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Taking up the climate change challenge: a new perspective on central banking

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Taking up the climate change challenge: a new perspective on central banking

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Abstract

The awareness about climate-related financial risks is gaining momentum both in the policy and academic debates. The role of countries' institutional dimension and central bank governance structures in the adoption of green prudential regulation is, however, overlooked in the current discussion. The paper fills this gap by proposing an analysis of the state-of-the-art, challenges and perspectives, of "green" central banking. The study complements existing research that usually points to an "extended" monetary policy mandate, including, for example, sustainability objectives or green growth, as the primary motivation for a central bank to engage in "green" financial policymaking. According to our research, the decision to implement green regulations is not exclusively related to the mandate *per se*, but on the central bank's independence and on how the interaction between the monetary and prudential policy is structured. Moreover, the higher exposure to climate-related adverse events also plays a crucial role in the adoption of green prudential regulations. To avoid potential conflicts between monetary policy and green prudential regulation caused by existing intertwined transmission mechanisms, on the one hand, our analysis emphasizes the importance of having a central bank that hosts the green prudential regulation under its governance roof. On the other hand, when the "green" governance models studied in the paper are in place, the Tinbergen principle is safeguarded.

Keywords: Central banking, Policy mandate, Macroprudential policy, Central bank governance, Climate change.
JEL: G28, E58, Q54, Q56, Q58

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1 Introduction

Climate change is one of the defining challenges of the 21st century. It is recognized that the rise of global temperature to 2C requires a structural shift in the global economy from a high to a low-carbon path. However, currently available green financial resources are not enough to meet the investment requirements for a transition to a green and low-carbon economy (see IEA, 2018a, among others).

Until recently, monetary policy has not been considered relevant for long-term climate change mitigation. However, climate change is likely to affect monetary policy one way or the other (Coeuré, 2018). Moreover, due to financial regulatory oversight on money and credit flows, central banks have, on the one hand, a dominant position in promoting "green finance" through fair pricing of climate risks by financial intermediaries. On the other hand, the central bank's implicit or explicit responsibility for financial and macroeconomic stability urges monetary authorities to address climate-related and other environmental risks on a systemic level (Carney, 2015). The analysis of the role and the potential of central banks and financial regulatory authorities in green finance governance, and their capacity to address environmental risks and promote sustainable finance is therefore crucial.

When considering the current state and countries' experiences in green finance governance, we observe that central banks started to take seriously into account the possibility of climate-related finance risks and green structural changes to affect the financial system. The policy commitment, however, varies across countries and some research questions still need to be addressed. In particular: Are there any institutional factors that contribute to the adoption of green financial policies? Which kinds of central bank governance architectures are currently available when prudential authorities decide to "go green"? What are the advantages and disadvantages of the adoption of the different green central bank governance models?

Drawing on a recent database on "green" central banking (D'Orazio and Popoyan, 2019a), this paper aims at contributing to existing literature by filling research gaps concerning (i) institutional factors that contribute to the adoption of green prudential regulations, and (ii) the challenges posed by the interaction between central banks and prudential authorities that have embraced "green" policy objectives. The policy relevance of this research is twofold. First, the analysis proposed in our paper can help policymakers detecting, and disentangling, coordination issues that can arise in the conduct of monetary policy when a green financial policy concern is active. Second, it could provide suggestions on how to implement - or enhance - a governance architecture that could support the low-carbon transition. Indeed, a clear understanding of the increasing complexity of the monetary-financial policy landscape could help to address climate mitigation and contribute to the green structural change, by finding effective policies and instruments

to unchain "green" financial resources and scale-up investments towards climate-friendly sectors.

In Section 2, the paper outlines the background literature of our study and presents the theoretical framework of monetary and prudential policy interactions in the context of existing research[1]. Then, the dataset and the methodology are presented in Section 3, and the results of our analysis are discussed in Section 4. Regarding the analysis of the factors that affect the decision of the adoption of financial regulations aimed at a green economic transition, our investigation stresses the relevance of the independence of the central bank, the type of central bank governance structure, the income group, as defined by the World Bank, and the exposure to extreme weather events. Concerning the governance structure, our results emphasize, on the one hand, that the governance models that see independent central banks assuming a leading role (i.e., the pure central bank model) are those that are more likely to promote *voluntary* green prudential regulations. On the other hand, we find that *mandatory* regulations are associated mostly with a separate committee governance model. A rationale for this is that this model is quite successful in mitigating the downsides of both separate structure models and pure central bank models. Concerning the income group and the exposure to adverse climate events, we find that the countries which adopted green regulation are low- and middle-income countries and have been more exposed to both climate change and physical and transition risks. Both these factors seem to contribute to their decision to cope with the climate emergency and possible financial instability issues in a timelier way than other countries. Finally, Section 5 concludes.

2 Background

The analysis of the role played by climate finance to promote adaptation and mitigation policy actions for climate change has been growing in the past decade both in academic research and in policy debate.(Haigh, 2011; Gomez-Echeverri, 2013; Rozenberg et al., 2013). On the policy level, the Paris Agreement (COP, 2015) was a crucial event to rethink the actions of the international community. Indeed, besides traditional environmental themes (e.g., reduction of greenhouse gas emissions and climate change adaptation), the COP21 acknowledged the challenges related to the financing of a green transition. In particular, Article 2 calls for "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development" (COP, 2016). Furthermore,

[1]In the paper, there is no strong separation between micro-prudential, which focuses on the health of individual financial institutions and macro-prudential policies, which address risks to the financial system as a whole. The reason for our choice is threefold: (1) macro-prudential policy is, in fact, backward-looking (i.e., micro-prudential) in nature; (2) micro- and macro-prudential policies are, institutionally, under the same roof in the majority of cases; (3) the only prudential instrument that is inherently macro-prudential (i.e., the countercyclical capital buffer) is "deactivated" in the majority of countries.

climate finance, defined as "local, national or transnational financing drawing from the public, private sources of finance that seeks to support mitigation and adaptation actions that will address climate change" was described as one of the crucial factors to achieve the COP21 goals (COP, 2015, 2016). Nevertheless, although positive trends of development of green finance have been detected in the past years (see Buchner et al., 2017; Berrou et al., 2019, among others), currently, the flow of financial resources is not sufficient to close the "green finance gap" (Krogstrup and Oman, 2019). As a result, the existing volumes of climate finance fall short to meet the 2C scenario (Jernnäs et al., 2019), and a green structural change is difficult to achieve. Indeed, when looking at current trends of "green" investments, it is evident that there is an investment gap that needs to be filled (see OECD-IEA, 2014; IEA, 2018a,b, among others). By considering this framework, the role of green central banking to close the green finance gap cannot be underestimated, also because, due to market failures, financial markets are not able to deliver appropriate financial flows on their own (Hall, 2002; Stiglitz et al., 2017; Ameli et al., 2019).

Another important issue concerns the financial risks posed by climate change in an already "carbon-biased" financial system, which, if not correctly addressed, can compromise the safeness and soundness of the financial system (D'Orazio and Popoyan, 2019b). The awareness about climate-related financial risks has been gaining momentum both in the policy and academic debates (see Dietz et al., 2016; Batten et al., 2016; Carney, 2018; Lane, 2019; Nieto, 2019, among others). After the famous speech of the Governor of the Bank of England, Mark Carney (Carney, 2015), in the European Union (EU), a new wave of discussion started with the creation of the Task-force on Climate-related Financial Disclosures (TCFD, 2017) advocated by the Financial Stability Board, and the High-Level Expert Group by the European Commission. These initiatives and further steps towards the creation of the Network for Greening the Financial System (NGFS) provide evidence about intensified political debates and actions taking on from 2015 (Carney, 2015; NGFS, 2017a; HLEG, 2018). The result of this debate is that two EU countries, namely the Netherlands (Vermeulen et al., 2018) and the United Kingdom (BoE-PRA, 2019), have recently announced their commitment to require climate-related stress tests for the financial intermediaries (see Giuzio et al., 2019; Cleary et al., 2019, for an overview). Another EU country active in green financial policies is France, which through the Autorité de Contrôle Prudentiel et Résolution (ACPR), is working toward the integration of climate-related risks into the prudential supervision (BdF-ACPR, 2019b,a)[2].

