, credit allocation policies. These financial and monetary policies to promote green private investments should complement tax and investment policies and broader governments' responsibilities, but not substitute for them.

Before going on to discuss these policy options, it is appropriate to set some important aspects of the discussion that follows in the framework of the impact that climate change can have on financial stability (and hence, also on monetary stability). Carney (2015) highlights that the channels through which the latter affects are: physical risks, transition risks and liability risks (a financial risk of a contingent character). After reviewing the nature of these risks and their magnitude and impact on financial stability, we analyze the financial policy tools to manage them.

1. Types of climate-related risks

As already mentioned in section II, physical risks are those that arise from climate- related hazards. From a financial perspective, the increasing severity and frequency of extreme climate-related weather events may cause damage to households' real estate (including mortgage portfolios), losses to firms, and losses to governments, resulting in higher payment of insurance claims, the devaluation of assets and the guarantees that support loans.

Insured losses may place insurers and reinsurers in a situation of fragility as claims for damages increase. Non-insured losses, which represent 70% of weather-related losses (Bolton et al, 2020, p. 17), may affect the value of the financial assets of financial institutions besides insurers, such as banks and pension funds, and reduce banks' ability to lend to households and corporates. In other words, "climate-related risk is not necessarily a distant possibility in the future but rather a clear and present danger to financial stability since the assets at physical risk are large (for producers, for financial investors, etc.) and the costs of weather-related accidents are also very high and rising, for both insurance companies and their clients, and especially for uninsured parties" (Pereira Da Silva, 2019, p. 2). A vivid example of a situation of this tenor is the case of Hurricane Dorian in The Bahamas in September, 2019, which not only devastated properties but also led to a sudden-stop in housing insurance and credit in that country.

Transition risks, prompted by changes in climate-related policies,, technological disruptions and changes in consumer preferences, are likely to have significant impacts on asset prices as a consequence of changes in investors' perception of the profitability and sustainability of certain companies or economic sectors and adjustments in the valuations of a wide range of assets. Thus, there will be a good number of "stranded assets and sectors" (due to depreciation/obsolescence/company closings), both directly and indirectly related to carbon (see section II). This can affect the cash flow of debtors and impair their ability to pay obligations, impacting banks, bondholders, etc. If the changes are abrupt, a sale could take place "at bargain prices", which could trigger a financial crisis (Pereira Da Silva, 2019, p. 2).

Finally, liability risks may arise from future demands for compensation charges on companies, insurers or lenders to economic agents affected by claims related to physical risk or for having financed and supported projects that generate environmental pollution or GHG,

among others. These losses may affect the financial health of insurers and lenders, as well as the equity value of firms involved in polluting activities.

2. Potential magnitude of financial risks and their impact on financial stability

Quantifying the potential magnitude of these risks and the distribution of financial losses among economic sectors, firms, banks, insurers, etc. it is complex. The limitations and uncertainties of existing models for both macroeconomic and financial stability were discussed in section II.

Notwithstanding the foregoing, the NGFS (2019b, p. 14)) quotes a study of The Economist Intelligence Unit (2015) that estimates, for physical risks, "the discounted value at risk for private investors through the unmitigated impacts of climate change at $4.2 trillion (between now and the end of the century) [10]. This equals 3% of current assets.

However, in an extreme (tail) scenario of 6°C of global warming, present value losses in assets under management would amount to $13.8 trillion (equal to 10% of current assets). The public sector could incur present value damages of $13.9 trillion on average and up to $43 trillion in a 6° scenario".

In what concerns transition risks, estimates referred to by NGFS (2019b, p. 16) are: "IRENA (2017) finds that there could be about $10 trillion of stranded value. IEA (2017) on the other hand, finds about $320 billion of stranded capital[11] worldwide over the period to 2050 in terms of fossil-fueled power plants that would need to be retired prior to recovering their capital investment. In both studies, the assumption of an early and smooth transition results in the significant reduction of potential risks. Numbers on stranded assets differ greatly. IEA (2017) estimates that stranded assets could be about $2.3 trillion. IRENA (2017), however, estimates a potential for stranded assets of $18 trillion. Both estimates assume a late and abrupt transition scenario".

Consistent with the first estimate already mentioned, in the specific case of the Netherlands, Vermeulen et al. (2018) report the result of a stress test of Dutch financial institutions in which financial losses are brought about by disruptive policy measures, technological breakthroughs, or a drop in consumer and investor confidence. They estimate losses of up to 3% of assets for banks, 10% for pension funds, and 11% for insurers (quoted by NGFS, 2019b, p. 18).

Physical and transitional risks interact so that if policy actions to reduce GHG and induce structural adjustment in the economy are avoided or delayed, then greater physical risks would materialize. But at the same time, there is a high probability that such policy decisions (such as carbon taxes, regulations, etc.) will increase the risk of transition. This could

[10] Value at risk measures the loss a portfolio may experience, within a given time horizon, at a particular probability. The stock of manageable assets is defined as the total stock of assets held by non-bank financial institutions. Bank assets were excluded as they are largely managed by banks themselves.

[11] "Stranded capital" refers to transition-risk-related losses of capital spending that went into a project (e.g. the amount invested in oil field exploration). "Stranded value" represents the transition-risk-related losses of financial *valuation* of a firm (or a project), this is the forward looking impact on future discounted cash flows which would have been generated by the firm or project (NGFS, 2019b, p. 17)

reinforce financial failures in credit markets or abrupt reallocations of assets from brown to green activities.

It should also be borne in mind that macroeconomic and financial shocks can interact and amplify. Therefore, if natural disasters reduce collateral values of the housing and corporates stock, their balance sheets would weaken. Households consumption may decline; and increased uncertainty from climate-related events could affect corporates´ investment decisions and banks´ willingness to lend to them.

