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ADVANCED REVIEW

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Three tales of central banking and financial supervision for the ecological transition

William Oman[1] | **Mathilde Salin**[2,3] | **Romain Svartzman**[2,4]

[1]International Monetary Fund (IMF), Washington, DC, USA

[2]Banque de France, Paris, France

[3]Université Paris-Saclay, AgroParisTech, CNRS, École des Ponts ParisTech, CIRAD, EHESS, UMR Cired, Nogent-sur-Marne, France

[4]Institute for Innovation and Public Purpose (IIPP), University College London, London, UK

Correspondence
Romain Svartzman, Institute for Innovation and Public Purpose (IIPP), University College London, London, UK.
Email: romain.svartzman@gmail.com

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Abstract

The academic literature and policy discussions on the role that central banks and financial supervisors (CBFS) should play in the ecological transition, almost nonexistent five years ago, have since grown at an impressive pace. This has resulted in a wide range of proposals that often generate debates and even misunderstandings, for lack of a coherent analytical framework. Against this backdrop, this article provides a comprehensive overview of the different theoretical backgrounds and worldviews that inform existing proposals, and discusses the challenges and debates they generate when assessed from other perspectives. We identify three main approaches, or three "tales" of central banking and financial supervision in the face of ecological threats: (i) one that argues that CBFS should focus on assessing the (so-called "physical" and "transition") risks that environmental issues pose to price and/or financial stability; (ii) one that places great emphasis on the ability of CBFS to help trigger systemic change, and thereby promotes proactive actions by CBFS to steer financial markets toward greening their activity beyond a risk-based approach; (iii) one that sees CBFS transformation as necessary but part of broader institutional change that they cannot deliver on their own, thereby requiring an evolutionary perspective. Through this comprehensive literature review, this article seeks to provide a coherent framework through which future academic contributions and policy proposals can be better understood and assessed.

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KEYWORDS

central banking, decarbonization, financial stability, institutional change, price stability

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1 | INTRODUCTION

In the academic field of economics, the standard approach to environmental problems has been to define them as "negative externalities," leaving no role for central banks and financial supervisors (CBFS) in solving them. According to this view, the emission of greenhouse gases (GHGs) generates (the externality of) climate change, and the role of policymakers is to ensure that market prices account for the "social" cost of production (which includes the cost generated by GHG emissions) instead of only considering the "private" costs for the producer. To do so, the "first-best" solution is for the government to introduce a carbon price, usually in the form of a "Pigouvian" tax (Pigou, 1920) on GHG emissions, or through an emission permit trading system.

It follows from the above that CBFS' mandates and actions "should not be 'polluted' through considerations that can be dealt with [using] other, proper instruments. Otherwise, central banks will soon face calls to correct market outcomes in other areas as well" (Tirole, 2019). In other words, central banks would need to focus "on their core narrow mission, and let the other institutions of society address big political causes. Boring as that may be" (Cochrane, 2020).

Notwithstanding these considerations, the past few years have seen the emergence of diverse and sometimes intense debates on the role of CBFS with regards to environmental issues. These debates may have been caused in part by the expectations and public discussions generated by the unprecedented actions taken by central banks since the 2008 Global Financial Crisis (Goodhart, 2010; Monnet, 2021). These have included, until recently, very low or even negative policy interest rates, a significant increase in the size of central banks' balance sheets through the purchase of public and private assets, and new types of interventions such as currency swap arrangements among central banks.

But more fundamentally, it is CBFS authorities themselves who increasingly acknowledged that climate change (and more recently other environmental issues) are of interest to them (Quorning, 2023). The reason invoked is that climate change, biodiversity loss, and other ecological issues can generate significant threats to financial and monetary stability, which CBFS have the mandate to safeguard (NGFS, 2019; NGFS, 2020a). Such risks and threats could even generate "Green Swans" (Bolton et al., 2020a, 2020b): disrupting events that could cause a systemic financial crisis with long-lasting effects.