When looking at the debate beyond the EU, a more heterogeneous picture emerges. Many developing and least-developed countries, primarily located in East and South Asia, are adopting mandatory and voluntary prudential financial instruments intending to chan-

[2]Taking a close look at the adopted green prudential instruments across the globe, the following dynamics emerge. The EU countries, while discussion only the adoption of green financial tools lean towards macro-prudential tools. Developing countries, instead, already having adopted those instrument either on mandatory or voluntary bases prefer macro-prudential tools. This dynamic is emphasized in Appendix A.

nel credit toward green productive sectors or tame climate-related financial instability. This evidence brings a green monetary policy "dilemma" to the attention of policymakers and researchers. On the one hand, there is an urgency for central banks to contribute to keeping global warming below 2C by closing the green finance gap and maintaining financial stability; on the other hand, the dilemma is concerned with the question on how to preserve the central bank's mandate and independence while "leaning against climate-related risks" (Campiglio et al., 2018; Schoenmaker, 2018; de Galhau et al., 2019). This dilemma is, in turn, related to the literature, triggered by the 2007-2008 financial crisis, on central bank governance/mandate structures and potential tensions with other policies when a central bank is "long-handed" (Bernanke, 2013; Smets et al., 2014; Mester, 2017). In this debate, many scholars point out concerns regarding the necessity to enlarge the central bank mandate when taking into account also prudential policy, thus implying a possible loss of independence by the monetary authority (see Dalla Pellegrina et al., 2013; Masciandaro and Volpicella, 2016; Lazopoulos and Gabriel, 2019, among others). With this background in mind, it is straightforward to see how the debate on the need to scale-up green finance and contain possible financial instabilities deriving from a disorderly "green transition", echoes the discussion on the monetary-prudential policies started after the financial crisis.

The discussion on central banking evolves in two main directions, posing two essential questions: (i) What are the main implications for central banks embracing the climate-related financial risks in an enlarged policy mandate?(ii) What is the best strategy for greening central banks? (ii) What are the main implications for central banks embracing the climate-related financial risks in an enlarged policy mandate? In this paper, we provide an in-depth analysis of these issues, by keeping in mind the possible conflicts between the joint conduct of monetary policy and green prudential policy tools. Indeed, the goals and toolkits of green prudential regulation and monetary policy differ substantially (Smets et al., 2014; Svensson, 2018). Whereas the former focuses on green financial stability, i.e., reducing systemic risks posed by climate change, decarbonizing banks' balance sheets, favouring the flow of funds to green sectors, and on the choice of the green tools (Lamperti et al., 2019), the latter relies, in the majority of the cases, on the policy rate to ensure price stability. However, since their field of influence passes through the financial system, they are characterized by an intertwined transmission mechanism (Barnea et al., 2015; Brunnermeier and Sannikov, 2014b). Moreover, considering that one policy is shaping the playground of the other, their respective impact should be taken into consideration in their implementation. In particular, we argue that the existence of climate-related financial risks, together with the need to scale up green finance, call for the development of a "synthesis" between monetary and green prudential policymaking. The implementation of this synthesis creates the basis for a critical discussion about whether stretching central banks' mandate violates the well known principle of Tinbergen according to which "for

each policy objective, at least one policy instrument is needed" (Tinbergen, 1939, 1952). In the case of "green central banking", this would imply that an adequate instrumental set for the central bank's "leaning against the climate-related risk" strategy is required.

By considering Tinbergen's *"n objectives - n tools"* formula, the inclusion of a sustainable finance goal in the price stability mandate could, on the one hand, jeopardize the principle itself and, on the other hand, lead to an over-stretching of the central bank mandate. Motivated by such considerations, the latter becomes less clear and too broad, thus undermining the authority's independence. However, if the green prudential regulation is considered as an "offspring" of the more general prudential policy, the "leaning against the climate-related risk" function can be undertaken without violating the Tinbergen principle. As shown in Figure 1, in this setting, monetary policy is concerned with the primary objective of price stability, while prudential policy - enriched with the greened tools - is concerned with financial stability, hence reaching also the sustainability objective. Consequently, issues regarding the mismatch between the number of instruments and the number of objectives, do not arise.

3 Data and methodology

3.1 Data

Data have been retrieved from the D'Orazio and Popoyan (2019a) database. It represents a unique database, providing information on the type of institutional governance, the mandate, the type of green regulation (if any), the institution responsible for its implementation, or promotion. It complements existing prudential tools database, like the one developed by Cerutti et al. (2015, 2016, 2017) and similar studies on "standard" prudential instruments (Akinci and Olmstead-Rumsey, 2018; Fendoğlu, 2017; Dassatti Camors et al., 2019; Jiménez et al., 2017).

The countries included in our study, and their features regarding the prudential regulation adopted or under discussion, are listed in Table 4, Appendix A. Two samples have been created:

(a) the first, labeled with `GCB`, includes those countries that are reported to have adopted, either on a mandatory or voluntary base, a green prudential regulation which is defined by the Green Prudential Regulation Index (`GMP`)[3]. By using this index (`GMP=1`), we refined the original database and created a sample of 25 countries.

(b) the second sample, labeled with `NGCB`, includes 23 countries with `GMP=0` that are

[3]The index contained in D'Orazio and Popoyan (2019a) has been modified for the analysis conducted in this paper. Countries that adopted voluntary or mandatory green regulation are "aggregated" under GMP=1. GMP=0, instead, indicates countries that are discussing the possible implementation of a regulation, as in the original database.

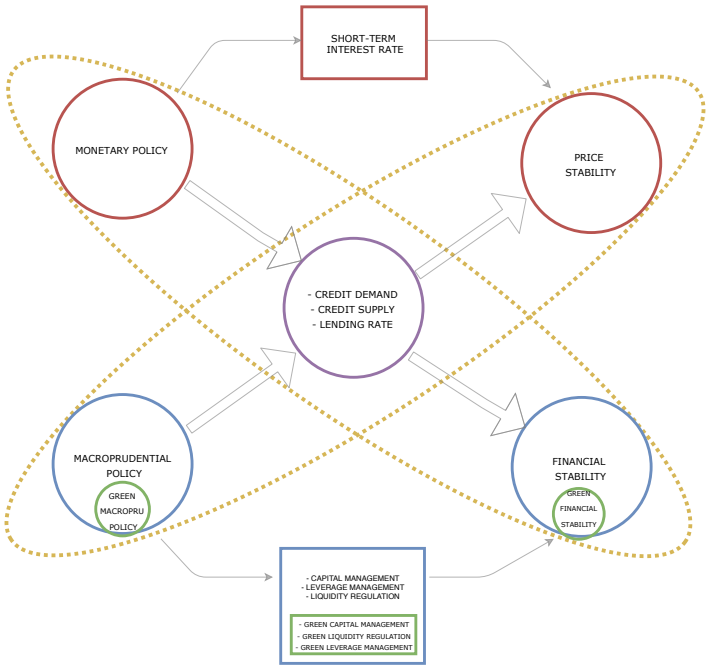

Figure 1: Monetary and prudential policies interactions and transmission mechanisms in presence of climate-related financial risks.
Note: The red shapes at the top of the Figure represent the monetary policy transmission mechanism that is in place with the objective of price stability. The blue shapes at the bottom represent the prudential policy transmission mechanism with the objective of financial stability, also embracing green prudential features. The two crossing ellipses highlight the common field of influence of the two policies.

reported to be discussing green financial regulations (such as stress testing or climate-related risk disclosure), or climate change concerns in their policymaking.