All this could result in a "climate Minsky moment" (Carney, 2016): a severe financial tightening of financial conditions for companies that rely on carbon-intensive activities (so-called "stranded assets"). "A wholesale reassessment of prospects, as climate-related risks are re-evaluated, could destabilize markets, spark a pro-cyclical crystallisation of losses and lead to a persistent tightening of financial conditions" (Carney, 2016, p. 2). The paradox is that "success is failure", "extremely rapid and ambitious measures may be the most desirable from the point of view of climate mitigation, but not necessarily from the perspective of financial stability over a short-term horizon" (Bolton et al, 2020, p. 7). In any case, as already pointed out, earlier action also allows more time for new technologies to enter the market in response to price signals, leading to a larger green sector and lower transition costs.

Climate-related risks are, therefore, a real threat to financial stability and could originate what Bolton et al (2020) have called "green swan" events: potentially extremely financially disruptive events that could be behind a systemic financial crisis, that can put central banks under pressure to buy a large set of assets that have a devalued value due to physical or transition impacts, in a sense transforming them into "climate rescuers of last resort". However, in their view, "Central banks cannot (and should not) simply replace governments and private actors to make up for their insufficient action, despite growing social pressures to do so" (Ibid, p. 2). Rather, financial policies should be put in place to prevent such extreme financial instability events.

In brief, central banks and supervisors (and policy makers) have an important role to play in contributing to the development of environment and climate risk management in the financial sector and to mobilize mainstream finance to support the transition toward a sustainable economy. This is precisely the *raison d´être* of the Network for Greening the Financial System (NGFS), a group of Central Banks and Supervisors willing to exchange experiences and share best practices, to which we will refer in more detail in section V.2. In the next section, some alternative public policy actions are reviewed.

3. Financial policy tools

Following Krogstrup and Oman (2019, p. 18) and the extensive recent literature on the subject, financial policy actions by central banks, regulators and financial supervisors (in what concerns their respective competences if they are not all unified at the central bank[12]) can be grouped around the following criteria: a) those that aim at improving transparency

[12] It should be taken into account that in some cases (e.g., a large number of European countries), central banks are responsible for both monetary and foreign exchange policies as well as for financial regulation and supervision, but in others (e.g., more than half of Latin American countries) the latter are managed by separate agencies, although with inter-institutional coordination mechanisms.

and risks disclosure in order to redress possible underpricing and lack of transparency of climate risks in financial markets and regulatory prudential frameworks; b) those aimed at developing a taxonomy of economic activities and the advancement of markets for green financial instruments; and c) those that can help reduce the short-term bias and improve governance frameworks of financial institutions.

a. Policies aimed at improving transparency and risks disclosure

The first set of policies are aimed at correcting a major market failure: the fact that climate risks may not be adequately reflected in financial institutions' balance sheets and in assets prices. Non-transparent and underpriced climate risks imply that investments subject to climate-related risks are effectively subsidized. Therefore, standardizing climate-related risks disclosures and making them mandatory can help support and improve pricing and transparency of these risks (Krogstrup and Oman, 2019). Gathering and disseminating relevant climate-related financial data could also enhance risk assessment in financial regulation and stress tests.

Additionally, it is instrumental to lay solid foundations for the definition of an adequate taxonomy of "green" and sustainable assets in relation to climate and other environmental considerations, in achieving consistency in the classification of "green" versus "non-green" and "brown" assets as a base for the analysis of potential risk differentials between different types of assets and for the development of green bonds and markets, as well as carbon pricing.

In this regard, the efforts of the Task Force on Climate Related Financial Disclosure (TCFD, 2017 and 2019; see also the Annex Box below) should be particularly highlighted. The Task Force was established by the Financial Stability Board (FSB) to develop a set of voluntary, consistent disclosure on relevant and prospective information about potential (financial) impacts of climate change, for use by companies (especially those issuing public debt or equity and financial institutions) in providing information to investors, lenders and insurance underwriters[13]. Its recommendations, "developed by the market for the market", aimed at ensuring that climate-related risks are understood and discussed at board level, considered in risk management and investment decisions and embedded into firms' strategies. They may allow investors and external stakeholders to better value assets and investment projects, and to mobilize financial resources to facilitate the transition to more sustainable and resilient activities.

This initiative has been keenly supported by the community of central banks and financial supervisors gathered around the NGFS (2019a, p. 5), which has underscored the importance of robust data on climate-related risks and its integration into financial stability monitoring and prudential micro-supervision. The NGFS (2019a, 2020a) has also recommended central banks and supervisors to gradually develop tools to map physical and transition risk transmission channels within the financial system and conduct quantitative climate-related risk analysis to size the risks across the financial system and how the impact of climate change can be included in macroeconomic modelling and forecasting and financial stability monitoring. Given the forward-looking nature of these risks and the inherent uncertainty

[13] https://www.fsb.org/2017/06/task-force-publishes-recommendations-on-climate-related-financial-disclosures/

about future events, innovative methodologies like scenario analysis are being developed to explore the impact of different possible futures (NGFS, 2019b). Some leading central banks are also preparing to apply these tools on stress tests scenarios for the financial firms they supervise[14].

Supervisors should aim at ensuring that individual supervised institutions identify their exposures to climate-related risks, assess the potential losses should these risks materialize, ensure adequate management of them and take mitigating action where appropriate. For that purpose, authorities should set supervisory expectations based on their understanding of a prudent approach to climate-related and environmental risks (NGFS, 2020a).