3.2 Variables

In this section, we describe the variables used in our analyses; they are summarized in Table 5, Appendix A.

First, the *central bank governance* index (CB model) is taken into account. According to it, we can distinguish three central bank governance types; namely, (a) central bank model, (b) separate committee, and (c) separate structure model. Following existing literature on central bank governance (IMF, 2013a; Smets et al., 2014), we provide the definitions of the models. In the central bank model, monetary and prudential policies are "under one roof" because the prudential policy is contained in the central bank mandate, and the central bank is the prudential authority. In the separate committee model, monetary and prudential policies are instead separated. In this case, prudential regulation is

still in the central bank mandate, but the central bank is not the responsible authority for the implementation of financial policies. Usually, there is a separate committee in charge of that. Finally, in the separate structure model, monetary and prudential policies are separated as in the previous model. However, in this case, several agencies such as ministries, bank associations, government, capital market regulators, can take on the role of prudential authority.

We then include the *central bank mandate*, which has usually price stability as its main objective; it can target price and financial stability or growth, and multiple objectives, in other cases.

Central bank independence (CBI), i.e., central banks' ability of controlling monetary instruments, has been considered because of the importance the literature has traditionally attributed to this feature (see Cukierman and Webb, 1995; Moser, 1999; Cukierman, 2009, among others). Regarding the choice of the index, we resorted to Bodea and Hicks (2014), which set up an original dataset that codes independence annually and covers legislation changes over forty-three years. According to the authors, the four characteristics considered to build the index are: "First, a bank is viewed as more independent if the governor is appointed by the central bank board rather than by the government, is not subject to dismissal, and has a long term of office. Second, the level of independence is higher the greater the extent to which policy decisions are made without government involvement. Third, a central bank is more independent if its charter states that price stability is the sole or primary goal of monetary policy. Fourth, independence is greater if there are limitations on the government's ability to borrow from the central bank. In our view, it is the best proxy for CBI for several reasons, one of them being that this measure takes the conservativeness of the central bank as embedded in the law into account, i.e. the more priority the central bank law gives to price stability the higher the score of the index. (Bodea and Hicks, 2015, p.5)".

A fourth variable is the financial sector size, which is the level of bank assets to GDP and has been retrieved from the 2018 World Bank Financial Development and Structure dataset. Other institutional indicators - such as continent, OECD membership, and income group - are also included. Additionally, we introduced the membership of the Basel Committee on Banking Supervision and two variables related to the participation to international networks of central banks; namely, the Network for Greening the Financial Sector (NGFS), and the Sustainable Banking Network (SBN), that were chosen because of their role in enhancing financial regulation at the international level and promoting awareness for climate-related issues.

The Basel Committee is the primary global standard-setter for the prudential regulation of banks and provides a forum for cooperation on banking supervisory matters. It was founded at the end of 1974 with the mandate to strengthen the regulation, supervision, and practices of banks worldwide to enhance financial stability. Its 45 members comprise

central banks and bank supervisors from 28 jurisdictions.
The NGFS is a voluntary network of central banks and supervisors established in December 2017. It aims to "...[ ]help to strengthen the global response required to meet the goals of the Paris agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development[ ]..." (NGFS, 2017b).
The SBN is a voluntary community of financial sector regulatory agencies and banking associations from emerging markets committed to advancing sustainable finance in line with good international practice. It was launched in September 2012 and represents a platform for knowledge sharing and capacity building to facilitate the mobilization of practical support for members to design and implement national initiatives towards sustainability.
Finally, we also considered the latest available Climate Risk Index, periodically published by Germanwatch (Eckstein et al., 2020). The index is based on the analysis of the extent to which countries and regions have been affected by weather-related loss events (storms, floods, heatwaves, etc.).

4 Analysis

The analysis is divided into three steps:

a) *Discussion of green central banking models* to analyze how the central bank governance models are distributed in our samples.

b) *Discussion of the advantages and disadvantages* of different types of central bank models when a green prudential approach is adopted.

c) *Fixed-effect Principal Component Analysis (PCA)* to study the extent to which institutional and country-specific factors influence the decision of policymakers to adopt green financial regulations on a voluntary/mandatory bases (in the case of the GCB) and those factors that contribute to the debate the possibility of "greening" policymaking (in the case of NGCB).

4.1 Green central banking and governance types: analyzing the diffusion

By inspecting the GCB sample, we observe that when the green prudential index is adopted, *separate models* are the most common (64% of the sample). A "pure" central bank model characterizes instead 36% of the GCB sample. Finally, 72% of the sample features a central bank with a leading and significant role in the green policymaking, i.e., the central bank and separate committee models. Regarding the NGCB sample, we observe that a "pure" central bank model characterizes the 22% of the sample; 61% is characterized by a separate committee structure and 17% by a separate structure model. In total, 78% is described by a separate structure model compared to a 64% in the GCB

sample. Compared to the 72% observed in the GCB sample, 83% of the countries of the NGCB sample is characterized by a leading role of the central bank.

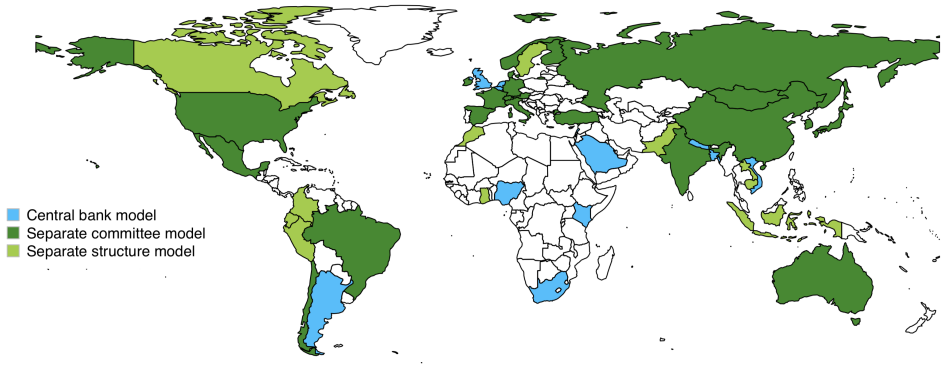

Figure 2: The distribution of central bank governance models.

The diffusion of governance models in both samples is shown in Figure 2. By complementing this information with the one contained in Figure 3, we observe that the leading authorities that collaborate with central banks in greening the financial sector are, in the case of separate models, bank associations in Cambodia, and Mongolia, capital market authorities in India and Morocco, and regulatory authorities in China. In other cases, the responsible authority is either a banks' association (Colombia, Ecuador, Kenya, Mexico, South Africa, and Turkey) or a separate prudential regulatory body (Indonesia and Singapore). Both figures highlight the existence of "polarized" governance architectures, with a dominant role of central banks, either in terms of the central bank model (e.g., Nigeria, South Africa, Kenya, Bangladesh, Vietnam, and Nepal) or the separate committee model (Brazil, China, France, India, Japan, Mexico, Mongolia, and Turkey), where, in the majority of cases, the monetary authority chairs the committee. Moreover, as shown in Figure 3, when we consider the countries that are discussing the introduction of green principles in their policymaking, we observe that the tendency of leaning on separate green prudential governance is present also in the case of developed countries. In particular, Denmark and Italy rely on joint decision-making between the central bank and the ministry of finance, Finland, on the separate financial regulator and central monetary authority, Luxembourg, on the bank association.

Another interesting analysis concerns the interlinkages among the strength of policies, the type of instrument adopted, and the model of central bank governance. As shown in Table 1, regarding the first category of tools that include liquidity requirements, lending limits, and differentiated reserve requirements, we observe a majority of mandatory instruments. Interestingly, they are associated with a model of governance where the central bank plays a leading role, and the prudential regulation is included in the mandate. Stress tests are active only in four countries and are adopted mainly on a voluntary base, except for China. In this case, the governance types are equally divided between the

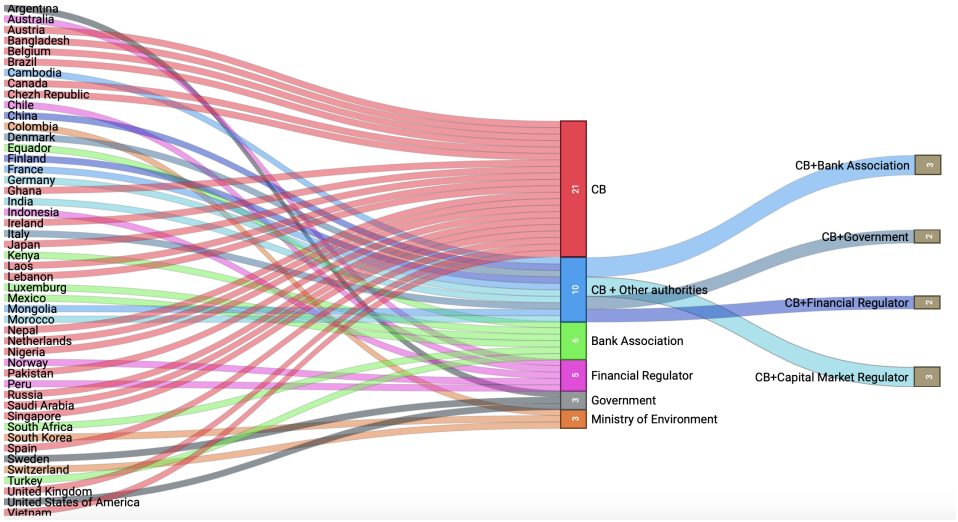

Figure 3: State-of-art in green prudential governance.

separate committee and the central bank models. Finally, regarding the measures related to climate-related risk management, disclosure, and assessment, we observe that they are distributed evenly across the three types of governance.

4.2 Advantages and disadvantages of different green central bank governance models

In this section, we try to shed light on the implications of our findings, by bridging the empirical results with the theoretical framework sketched in Section 2. The pros and cons of the different governance structures are discussed[4] and summarized in Table 2.

When the *central bank model* is in place (as in the case of Nigeria, Kenya, South Africa, Vietnam, Bangladesh, Nepal, and Lebanon), the green prudential regulation is part of a more general prudential setup and is under the central bank's roof, implying that the central bank is also the green prudential authority. The *separate models* opt for an integrated governance approach, by either combining the expertise of multiple agencies while giving a leading role to the monetary authority, as in the case of the separate structure model or by relying on a separate committee, which is the green prudential regulation authority. In the second case, usually, the central bank is a leading figure, but coordination is more sensitive, and the tension between monetary and prudential policies is more emphasized. Separate models thus require a higher level of coordination and cooperation between the central bank and the prudential authority since the "distribution" of the green prudential regulation among several authorities may complicate the decision-making, weaken

[4]This analysis is inspired by studies on more general prudential architecture (see Lim et al., 2013; IMF, 2013b; Smets et al., 2014; Bundesbank, 2015; Brunnermeier and Sannikov, 2014a; Svensson, 2017, among others).

Type of instrument	Strength of policy	# instruments	Governance	# countries
Lending limits, liquidity requirements differentiated reserve requirements	voluntary	5	CBM	3
			SCM	1
			SSM	1
	mandatory	7	CBM	3
			SCM	4
			SSM	0
Climate-related stress test	voluntary	3	CBM	2
			SCM	1
			SSM	0
	mandatory	1	CBM	0
			SSM	1
			SSM	0
Climate-related risk management, disclosure and assessment	voluntary	7	CBM	2
			SCM	2
			SSM	3
	mandatory	7	CBM	2
			SSM	2
			SSM	3

Table 1: Summary statistics of the distribution of the strength of policies by instrument type and governance model. Legend: CBM: central bank model; SCM: separate committee model; SSM: separate structure model.

accountability and increase the risk of an inaction bias. The prominent position of central banks in a committee of representative agencies could smooth the coordination problem. For a green prudential authority to work efficiently, independence from both political and financial markets' influences should be granted. However, as observed in the case of the "pure"central bank model, although it explicitly assumes high independence of the policy-maker, in many jurisdictions, the independence of the central bank is indeed very low (see, e.g., Bangladesh and Vietnam), thus compromising the efficient and flawless conduct of the policy agenda. The importance of having a central bank that has the green prudential regulation in its mandate is supported by the fact that tools and transmission mechanisms of monetary and prudential policy are so profoundly intertwined that it is both ineffective and impossible to delineate a clear separation of the two policy objectives (as shown in Figure 1). For example, green prudential measures that could be used to reduce carbon-intensive lending and canalize resources to sustainable sectors have an impact on money creation, which directly feeds into price stability (D'Orazio and Popoyan, 2019b). Therefore, since climate change influences the financial market conditions, it seems that policymakers around the world have started considering it a concern for monetary policy decision-making as well. Besides, the close interaction between monetary and prudential policy leaves room for the "bottleneck approach" (Brunnermeier and Sannikov, 2014b). Consider, for example, a situation in which carbon-intensive sectors are profoundly affected by a debt overhang as a consequence of the low-carbon disorderly transition. It is evident that these sectors should be primarily supported, because, if this situation does

materialize, the "contraction" of the carbon-intensive industry could quickly end up in a liquidity spiral, and consequent fire sales of assets, which in turn could end-up in self-reinforcing deflationary spirals. In this framework, the monetary policy equipped with a price stability mandate is shorthanded, whereas green prudential policy can target a specific sector.

	Central bank model	**Separate committee model**	**Separate structure model**
Governance type	MP & GPR "under one roof" • GPR is in CB mandate • CB is the GPR authority	MP & GPR are separated • GPR is in CB mandate • CB is not the GPR authority • Separate committee is the GPR authority	MP & GPR are separated • GPR is not in CB mandate • CB is not the GPR authority • Multiple agencies can take the role of the GPR authority
Pros	• Full MP-GPR interaction	• Easy separation of objectives (compliance with Tinbergen principles)	• Easy separation of objectives (compliance with Tinbergen principles)
Cons	• Time inconsistency • Reputation • Overstreaching CB mandate	• Coordination issues • Inaction bias	• Coordination issues • Limited interaction

Table 2: Features of different central bank governance models when a green prudential regulation is adopted.
Note: CB: central bank; GPR: green prudential regulation; MP: monetary policy.

We can draw some interesting conclusions when we combine this theoretical outlook with the empirical results of our investigation. Our results emphasize, on the one hand, that the governance models that see independent central banks assuming a leading role (i.e., the "pure" central bank model) are more likely to promote *voluntary* green prudential regulations. On the other hand, we find that *mandatory* regulations are associated mostly with a separate committee governance model. A rationale for this is that the separate committee model's institutional setup tries to overcome both the weaknesses of the pure central bank and separate structure models. Although the ownership of the prudential policy is "housed" into the central bank, as in the CB model, the separate committee model argues for a clear separation between the objectives, instruments, and communications of monetary and prudential policies[5]. According to Smets et al. (2014), this model benefits from balanced coordination without failing into time inconsistency, and it takes all the benefits of the central bank model, namely, the expertise in the analysis of systemic risk, independence for short-term political pressure, coordination between two policy decision making processes. This allows the policymaker to mitigate the financial dominance, reputational risk, and time inconsistency risk that are greater in the pure central bank model.
Additionally, according to us, the separate models that consider the green prudential policy as an "offspring" of the traditional prudential policy, safeguard the Tinbergen principle.