The relevance of this kind of assessments is illustrated in the study by Battiston et al (2017). The authors explore how climate policy risk might propagate through the financial system, based on a network-based climate stress-test methodology of the exposures of financial actors to all climate-policy-relevant sectors of the economy, as well as the exposures among financial actors themselves, across several types of financial instruments, and apply it to large Euro area banks in "green" and "brown" scenarios. They find that direct and indirect exposures to sectors that would be affected by climate policy represent a large portion of equity portfolios of investment and pension funds, and banks' loans to climate-sensitive firms are similar to banks' capital. They also conclude that an early and stable policy framework would allow for smooth asset value adjustments, whereas a late and likely abrupt policy framework could have adverse systemic consequences. Interestingly, the authors point out that the transition to a low-carbon economy could have net positive aggregate effects, particularly because the market share of renewable energy and energy efficient sectors is expected to massively increase. In any case, climate policy could lead to winners and losers among financial actors, depending on the composition of their portfolios.

b. Policies aimed at supporting the development of a taxonomy of economic activities and the advancement of markets for green financial instruments.

Financial regulators and supervisors can take a leading role in bringing together relevant stakeholders and experts to develop a taxonomy that enhances the transparency around which economic activities contribute to the transition to a "green" (low-carbon and environmentally sustainable) economy, and which others are more exposed to climate-related risks ("brown"). Such a taxonomy would facilitate financial institutions' identification, assessment and management of climate and environment-related risks; help gain a better understanding of potential risk differentials between different types of assets (green, non-green and brown), identify sustainable companies and assets, and mobilize capital for green and low-carbon investments consistent with the Paris Agreement and out of "brown" activities (NGFS, 2019a).

[14] Some of the more emblematic cases cited in the literature are England, France, the Netherlands, Brazil and China.

Policymakers would thus need to ensure that such taxonomy[15] is robust and detailed enough to prevent greenwashing[16] and facilitate risk analysis. In this respect, it is worth recalling that the trade in green financial securities is hampered by lack of transparency, standardization and missing markets. Big challenges remain as to how to define and certify credibly and transparently green securities, however, making this a market prone to lemons problem (Krogstrup and Oman, 2019, p. 27).

A taxonomy of "green" assets can also be an enabler of policymakers and supervisors' role. First, it is a pre-requisite for preparing stress-test exercises and the assessment of financial institutions' risk profile. It is also a prerequisite for scaling up green finance and policymakers support in identifying market barriers and dysfunctionalities on the supply and demand side, and best practices to overcome such barriers. Additionally, like any other investor, central banks will benefit from these taxonomies when implementing sustainable investment strategies for their own investment portfolios (an issue to which we will return below), thus "leading by example" (NGFS, 2019a).

Concerning prudential regulation, some analysts have proposed adapting micro and macroprudential policies to explicitly consider climate-related risks and internalize systemic climate risk. "Tools could include reserve, liquidity and capital adequacy requirements, loan-to-value ratios, and caps on credit growth, as well as sectoral capital buffers targeting credit to particularly climate-exposed sectors" (Krogstrup and Oman, 2019, p. 26), and integrating green supporting and brown penalizing factors in capital requirements, or defining minimum amounts of green assets on financial institutions' balance sheets (Dikau and Volz, 2019)[17]. In this line, "if climate stress tests find that climate-related risks are material, systemic capital buffers could be applied to mitigate the exposure to climate-related risks" (Bolton et al, 2020, p. 51).

There is controversy, however, on the effectiveness of these climate-related prudential regulations Bolton et al (2020, p. 53) consider that they "may only very partially contribute to hedging financial institutions from 'green swan' events". Krogstrup and Oman (2019, p. 29) refer to studies that consider that "lowering capital requirements on bank loans to green sectors could undermine macroprudential policy goals and financial risk mitigation; the Basel Committee has consistently adopted an approach in which prudential rules are based only on risk considerations, to shield them from influences like industrial policy goals or political interference in banks' lending practices".

As illustrated below, central banks and supervisors have considered that, to further progress in their analysis and recommendations on whether to integrate climate-related or

[15] An example is the European proposal to develop a unified EU classification system to determine which economic activities can be regarded as environmentally sustainable for investment purposes. The EC´s proposal identifies the following environmental objectives for an economic activity to be considered sustainable: (i) substantially contribute to at least one of the environmental objectives, (ii) do no significant harm to any of these objectives, (iii) comply with minimum safeguards, and (iv) comply with technical screening criteria by an independent third party. Until now, no regulatory taxonomy has been implemented globally, but there are some market-driven taxonomies as reference, like the Climate Bonds Standards (released by the Climate Bonds Initiative) and the International Capital Market Association's Green Bond Principles.

[16] Defined by the Investospedia as "an unsubstantiated claim to deceive consumers into believing that a company's products are environmentally friendly".

[17] Prudential regulations in this line has been adopted by the Banco Central do Brasil and Banque Du Liban (Dikau and Volz, 2019).

environmental risks into capital requirements, more work is needed on data and assessment methods for quantifying risks and calibrating prudential requirements, a taxonomy of green and brown assets and, as a result, statistical evidence of a risk differential between "green" and "brown" assets. Consequently, to date the focus is currently placed on raising awareness.

In this respect, a recent survey by the Basle Committee on Banking Supervision (BCBS, 2020, p. 1) has found that "the majority of its members consider it appropriate to address climate-related financial risks within their existing regulatory and supervisory frameworks…(and) have conducted research related to the measurement of climate-related financial risks, while a number of members identified operational challenges in assessing climate-related financial risks such as data availability, methodological challenges, and difficulties in mapping of transmission channels (…) approximately two-fifths of members have issued, or are in process of issuing, more principles-based guidance regarding climate-related financial risks. However, the majority of members have not factored, or have not yet considered factoring, the mitigation of such risks into the prudential capital framework".