[5]There is a vast literature advocating this model. Silvo (2019) analyzes interactions between the monetary and prudential setup and finds that this model is the best in terms of the optimal planner. Carrillo et al. (2017) discusses the model within the Tinbergen principle, concluding that it is the best in terms of welfare gains. Moreover, we observe that the real-world usage of this model is more widespread to compare with the other two (see Figure 2 and Table 1)

4.3 Adoption of green prudential regulations: a fixed-effect PCA analysis

In this section, we discuss the results of the PCA analysis. It allows us to implement a robust dimensionality reduction, revealing the structure of our complex dataset. Moreover, it helps us in understanding which are (i) the main components that correspond to the directions maximizing the variance of the data projected on them, and (ii) the variables that contribute most to the principal components. Further details of the PCA analysis are reported in Appendix B.

This step of the investigation is relevant because it allows us to highlight the factors that affect the decision to adopt green prudential regulations. According to the analysis shown in previous sections, it is possible to detect a clear connection between the diffusion of *voluntary* and *mandatory* green regulations and a particular type of governance model. However, as reported in Table 3, the share of both the governance models with a leading central bank role are similar in the two samples. This suggests that the central bank governance model alone is insufficient to explain the adoption's decision and, thus, we need to explore the role of additional variables, as discussed in Section 3.2.

	Governance type				
	CBM	**SCM**	**SSM**	**CBM&SCM** Leading role of the CB	**SCM&SSM** Separate structures
GCB	36%	36%	28%	72%	64%
NGCB	21.73%	60.83%	17.39%	82%	79%

Table 3: Share of central bank governance models by sample.

To have a better understanding of the *quality* of the variables included in the analysis, i.e., their contribution to the two dimensions, we report in Figure 4 the factor maps of the squared loadings of the variables on the components. Each variable is a point whose coordinates are given by the squared loadings on the principal components. `Dim.1` is observed on the horizontal dimension of the factor map, while the `Dim.2` on the vertical one. The variables that are away from the origin of the circle and close to the perimeter are well represented on the factor map; variables that are not perfectly represented by the principal components are close to the center of the circle. Moreover, different colors help us to grasp the contribution of the variables to the two dimensions. Dark orange suggests a good representation of the variable on the principal component, while light blue indicates the opposite.

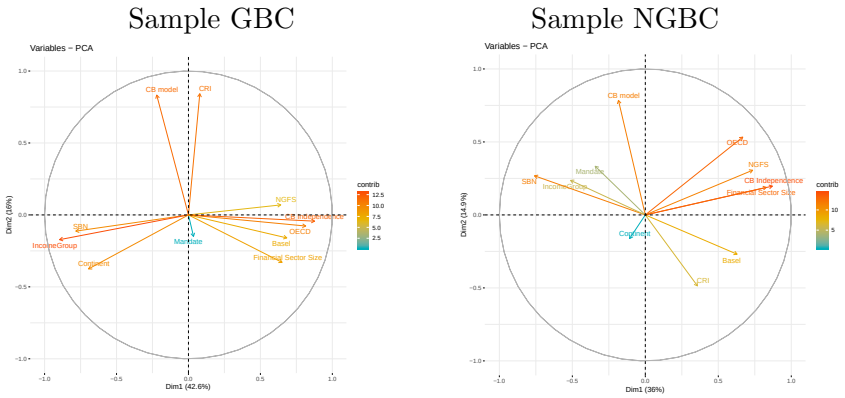

Figure 4: Contributions of the variables to `Dim.1` and `Dim.2`.

In the GCB sample, the strongest contribution to both dimensions is provided by four variables, namely, income group, central bank independence, central bank governance, and exposure to extreme weather events. Other contributing variables are `OECD` and `SBN` membership. Regarding NGCB countries, we observe that the `CBI` variable, similarly to what observed in the other sample, plays an important role. However, we observe different additional contributing variables. In particular, we observe a higher contribution coefficient for the `OECD`, `SBN` and `NGFS` memberships and the financial sector size. The exposure to adverse climate-related events is found to be less relevant than in the GCB sample. The rationale for this is that the NGCB sample comprises countries that have been (on average) less affected by climate-related damages in the two years preceding the discussion on green financial regulations. This suggests that higher exposures to climate-related events strongly influence the decision of a country to adopt green financial regulations.

When focusing on the governance variable, interestingly, it scores high in the contribution rank in both samples; indeed, it is the third contributing variable in the GCB sample and the fourth in the NGCB sample (see Appendix **??**). Another interesting finding is related to the participation of the countries to international networks or associations of central bankers and regulators, such as the NGFS and the SBN. On the one hand, the SBN membership is relevant in both samples, as it actively promotes the adoption of a green perspective in policymaking[6]. On the other hand, the contribution of the variable NGFS is more pronounced in the NGCB sample and has no role in the GCB. We observe that among the 25 components of the GCB sample, only 8 are members of the NGFS; out of these, only two, namely China and Colombia, are members of the NGFS and the SBN. Finally, regarding the mandate, it is found to contribute only marginally to the realization of the dependent variable in both samples, as very low squared loadings values are observed (see Tables 9 and 12, and Figures 7 and 8).

[6]It scores 6th in the GCB and 5th in the NGCB sample.

Overall, the PCA analysis confirms the core concern that motivates our investigation, namely that central bank governance arrangements and independence, cannot be disregarded when studying the factors that contribute to the adoption of green prudential regulations[7]. However, as the PCA points out, the adoption decision is also influenced by other factors that are different between the two samples. In particular, for the countries that adopted a mandatory or voluntary regulation, it seems that what matters is the income group and exposure to climate risks. For countries that are currently discussing the adoption, we observe a more significant role of OECD membership and the financial sector size.

5 Concluding remarks

The last few years have been characterized by increasing attention from central bankers to the design of effective responses to climate change challenges. The number of central banks taking a step in this direction has been rising; however, the overall number is still quite limited.

By using the most recent available data on "green" central banks, the paper introduces an analysis to fill the knowledge gap regarding (i) the factors that contribute to the adoption of green prudential regulations, (ii) the type of central bank governance that are available when the central bank decides to "go green" and (iii) the challenges posed by the interaction between central banks and prudential authorities that have a "green" policy objective.

By proposing this investigation, the paper complements existing research that usually points to an "extended" monetary policy mandate, including, for example, sustainability objectives or green growth, as the primary motivation for a central bank to engage in "green" financial policymaking (see Campiglio et al., 2018; Dikau and Volz, 2018, among others). According to our research, the decision to implement green regulations is not exclusively related to the mandate *per se*, but on the central bank's independence and on how the interaction between the monetary and prudential policy is structured. The principal component analysis supports these findings and confirms the core concern that motivates our investigation, namely; institutional features cannot be disregarded when studying the factors that contribute to the adoption.

Regarding the CBI, we find that (i) countries characterized by the central bank and the separate committee models display higher independence (on average) in both samples, and (ii) in the case of GCB, the independence is lower (on average) when compared to the NGCB sample (see Figure 5, Appendix A).

Regarding the governance types, two main features emerge. On the one hand, countries that exhibit a governance model where the central bank has a leading role in both monetary

[7]This result is confirmed when we perform the PCA on the 48 countries considered in one sample.

and prudential regulation, i.e., the "pure" central bank model and the separate committee model, are the most diffused in both samples. According to the theoretical framework sketched in Section 2 and the analysis conducted in Section 4.2, the coordination, and interaction between the monetary and prudential policies are "smoother" in the case of the "pure" central bank model rather than in the separate structure case, where coordination issues may arise because the green prudential authority is separated from the monetary authority. It is essential to have a central bank that has the green prudential regulation in its governance architecture because tools and transmission mechanisms of monetary and prudential policies are so profoundly intertwined that it is difficult to delineate a clear separation of the two policy objectives. Moreover, according to the evidence collected in the paper, these features seem to be particularly beneficial for the process of the adoption of green regulations.