In the same vein, the NGFS (2020a, p. 5) also notes that "given that methodologies for climate-related and environmental risk quantification are still being developed, most supervisors have not yet imposed (additional) capital or solvency requirements specifically linked to these risks." It argues that more research is needed on the transmission channels and loss potentials of such risks, the potential specific risk profiles of different groups of assets and exposure, and more and better-quality climate and environmental data and methodologies for better assessing and mitigating climate-related and environmental risks.

c. *Policy instruments that can help reduce the short-term bias and improve the governance of financial institutions.*

In this regard, Bolton et al (2020, p. 66) propose that central banks and financial regulators and supervisors contribute to financial stability by "proactively promoting long-termism by supporting the *values* or *ideals* of sustainable finance". This can be done through prudential and corporate governance reforms and especially by the adoption of environmental, social and governance (ESG) standards in the financial sector, especially among pension funds and other asset managers. As already mentioned, central banks can promote financial institutions' adequate disclosure practices, pricing of climate-related risks and efficient allocation of capital thereof. Due to their specific role, central banks, financial regulators and supervisors are well-placed to monitor the market dynamics of green finance that help mobilize capital for green and low-carbon investments consistent with the Paris Agreement. Furthermore, depending on each particular country's institutional framework, some central banks and regulators can also play a role as catalysts for a sound scaling up of green finance (Krogstrup and Oman, 2019; NGFS, 2018b).

Private sector moves towards long-termism and supporting the values of sustainable finance are already underway. For example, Blackrock's President Fink (one of the largest wealth managers worldwide), informed in his 2020 letter to the CEOs, that "the firm has announced a series of initiatives to place sustainability at the epicenter of its investment approach, such as: the integration of sustainability in the construction of portfolios and risk management, the liquidation of investments that present a high risk in terms of sustainability, the launch of new investment products that discard fossil fuels and the reinforcement of our commitment

to sustainability and transparency in our responsible investment activities" (Fink, 2020). It is also worth noting his commitment to the disclosure guidelines in accordance with TCFD and his invitation that the companies in which BlackRock invests also adhere to these guidelines[18].

It is worth mentioning that a study by Blackrock Investment Institute (2018, p. 2) analyzed "traditional equity indexes alongside ESG-focused versions" and found that "annualized returns since 2012 (for ESG) matched or exceeded the standard index in both developed and emerging markets, with comparable volatility…Early evidence suggests that focusing on ESG may pay the greatest dividends in emerging markets". The study concluded therefore that "ESG can be implemented across most asset classes without giving up risk-adjusted returns".

In contrast with that, in what concerns specifically the banking activity, a recent survey of the NGFS (2020b, pp. 3-4) among forty-nine banks in eighteen jurisdictions (plus one supranational) concludes that they "have not established yet any strong conclusions on a risk differential between green and brow". This is explained to great extent because "the prerequisites for tracking the risk profile of green or brown assets (…e.g. a clear taxonomy and available granular data…), are not yet in place in most jurisdictions"[19]. Given that, most of the respondent banks have used "an international or national classification in the form of a voluntary classification or principle"[20] or "an internally developed classification".

In spite of all that, "most of the institutions have undertaken an operational commitment towards greening their balance sheets, with 57% of the respondents undertaking commitments that affect their daily operations either by limiting their exposure to brown assets or by setting green or positive-impact targets. However, the survey responses highlight that the underlying justification is not based on an attested financial risk differential between green and brown assets but rather on a more diffuse perception of risks. Most banks tend to consider their actions to be part of their corporate social responsibility or mitigation measures for reputational, business model or legal risks" (NGFS, 2020b, p. 3).

It is also worth highlighting that, according to the Climate Bonds Initiative, global green bonds and green loans issuance reached an adjusted $257.7 billion in 2019, marking a new global record. The total is up by 51% on the 2018 figure of $170.6 billion. The volume was primarily driven by the wider European market, which accounted for 45% of global issuance; the Asia-Pacific and North American markets followed at 25% and 23%, respectively. In 2019, there were 1788 green bonds from 496 issuers, out of which 250 were new issuers, and there are 51 jurisdictions, of which 8 were new[21]. In any case, green

[18] The Economist (2020) also headlined on another broadly referenced investor as "Grantham on divesting from Big Oil - A contrarian investor on the hazards of owning fossil-fuel stocks".

[19] Respondents also highlight that they "encounter different challenges when trying to classify different types of assets (e.g. loans, bonds, investments). For loans in particular, whilst the classification of single purpose loans (e.g. within project finance) may seem quite obvious, loans for general corporate purposes have a weaker direct link to a physical asset or a project and seem more difficult to classify" (NGFS, 2020b, p. 4).

[20] Respondents mention the European Union and the Chinese taxonomies and a number of other national ones. Among the international classifications and principles, respondents mention the TCFD Recommendations, the UNEP FI framework (including the Principles for Responsible Banking), the ICMA´s Green Bond Principles, the Green Loan Principles and the Equator Principles, among others (NGFS, 2020b, pp. 7-8).

[21] More information is available at: https://www.climatebonds.net/resources/reports/2019-green-bond-market-summary

bond markets remain small (total accounts for just 0.5% of global bond universe) but growing rapidly.

Additionally, according to the Institute of International Finance (IIF, 2020), "with the Covid-19 pandemic serving as a real-life "stress test" for ESG investing strategies, the relative performance of sustainable assets has been remarkable" during the atypical first half of 2020. In a "sample of 41 sustainable equity indices, over 75% of sustainable indices have outperformed non-ESG peers year-to date, by a substantial 8 percentage points for the median fund. ESG fixed income strategies have also proved resilient during recent market turmoil. Across a commonly used set of 10 fixed-income ESG indices, 70% of them have outperformed their non-ESG counterparts this year".