On the other hand, *green separate models*, i.e., separate committee and separate structure models, are also quite common in both samples (see Table 3). From a theoretical perspective, we emphasize that *separate models* that consider the green prudential policy as an "offspring" of the traditional prudential policy, safeguard the Tinbergen principle. However, they will require a higher level of coordination and cooperation between the central bank and the prudential authority since the "distribution" of the green prudential regulation among several authorities may complicate the decision-making, weaken accountability and increase the risk of an inaction bias. The evidence collected so far suggests, interestingly, that the central banks that are characterized by these governance arrangements are quite active in discussing the adoption of green regulations and green financial principles.

Besides central bank governance arrangements and independence, our analysis emphasizes that other factors matter as well. In particular, the exposure to high impact climate-related events and being part of the low- and middle- income groups, contribute to the decision "to go green" and adopt financial regulations. We observe that low- and medium-income countries are the leaders in adopting green prudential approaches. This suggests that as these countries are more exposed to climate change (Li et al., 2019; Thomas et al., 2019), and physical and transition risks, they try to cope with the climate emergency and possible financial instability issues in a timelier way than other countries. Japan, France, UK, South Korea, and the Netherlands represent exceptions. They are the only high-income countries that adopted prudential regulations (on a voluntary base) and have been reported to be exposed and vulnerable to extreme events.

Finally, the participation of international networks or associations of central bankers and regulators is also found to play a role as they encourage the adoption of good practices to manage risks and to mobilize capital for green and low-carbon investments.

In our view, the investigation on the governance structures, taking into account the new challenges posed by the socio-economic structural change following the climate emergency, represents an engaging avenue of future research that could bring together researchers and

policymakers to contribute to the improvement of the green institutional architecture. According to us, the understanding of the interplay between the implementation of the green prudential policy and the type of central bank governance structure is of utmost importance to achieve this objective. The rationale and policy relevance of our research is twofold. First, the analysis proposed in the paper can help policymakers detect, and disentangle, coordination issues that can arise in the conduct of monetary policy when a green financial policy concern is active. Second, it could provide suggestions on how to implement - or enhance - a governance architecture that could support the low-carbon transition. A better understanding of the increasing complexity of the monetary-financial policy landscape could help address climate mitigation and contribute to the green structural change, by finding effective policies and instruments to unchain "green" financial resources and scale-up investments towards climate-friendly sectors. Our results could thus be used to provide further insights into the challenges of green central bank models and how to enhance existing governance structures more effectively to address the challenges of climate change better. However, further investigation is needed to assess the efficiency of different governance structures. We leave it for future research, highlighting that it will crucially depend on the availability of more data at the country level.

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Appendices

A Additional information on the dataset

Country	Under discussion	Voluntary GMP	Mandatory GMP	Type of instrument	Sample
Argentina	✓				NGCB
Australia	✓				NGCB
Austria	✓				NGCB
Bangladesh			✓	LL	GCB
Belgium	✓				NGCB
Brazil		✓	✓	LL	GCB
Cambodia		✓		LL	GCB
Canada	✓				NGCB
Chile	✓				NGCB
China			✓	LL, ST	GCB
Colombia			✓	RDA	GCB
Czech Republic	✓				NGCB
Denmark	✓				NGCB
Ecuador		✓		RDA	GCB
Finland	✓				NGCB
France		✓		ST	GCB
Germany	✓				NGCB
Ghana	✓				NGCB
India			✓	LL	GCB
Indonesia			✓	RDA	GCB
Ireland	✓				NGCB
Italy	✓				NGCB
Laos	✓				NGCB
Luxemburg	✓				NGCB
Japan		✓		LL	GCB
Kenya		✓		LL	GCB
Lebanon			✓	DRR	GCB
Mexico		✓		RDA	GCB
Mongolia			✓	RDA	GCB
Morocco		✓		RDA	GCB
Nepal			✓	RDA	GCB
Netherlands		✓		ST	GCB
Nigeria			✓	LL, LR, RDA	GCB
Norway	✓				NGCB
Pakistan			✓	RDA	GCB
Peru		✓		RDA	GCB
Russia	✓				NGCB
Saudi Arabia	✓				NGCB
Singapore	✓				NGCB
Spain	✓				NGCB
South Africa		✓		RDA	GCB
South Korea			✓	LL, RDA	GCB
Sweden	✓				NGCB
Switzerland	✓				NGCB
Turkey		✓		RDA	GCB
United Kingdom		✓		ST	GCB
United States of America	✓				NGCB
Vietnam			✓	LL, RDA	GCB

Table 4: Analyzed countries: type of GMP, type off instruments implemented and sampling. *Legend: LL: lending limits; ST: Stress-test; RDA: risk disclosure & assessment; LR: liquidity requirement; DRR: differentiated reserve requirement*

Variable	Description	Source	In the database D'Orazio and Popoyan (2019a)	Year
GMP	Green macroprudential index 0 = green prudential measures under discussion, 1 = green prudential measures active on a voluntary or mandatory base	Central banks' official documents, acts, modifications.	✓	Jan. 2020 update on the original database
CB_MOD	Type of central bank governance structure. 1 = *central bank* model, 2 = *separate committee* model 3 = *separate structure* model.	Central banks' official documents, acts, modifications.	✓	Jan. 2020 update on the original database
MAND	The variable takes different values depending on the type of objectives specified with respect to monetary policy: 1 = price stability; 2 = price & financial stability; 3 = growth; 4 = other, mix of objectives	Central banks' official documents, acts, modifications.	✓	Jan. 2020 update on the original database
CONTINENT	Continent. 0=Europe; 1=America; 2=Asia; 3=Africa	World bank classification.	✓	Jan. 2020 update on the original database
INCOME GROUP	Income group as defined by the World Bank. 0=high income; 1=upper-middle income; 2=lower-middle income.	World bank classification.	✓	Jan. 2020 update on the original database
BASEL	Member of the Basel committee. 0=no member; 1= member.	Basel Committee website.	✓	Jan. 2020 update on the original database
OECD	Member of the OECD. 0=no member; 1= member.	OECD website.	✓	Jan. 2020 update on the original database
CRI	Climate Risk Index 2018.	GermanWatch e.V. (Eckstein et al., 2020)		Jan. 2019
CBI	Central Bank Independence index. The index ranges from zero (no independence) to 10 (maximal independence)	Bodea and Hicks (2015)		2015
FIN_SEC_SIZE	This variable measures the deposits money bank assets to GDP	World Bank's Financial Development and Structure Dataset.		Oct. 2019
NGFS	Member of the Network for Greening the Financial System. 0=no member; 1= member.	Network for Greening the Financial System website.		Jan. 2020
SBN	Member of the Sustainable Banking Network. 0=no member; 1= member.	Sustainable Banking Network website.		Jan. 2020

Table 5: Description of variables, and data sources, used in the empirical analyses. The variables are retrieved from the D'Orazio and Popoyan (2019a) database and were updated to match the latest available data regarding the diffusion of green prudential regulations. Regarding the central bank independence index, the latest available data are from 2015. However, by consulting the database, we noted that the values for the countries considered have not changed in the past 20 years.

	CB model	Mandate	CRI	Basel	OECD	NGFS	SBN	CB Independence	Financial Sector Size	IncomeGroup	Continent
Min. :	1.000	1.00	1.00	0.000	0.0	0.0000	0.0000	2.000	19.13	0.0000	0.000
1st Qu.:	1.000	1.00	25.00	0.000	0.0	0.0000	0.0000	3.475	56.03	0.0000	0.000
Median :	2.000	2.00	58.50	1.000	0.5	0.0000	0.0000	4.600	82.16	1.0000	1.000
Mean :	1.938	1.75	59.71	0.625	0.5	0.4583	0.3958	5.392	91.86	0.8125	1.167
3rd Qu.:	2.000	2.00	90.25	1.000	1.0	1.0000	1.0000	7.625	130.95	2.0000	2.000
Max. :	3.000	3.00	135.00	1.000	1.0	1.0000	1.0000	8.800	178.99	2.0000	4.000

Table 6: Summary statistics.