V. Monetary policy tools and other actions central banks can undertake

Central bank mandates, traditions, legal and institutional frameworks differ across countries. As with many other institutions, their role and functions, while maintaining their essence, have certainly adapted and evolved dynamically in response to changing contexts and societal needs. For most central banks, however, its core responsibility is safeguarding the purchasing power of the legal currency (i.e., a low and stable inflation rate). In several cases, this primary goal is also complemented with aiming to support stable aggregated output and employment around its potential level. Instrumental to these policy objectives, central banks target an inflation level and set a reference interest rate (or directly manage the monetary base), and intervene in the market to guarantee that the short-term market interest rate is close to the monetary policy target. Changes in the reference rate affect inflation and short-term growth through different transmission mechanisms. Additionally, ensuring the smooth functioning of payment systems and safeguarding financial stability has traditionally been the other main concern for central banks, which have historically acted as lenders of last resort.

As discussed in previous sections, environmental factors and climate-related physical and transition risks will most likely progressively impact prices, aggregate demand, actual and potential economic growth, and financial stability, all of which are core objectives of most central banks. A number of climate-related events affecting supply and prices might just be transitory. But the probability of structural changes affecting price levels for a longer period, as well as the long-term sustainable level of resource utilization and the long-run real interest rate (either as a result of physical risks or from policy actions affecting the transition, for instance from carbon taxes), raise challenging questions as to how monetary policy can and should react. An even more serious challenge may arise in case of a severe financial and economic crises triggered by deep and rapid changes in financial markets from the so called "green swan" events, with sharp declines in the economy, rising unemployment and lower inflation.

As a result, climate change might call into question the long-term ability of central banks to maintain price and financial stability and asset quality. Increasingly, therefore, central banks have to analyze and discuss whether and what they can and should do to confront climate change in order to efficiently and successfully safeguard price and financial stability (Breman, 2020).

1. Monetary policy tools and the boundaries of central bank mandates

In principle, central banks can potentially use the valuable arsenal of policy tools at their its disposal to respond to the challenges arising from climate-related shocks, even within a restricted interpretation of their mandates. Transitory events affecting supply and prices may not necessarily justify a monetary policy response, but structural changes affecting price levels for a longer period, as well as the long-term sustainable level of resource utilization, may entail a demand for firmer responses. This situation, however, raises conflicting trade-offs among central banks goals of stabilizing inflation and stabilizing output fluctuations. Following Dikau and Volz (2020, p. 10), "solely responding to the inflationary component (by raising interest rate), without taking rising prices and decreasing output resulting from climate policy into account, may lead to unnecessarily large output losses"; and also that "in a scenario where the introduction of a carbon tax causes aggregate output to decline and inflation to spike (…). In the case of a strict inflation-targeting regime, the central bank would respond to the spike in inflation by raising interest rates, thereby further slowing the economy, but also causing exchange rate appreciation".

Facing severe financial and economic crisis such as "green swan" events, central banks could be compelled to deploy a wider range of tools at their disposal such as the interest rate and expanding their balance sheets through bond purchases. More sophisticated policy actions could include communication on forward guidance.

Other more specific aspects of the discussion on ways in which central banks could proactively support the transition to a low-carbon economy relate to how they can reflect climate risks in their monetary policy frameworks. These include: i) integrating climate risk analytics into central banks' collateral frameworks (for instance, by adjusting haircuts and valuations on "brown" assets and even excluding them from the pool of eligible collateral); ii) using sustainability criteria in their large-scale asset purchases and refinancing operations to exclude carbon-intensive assets and favor green assets, thereby boosting their prices (also referred to as "green" quantitative easing)[22]; and iii) implementing parallel asset purchase programs focused on low-carbon assets (see Krogstrup and Oman, 2019 and Dikau et al, 2020, for more details).

Dafermos et al (2018) show that a green quantitative easing (QE) program can indeed help reduce global warming but cannot by itself prevent severe climate change since the path of global atmospheric temperature is not very likely to change substantially by such a program (many other types of environmental policies and strategies are necessary). Besides, as discussed below, some of these alternative are contentious and raise governability concerns,

[22] According to Matikainen et al (2017, p1), "sectoral analysis of the quantitative easing (QE) corporate bond purchase programmes of the European Central Bank (ECB) and the Bank of England suggests a skew towards high-carbon sectors. Calculations made using publicly available information indicate that 62.1% of ECB corporate bond purchases take place in the sectors of manufacturing and electricity and gas production, which alone are responsible for 58.5% of Eurozone area greenhouse gas emissions, but only 18% of gross value added (GVA). For the Bank of England, manufacturing and electricity production –responsible for 52%of UK emissions– make up 49.2% of the eligible benchmark, but only 11.8% of GVA. Utilities, the most carbon-intensive sector by emissions, also make up the largest share of purchases for both the ECB and Bank of England. Renewable energy companies, already a relatively small portion of the bond market to begin with, are not represented at all in ECB or Bank of England purchases, while oil and gas companies make up an estimated 8.4% and 1.8% of their portfolios, respectively".

so that, as of late 2019, only the People's Bank of China had a dedicated policy to promote green finance via monetary policy among NGFS members (NGFS, 2019a, p 29).

Some others go a step further by proposing better access to central banks funding schemes for banks that invest in low carbon projects and even allowing for central bank credit allocation policies in favor of low carbon investments (either directly, by extending loans to companies via banks and currency interventions, or indirectly through guarantees, as in the case of China, India and Bangladesh) (see Krogstrup and Oman, 2019). As illustrated in more detail in Dikau and Volz (2019, p. 13), for central banks that employ these type of policies (only a few in developing and emerging economies), "green investment has often been added as an additional priority sector to existing and longstanding credit allocation policy schemes that otherwise pursue developmental objectives".

The list of "central allocative policy instruments" to promote sustainable development could include: i) preferred (subsidized) loan rates for priority sectors, asset classes, and firms; ii) differential rediscount rates (green targeted refinancing lines by central banks offering refinancing for commercial banks at preferential terms for specified green asset classes), iii) credit floors and ceilings (requiring commercial banks to allocate a percentage of their loan portfolio to specified classes of assets, industries, or geographical areas), and iv) assistance to development banks (so that they may play a risk-reducing and pioneering role by implementing green finance standards or by developing innovative financial products such as green bonds). Dikau and Volz (2019, p 13-14)

This is very much in line with Werner's (2016, p 375) Quantity Theory of Credit in that "when bank credit (is) guided towards productive use, high, stable and non-inflationary economic growth (can) be achieved". It is also consistent with the view of the proponents of the "credit creation theory of banking" who "pointed out that bank credit creation and growth in economic activity are connected, and credit for different types of transactions has a diverging effect on the economy. They have thus favoured bank regulation that directly targets bank credit, both its quantity and its quality (…) whereby economically desirable bank credit is encouraged, and economically harmful credit creation is forbidden or restricted quantitatively" (Ibid, p/ 377).

The mounting challenge of climate-related potential shocks are leading a growing number of central banks to adopt green finance policies or guidelines. Dikau and Volz (2020) examine the extent to which addressing climate-related risks and supporting sustainable finance fit into the current set of central bank mandates and objectives, using the IMF's Central Bank Legislation Database, and compare them to current arrangements and sustainability-related policies central banks have adopted in practice. Of the 135 central banks in their sample, "only 12% have explicit sustainability mandates, while another 40% are mandated to support the government's policy priorities, which in most cases include sustainability goals (...) On the other hand, 48% of central banks have no explicit or implicit sustainability objectives. However, many of them have nonetheless begun to engage in various green activities. Most of these activities aim at incorporating environmental and climate change-related risks into the core policy implementation frameworks (…) in order to efficiently and successfully safeguard macro-financial stability. As a consequence, an integration of ESG factors into central banks' core policy implementation frameworks (…) would be also covered by mandates that make no explicit or implicit reference to sustainability" (Dikau and Volz, 2020, pp. p 3, 4 and 16).

The mainstream literature considers, however, that monetary policy is not best suited for long-term climate change mitigation efforts and should remain focused in its short-term stabilization objective, and that the use of central bank balance sheets to tackle green swan events or further green investments and markets are highly controversial. It may imply stretching central banks' mandates (at least in most advanced and emerging economies), raising important questions of governance (thereby undermining their independence), and may risk distorting markets (Pereira Da Silva, 2019; Bolton et.al, 2020; Krogstrup and Oman, 2019).

Dikau and Volz (2020, p. 16) add in this respect that "a potential role of central banks in promoting sustainability in the financial system and "greening" the economy, however, is more contentious because of the possible distorting effects of such policies (…) While central banks have a potentially large number of instruments to affect the allocation of capital towards green investment, this does not imply that they should necessarily be tasked to do everything they possibly could". And they recall that "(Mark) Carney has voiced his distaste for a 'surreptitious' approach or implicit guidance through central bank soft power (...) Instead, Carney expressed support for explicit climate change-related regulation or carbon pricing. Regarding a 'promotional' role in enhancing green climate policy, Carney points to the limits of the mandated role of central banks, which, he maintains, cannot 'substitute for governments in climate policy' a view that he shares with virtually all central bankers" (Dikau and Volz, 2020, p. 8).

A balanced conclusion could be in Breman´s words (2020, p. 2) that central banks "can contribute to a more sustainable future, but only as a complement to other effective climate policy. Central banks will not be able to replace the need for an effective climate policy that should be focused on setting a price on carbon emissions".

2. <u>Contribute to coordinate macroeconomic policies and prudential regulations in order to successfully support an environmental transition.</u>

According to Bolton et al (2020, p. 2), central bank, regulators and supervisors should be more proactive in calling for broader and coordinated change, in order to continue fulfilling their own mandates of financial and price stability over longer time horizons than those traditionally considered. They believe that central banks can contribute to coordinate policies to combat climate change. In their opinion, this coordinating role is not incompatible with central banks doing their own part within their current mandates.

For that purpose, central banks need to coordinate their own actions with a broad set of fiscal, prudential and carbon regulations to be implemented by other players (i.e. governments, private sector, academia, civil society and the international community) in order to successfully support an environmental transition, having in mind that, as illustrated in previous sections, this is a collective action problem.

In the first place, it is of paramount relevance their involvement in data collection, research and analysis that sheds light on the economic consequences of global warming. A special mention deserves to be made to the increased international cooperation on environmental issues among monetary and financial authorities to build awareness and intellectual capacity and to encourage technical assistance and knowledge sharing. For this purpose, a group of central banks and supervisors created in December, 2017, the Network for Greening the

Financial System (NGFS), "willing, on a voluntary basis, to exchange experiences, share best practices, contribute to the development of environment and climate risk management in the financial sector, and to mobilize mainstream finance to support the transition toward a sustainable economy. Its purpose is to define and promote best practices to be implemented within and outside of the Membership of the NGFS and to conduct or commission analytical work on green finance" (NGFS, 2018a). As of May 2020, the NGFS had 66 institutions members and 12 observers (among which international financial organizations and standard setter bodies).