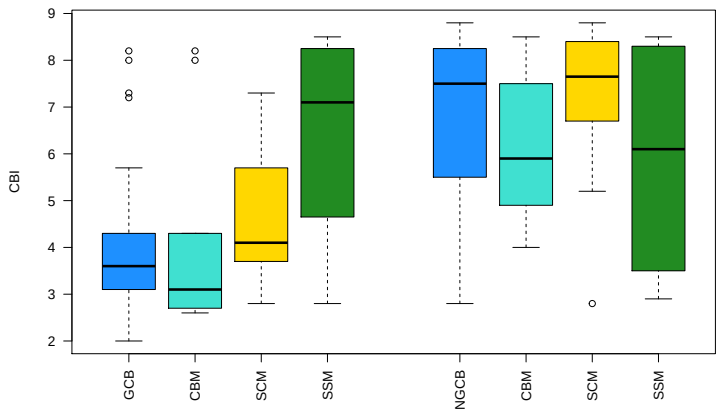

Figure 5: Distribution of the central bank independence index in the GCB and NGBC samples by central bank governance models. Legend: CBM: central bank model; SCM: separate committee model; SSM: separate structure model.

A.1 Structure of the dataset and correlation analysis

A very interesting correlation structure reported in Figure 6 rises out of the analysis of 2 separate samples of our dataset.

First, we analyze the sample composed by countries which have an "active" green prudential regulation (Figure 6, left plot). We observe a positive correlation between the central bank governance model (the variable `CB_MOD`) and the Climate Risk Index and a negative correlation with the financial sector size. The mandate is found to be negatively correlated with the continent, meaning that the countries that compose the sample are characterized by a broad mandate, which also includes growth targets besides price stability, and usually are located in continents other than Europe. The Climate Risk Index is negatively correlated with continent implying that countries that display a lower CRI (meaning that have been highly exposed to climate risk and losses in 2018) are located mostly in Asia and Africa. Basel membership is positively correlated with both central bank independence and OECD membership but negatively with the income group and, to a certain extent, also to the continent and SBN membership. The NGFS membership is found to be positively correlated with the central bank independence (i.e., the more independent is a central bank, the more it is a member of the NGFS) and negatively correlated with the income group (the lower the income level, the smaller is the probability to be a member of the network). Regarding the SBN membership, instead, we observe a positive correlation with the income group (the lower the income, most likely is the participation in the SBN) and the continent (the lower the income level, the highest the probability to belong to the SBN). Central bank independence is negatively correlated with the income group: the higher the independence, the lower the income level.

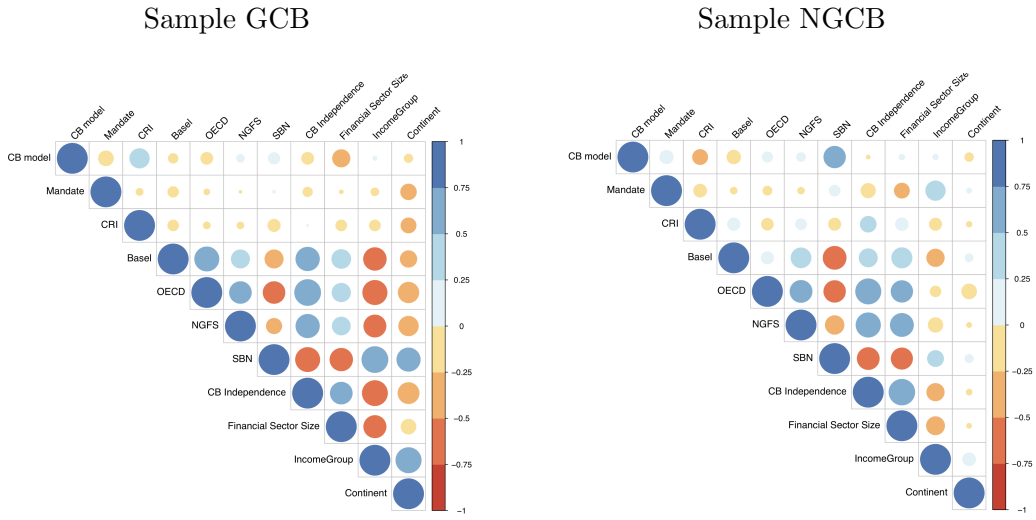

Figure 6: Correlation among the variables in the two samples.

In the second sample of data, which includes countries that did not adopt yet green prudential regulations (see Figure 6, right plot), we observe a positive correlation between the central bank model and the SBN membership. The rationale for this is that, usually, countries that are members of the SBN are found to have a separate structure model. In this sample, NGFS membership is positively correlated with central bank independence and financial sector size. Additionally, similarly to the first sample, NGFS membership is negatively correlated with SBN, meaning that the more a country is an NGFS member, the less it also participates in the SBN. Regarding the SBN variable, it is negatively correlated with both the central bank independence and financial sector size; this implies that the more a country is a member of the SBN, the lower is its central bank independence and the smaller is its financial sector. Moreover, we note that the correlation structures regarding the networks' of central banks' membership are quite similar and robust across the two samples.

B Multivariate analysis: description of the PCA implementation and main statistics

The PCA is used to analyzes a dataset representing observations described by several variables, which are, in general, inter-correlated. Its goal is to extract the important information from the dataset and to express this information as a set of new orthogonal variables called principal components. In particular, we use the PCA to achieve the following goals: (a) extract the most critical information from our complex dataset; (b) compress the size of the dataset by keeping only this important information; (c) simplify the description of the dataset, and (d) analyze the structure of the observations and the variables.

The PCA method is particularly useful when the variables within the dataset are highly correlated, as shown in section A.1. Correlation indicates that there is redundancy in the data; due to this redundancy, PCA can be used to reduce the original variables into a smaller number of new variables, that are the principal components, explaining most of the variance in the original variables. Therefore, the motivation behind using the PCA method in our analysis is to decorrelate data, thus removing second-order dependencies. The analysis is structured as follows:

1. Import the dataset;
2. Data standardization;
3. Computation of eigenvalues;
4. Definition of the components (dimensions);
5. Computation of the correlation between the variables and the dimensions;
6. Computation of the squared coordinates (loadings) and contribution of each variable to each dimension;
7. Representation of observations by means of their projections (Factor map/observation circles);
8. Comment on the quality of representation of the variables on factor map, i.e., cos2 (square cosine, squared coordinates).

In particular, in our analysis, we perform a PCA on a fixed effect model, meaning that the observations are considered to be the population of interest, and conclusions are limited to these specific observations. In this context, PCA is descriptive and the amount of the variance of the matrix of variables explained by a component indicates its importance.

In the following subsections B.2 and B.1, we report the results of the PCA analysis considering the two samples. Table 8 and 11 show the eigenvalues, which measure the amount of variation retained by each principal component. The sum of all the eigenvalues gives a cumulative variance of 66.53%, whereas the proportion of variation explained by each eigenvalue is given in the second column. Additionally, interesting insights are offered by the inspection of the contribution of each variable to the dimensions of the PCA; the larger the value, the more the variable contributes to the component (see Tables 9 and 12, and Figures 7 and 8).

According to the PCA, in both samples, the variables can be grouped into two main components or dimensions. In the GCB sample, the main variables that contribute to the first component `Dim.1` are the income group and CBI. Instead, the main contributing variables to the second component `Dim.2` are the CB model and the climate risk index (See Table 9, Appendix B). In the NGCB sample, the main contributing variables to `Dim.1` are `CBI` and the size of the financial sector; while CB model and OECD membership contribute more to `Dim.2` (See Table 12, Appendix B). To further support these results, we report

also the correlation between the active variables and the principal components, as shown in Tables 10 and 13.