The NGFS has organized its activities around three main workstreams (WS): microprudential and supervisory, macroprudential and scaling up green finance.

WS1 focuses on "the mapping of existing country experiences and supervisory practices (encompassing), for example, climate and environmental information disclosure, corporate governance structures for sustainability issues as well as scenario-based risk analyses", around the following three sub-areas: supervisory practices for integrating environmental (climate) risks into micro-prudential supervision; environmental information (climate risk) disclosure by financial institutions and options to encourage disclosure; the extent to which a financial risk differential exists between 'green' and 'brown' assets.

WS2 has as medium term objective to develop an analytical framework for assessing climate-related risks (including the impact of climate change and policies to mitigate it), the aim of which will be to size the impact of climate related risks on the economy both in the central case and in the event of tail scenarios. It will also aim to determine the timeframes in which risks could materialize. It will consider both physical and transition risks. It will also provide insight on integrating climate risk analysis into macroeconomic and financial stability surveillance.

Finally, the emphasis of WS3 is to outline the role that central banks and supervisors could play in promoting the scaling up of green finance. It will work on a comparative approach to green taxonomies, green bonds labeling and the prevention of greenwashing. Its main interests revolve around greening the activities of Central Banks and supervisors, understanding/monitoring the market dynamics of green finance and central banks/supervisors as catalysts for greening the financial system

In its First Comprehensive Report (NGFS, 2019a), the Network issued six main recommendations to the international community of central banks and supervisors to which this document has made several references. Summing up, they are: i) integrating climate-related risks into financial stability monitoring and micro-supervision; ii) integrating sustainability factors into own-portfolio management; iii) bridging the data gaps; iv) building awareness and intellectual capacity and encouraging technical assistance and knowledge sharing; v) achieving robust and internationally consistent climate and environment related disclosure; and vi) supporting the development of a taxonomy of economic activities. The first four apply to the work of central banks and supervisors while the last two address policymakers.

3. <u>Integrating sustainability criteria in their operational activities as administrators of investment portfolios and as corporates.</u>

Central banks and supervisors can potentially have a role to play in "leading by example" by incorporating sustainability/ESG criteria into their own portfolios and their operational activities as corporates, without prejudice to their mandates and status. This includes aspects such as: (i) management of corporate portfolios and pension funds, integrating some kind of "green" requirements in their management or target green financing; (ii) reduction of their carbon footprint as companies, including in-house climate/environmental-efficient use of resources such as energy, water or waste-management; and (iii) public disclosure of their engagement regarding the previous items[23].

Central banks can also look into their own investments portfolios and see how vulnerable they would be to climate-related risks, whether climate risks are appropriately reflected and integrating sustainability factors into their management. There are some notable references that can be mentioned in this respect.

For instance, in NGFS (2019c), the Network presents the results of a survey among its members on how they integrate sustainability factors in their portfolio management. The Report shows that some central banks are starting to play their part in scaling up green finance by accounting for climate and environment-related factors in their investment strategies and incorporating sustainability factors.

Central banks typically hold different portfolios with various goals, depending on their respective mandates, distinguishing four types: i) policy portfolios, ii) own portfolios, iii) pension portfolios, and iv) third-party portfolios. Policy portfolios are at the core of central banks' mandates and constitute by far the largest pool of assets they manage. It can include portfolios for foreign exchange intervention, the execution of asset purchase programs or other monetary policy goals. These holdings are subject to strict policy mandates, which typically require investments to meet high standards in terms of liquidity and credit quality (mainly consisting of supranational and high-grade sovereign debt). But, as indicated above, in the case of own and pension portfolios, there is some more room to adopt sustainable investment practices.

When granted that possibility, "negative screening and green bond investments are currently the most prominent strategies across central bank portfolios. Both are straightforward to implement as they do not necessarily require a significant adjustment of the asset allocation or the investment process. Some central banks take a step further and implement a best-in-class approach or integrate ESG criteria in their investment processes. These strategies are mostly applicable to equity holdings (and corporate bonds) within the own portfolios. By their very nature, these strategies are highly dependent on ESG data", as the NGFS (2020, p. 19) concludes.

A worth noting case is Norway's sovereign wealth fund, the world's largest, which manages $1.1 trillion of the country's assets administered by Norges Bank (Ibid,23). In September 2019 it announced that it would divest companies solely dedicated to oil and gas exploration and production in a bid to shield itself from a long-term fall in oil prices, a decision that affects its investments in some 95 companies[24]. Another case is the Banque de France's Responsible Investment Charter, which applies to the portfolios backed to own dedicated funds and pension liabilities. In order to identify candidate funds to invest in, it took into

[23] https://www.ngfs.net/sites/default/files/media/2019/09/24/mandate-ws3.pdf
[24] https://www.reuters.com/article/us-norway-swf-oil-idUSKBN1WG4R9.

account, aside from regular financial criteria, extra-financial factors, such as the impact of the projects financed by the fund vis-à-vis the energy and ecological transition, the consideration of ESG risks in investments, and the quality and nature of published impact indicators (NGFS, 2019c).

A recent study by researchers at the Bank for International Settlements (BIS) explores how environmental sustainability objectives might fit within central banks' reserve management frameworks. Using the example of green bonds, Fender et al (2019, p. 50) find that "sustainable investments can be included in reserve portfolios without forgoing safety and return, although their accessibility and liquidity currently pose some constraints". The results of an illustrative portfolio construction exercise suggest that adding both green and conventional bonds can help generate diversification benefits and, hence, improve the risk adjusted returns of traditional government bond portfolios, once liquidity requirements at the overall portfolio level are taken care of. Results based on historical returns (over the January 2014–July 2019 period) are qualitatively similar to those based on prospective returns (Fender et al, 2019, p. 60).

For countries willing to incorporate sustainability elements in their reserve management process but maybe lack have the technical capacity to design them, the BIS, responding to a growing demand for climate-friendly investments launched in 2019 an open-ended fund for central bank investments in green bonds to help central banks to incorporate environmental sustainability objectives in the management of their reserves[25].

VI. Some final reflections on the Covid-19 pandemic and a "green-recovery"

The Covid-19 pandemic has provided a vivid evidence of the fragility of global systems and has raised awareness of the potential shocks for the global economy in reaching tipping points if nothing is done to reduce greenhouse gases. Both the pandemic and climate change affect human lives and economic well-being, and both have a significant negative distributive impact. They have also made evident the need for policy-makers to co-operate on building more holistic approaches to identifying and managing global risks that have been neither fully considered nor priced, in a framework of multilateral cooperation (Pereira de Silva, 2020).

The time is now, therefore, for authorities worldwide, both national and international, to actively take account of climate change in engineering a "green" recovery. Coordination is needed, together with businesses and the civil society, to align their response measures with the Paris Agreement and the Sustainable Development Goals. There is a wide variety of policy actions that different public authorities can undertake in this direction. A number of them have already been mentioned in different sections of this paper. They include:

First, a policy mix aimed at reducing the carbon footprint by promoting sustainable investments, with a longer-term view of returns on investment projects. In this regard, establishing a floor in the carbon price (or reducing emission ceilings) and phasing out subsidies on carbon-intensive sectors is of foremost importance. As illustrated in section III, a carbon price policy is a key determinant in the development of the demand for energy and

[25] https://www.bis.org/press/p190926.htm)

emissions, and an important driver of investment in renewable energy. Public investment programs to boost recovery could be geared to a global green transition, focused on energy, transportation and housing.

Second, authorities could condition support measures provided to businesses to survive the current crisis upon them moving towards a more sustainable future. New technologies and changes in the locus of production, supply chains and work sites could also reduce greenhouse gas emissions. Notable examples of recent stimulus packages that take into account this and the previous criterion are the ones engineered in Denmark, Germany, France and the European Commission's Next Generation EU recovery proposal (IIF, 2019).

Third, financial authorities could evaluate measures aimed at advancing climate-related prudential regulation, minimizing climate-related risks for regulated financial institutions (Pereira da Silva, 2020), thus preventing a further build-up of climate risks in financial institutions' balance sheets. Calls have also been made for disclosures relating to climate change to be made mandatory for financial firms. Some financial regulators have already begun implementing policies along these lines (UK and France, in particular).

Fourth, in this same line, coordination could also extend to standard setters, by considering more "ecological" accounting frameworks, with the possible obligation to disclose additional types of exposure, and new accounting approaches (eg natural capital) to capture interactions between the economy and the natural world (Pereira da Silva, 2020).

Finally, central banks could attempt to more accurately reflect climate risks in central banks' balance sheets and operations, thus contributing to the achievement of climate and sustainability goals. As such, they could amend collateral frameworks to better account for climate change-related and other environmental risks, align asset purchases and refinancing operations with Paris Agreement goals, and adopt sustainable and responsible investment principles for portfolio management, including policy portfolios (Dikau et al 2020).

Annex Box

The Task-Force on Climate-Related Financial Disclosure (TCFD)

TCFD is a voluntary, market-led initiative aimed at firms making a disclosure of pertinent and prospective information on potential (financial) impacts of climate change, to bring "to the present" the issues arising from "future" climate change (through the analysis of various possible scenarios) and which has a strong emphasis on risks and opportunities related to the transition to a lower carbon economy.

The information refers to: i) its governance structure of a company around the risks and opportunities related to climate change; ii) its strategy in the face of the present and potential impact it may have on its business line and financial planning; iii) the processes designed to identify, assess and manage the risks associated with climate change; and iv) the estimates and objectives used by the company to assess and manage the most relevant risks and opportunities related to this problem.

Its objective is that the greater transparency in the disclosure of information on climate-related risks allows investors and external stakeholders to have a basis for the proper valuation of assets and investment projects, in order to better guide the market to mobilize financial resources that facilitate the transition towards more sustainable and resilient activities. Its focus is on commercial companies from various sectors, financial entities and investment fund managers.

Regarding metrics and objectives, the TCFD invites companies to disclose with transparency the estimates of the impact of their production processes with the so-called "scope 1" (direct emissions generated by them), "scope 2" (indirect emissions) and "Scope 3" (those generated throughout the entire value chain, backwards by its suppliers and outsourced processes, and forward by its consumers and distribution logistics).

The 2019 TCFD Progress Report recognizes the enormous difficulty of revealing information on environmental sustainability and identifying valid scenarios to carry out its analysis and make forecasts. It also recognizes that the first steps in this direction are only just being taken, that the methodologies for evaluating the financial risk spreads between "green" and "brown" assets are incipient, the availability of data is limited, and there are no common standards.

However, the results of the surveys carried out by the TCFD indicate that the number of companies that are in the process of implementing the TCFD recommendations is increasing and that the main motivation is the reputational benefits of proceeding in this regard, as well as the pressure from investors to provide information on climate-related risks (RRCs). Thus, although TCFD continues to be a private and voluntary initiative, it is expected that as the need for greater transparency in climate-related risks and opportunities becomes more urgent, financial regulators and supervisors may take additional steps to require that disclosures recommended by TCFD are formally incorporated as requirements of company reports. Risk rating firms may also soon begin to incorporate this factor in their evaluations.

As critical challenges to implementing the TCFD recommendations, respondents identified, in particular, the lack of standardized industry metrics and concerns about disclosing confidential business information.

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