Table 7 helps us in summarizing the results of the PCA by showing the variables that report an above the average contribution to explain the variance observed in the two samples. In doing so, we consider their joint contribution to both `Dim.1` and `Dim.2`. Moreover, in an attempt to clarify the specific role of each variable, we also provide the rank value, i.e., the relative importance of the variable deriving form the PCA.

Variables	**GCB sample**		**NGCB sample**	
	Contributing?	Rank	Contributing?	Rank
Basel membership	✗		✗	
CB Independence	✓	2	✓	1
CB model	✓	3	✓	4
Continent	✓	7	✗	
Climate Risk Index	✓	4	✗	
Financial Sector Size	✗		✓	3
Income group	✓	1	✗	
Mandate	✗		✗	
NGFS membership	✗		✓	6
OECD membership	✓	5	✓	2
SBN membership	✓	6	✓	5

Table 7: Overview of the rank and contribution of individual variables to Dim.1 and Dim.2. The contribution is determined according to the score reported by the variable with respect to the average contribution. The rank represents the relative importance in the contribution to both dimensions.

B.1 Countries with GMP=1

	eigenvalue	variance %	Cumulative variance %
Dim.1	4.69	42.64	42.64
Dim.2	1.76	15.96	58.61
Dim.3	1.27	11.53	70.14
Dim.4	0.93	8.49	78.62
Dim.5	0.67	6.06	84.69

Table 8: Countries with GMP=1. Principal component analysis: eigenvalues.

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
CB model	1.04	39.51	4.32	4.31	1.00
Mandate	0.03	1.27	62.38	9.83	0.70
CRI	0.13	40.42	0.47	8.21	0.48
Basel	9.97	1.45	8.91	2.39	27.53
OECD	14.16	0.34	2.35	4.69	10.05
NGFS	8.78	0.28	1.78	29.14	36.36
SBN	13.08	0.72	2.23	22.70	0.11
CB Independence	16.39	0.11	2.46	0.08	0.03
Financial Sector Size	9.03	6.20	0.00	16.81	23.28
IncomeGroup	17.11	1.68	1.20	0.24	0.00
Continent	10.29	8.02	13.89	1.59	0.45

Table 9: Countries with GMP=1. The contribution of the different variable to the different dimensions.

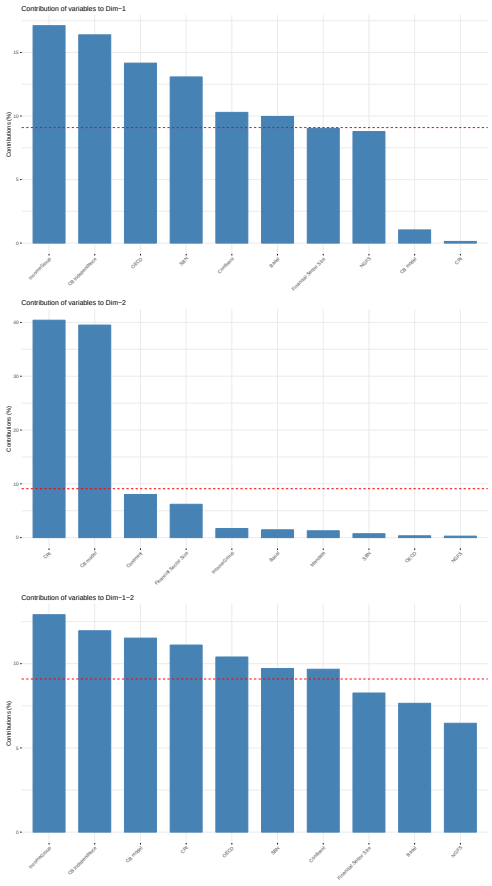

Figure 7: Countries with GMP=1. Contribution of the variables to `Dim.1`, `Dim.2` and both principal components. The red dashed lines indicates the expected average contribution of each variable.

Variable	Correlation	p.value
Dim.1		
correlation	p.value	
CB Independence	0.8768066	9.004185e-09
OECD	0.8150598	6.996305e-07
Basel	0.6837493	1.644245e-04
Financial Sector Size	0.6508397	4.266306e-04
NGFS	0.6417392	5.446498e-04
Continent	-0.6946918	1.165550e-04
SBN	-0.7831967	3.678383e-06
IncomeGroup	-0.8958539	1.437443e-09
Dim.2		
CRI	0.8424764	1.275088e-07
CB model	0.8330058	2.375653e-07

Table 10: Countries with GMP=1. The most significantly associated variables (sorted by p-value) with the principal component Dim.1 and Dim.2.

B.2 Countries with GMP=0

	eigenvalue	variance %	Cumulative variance %
Dim.1	3.96	35.97	35.97
Dim.2	1.64	14.93	50.90
Dim.3	1.28	11.63	62.53
Dim.4	1.04	9.44	71.98
Dim.5	0.93	8.49	80.46

Table 11: Countries with GMP=0. Principal component analysis: eigenvalues.

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
CB model	0.86	37.49	5.37	14.04	2.28
Mandate	2.98	6.77	27.01	2.04	24.02
CRI	3.23	14.41	1.93	2.64	48.23
Basel	10.00	4.41	8.00	2.43	0.63
OECD	11.27	17.30	0.08	11.97	3.82
NGFS	13.66	5.71	1.77	3.93	3.49
SBN	14.57	4.37	6.90	14.64	1.67
CB Independence	19.16	2.37	0.00	0.57	0.35
Financial Sector Size	17.37	2.17	0.00	2.85	0.26
IncomeGroup	6.62	3.41	23.55	4.04	1.35
Continent	0.29	1.60	25.38	40.85	13.90

Table 12: Countries with GMP=0. The contribution of the different variable to the different dimensions.

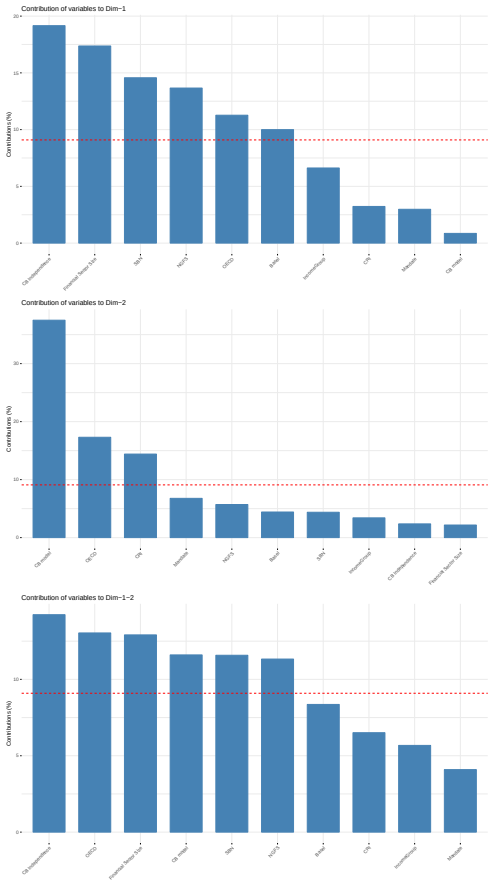

Figure 8: Countries with GMP=0. Contribution of the variables to `Dim.1`, `Dim.2` and both principal components. The red dashed lines indicates the expected average contribution of each variable.

Variable	Correlation	p.value
Dim.1		
correlation	p.value	
CB Independence	0.8706522	1.528511e-08
Financial Sector Size	0.8290058	3.054622e-07
NGFS	0.7352755	2.825019e-05
OECD	0.6677571	2.651326e-04
Basel	0.6289171	7.585000e-04
IncomeGroup	-0.5117870	8.918782e-03
SBN	-0.7592325	1.080372e-05
Dim.2		
CB model	0.7846336	3.433734e-06
OECD	0.5330603	6.074714e-03
CRI	-0.4863809	1.368810e-02

Table 13: Countries with GMP=0. The most significantly associated variables (sorted by p-value) with the principal component Dim.1 and Dim.2.