Moreover, the dominant school of thought, neoclassical economics, has tended to naturalize the role of central banks.[1] However, the notion that central banks' mandate requires that they focus on "their core narrow mission" hinges on presuppositions that are historically and ideologically situated. Indeed, visions of the role of CBFS all rest on a specific worldview, which in turn entails specific conceptions of money, finance, and the state. It is essential to decipher and denaturalize these mandates and therefore the theories and doctrines that support them. To our knowledge this has not yet been done in the literature.[2] As Max Weber warned, the use of an "ideal type" as a normative assessment tool to judge what should be results in a lack of axiological neutrality that leads economists to abandon their role as objective observers.[3]

In this context, the goal of this article is to provide a comprehensive and critical overview of the literature on the role of CBFS in the face of ecological challenges. The article is structured around the three main types of normative approaches (or "tales") to central banking and financial supervision with regard to ecological issues that we identify. The first view (Section 2), now embraced by most CBFS, argues that CBFS should be concerned with measuring and managing the risks that environmental issues such as climate change can pose to their core mandates of price and financial stability. The second view (Section 3) calls for a more proactive role for CBFS, emphasizing that they can take many actions (not grounded in a pure risk-based approach) that could steer financial institutions and financial markets toward more ecologically sustainable activities. The third view (Section 4) argues that the role of CBFS in the age of ecological challenges should be reassessed from an evolutionary perspective, one that asks how these institutions could and should interact with other agents (especially those in charge of fiscal policy) to solve such challenges. Section 5 concludes.

For each view of (or "tale" on) the role of CBFS (i.e., Sections 2–4), we proceed by: (i) making explicit the rationale or theoretical approach through which the problem is apprehended, and specifying the underlying worldview—and the associated conceptions of money neutrality, the efficiency of financial markets, and the role of the state in the economy—in which this rationale is anchored; (ii) presenting the main policy proposals that flow from the previous point; and (iii) discussing some debates that these proposals have generated and some of their potential limitations.

Table 1 provides a summary of these different views. While there are certainly other ways of organizing the literature, we believe that mapping the different proposals in such a way clarifies the terms of the debate and can therefore help inform future discussions on the role of CBFS in the age of ecological threats.

The rising scale of the response to ecological threats from the first to the second and third tales is underpinned by radically different presuppositions along the three dimensions listed above (money neutrality, efficiency of financial

TABLE 1 Three main views of the role of central banks and financial supervisors found in the economics literature.

	View 1: Risk-based approach	View 2: Proactive central banks and financial supervisors	View 3: Evolutionary role of central banks and financial supervisors and the state in the economy
Implicit underlying worldview	Money neutrality, efficient financial markets, market-fixing state	Money non-neutral, financial markets not efficient, market-shaping state	Money as a social institution, finance as inherently unstable, state as key for coordination across the economy
Rationale	Financial system resilience to climate-related risks within CBFS' mandate Climate change could affect CBFS' ability to deliver on price stability CBFS can contribute to transition by assessing physical/transition risks to price/financial stability	CBFS have significant power over finance, which has significant power over the economy Climate-related radical uncertainty requires precautionary approach CBFS can trigger systemic change, and should play proactive role to green financial system	Dilemma: CBFS may need to work on Views 1–2, but cannot substitute for other actors' insufficient actions CBFS and financial system are exposed to Green Swans—calling for policy coordination, system change CBFS transformation necessary but part of broader institutional change, requiring evolutionary perspective
Proposals	Measure climate-related risks to financial and price stability Forward-looking scenario analyses (climate stress tests), Basel framework Monetary policy: assess implications of climate for design of monetary regimes	Regulated financial institutions required to submit low-carbon transition plans Differentiated interest rates, double materiality "Green" QE, CB purchases of low-carbon bonds issued by public investment banks	CBFS could play a new role within the policy framework (e.g., coordination with other policy institutions; but fiscal, industrial, sufficiency policies must be in place) CBs would support governments by keeping borrowing costs low Direct monetary financing may be valid option
Potential limitations	CBs may directly or indirectly contribute to build-up of climate-related risks (double materiality) Climate risks hard to measure; good measurement does not naturally lead good capital reallocation Therefore, unclear that CBFS would be able to deliver on their price and financial stability mandate	Could lead CBFS to aim to resolve social problems that should fall on governments CBFS' actions need to be accompanied by measures in real economy Clashes could occur between existing objectives and environmental objectives (greenflation) Unclear CBs could deliver on inflation mandate, change in CB mandate likely needed	Issue of CB independence and compatibility of proposals with existing CB mandates CBFS have limited ability to address other ecological crises and are affected by ecological limits (growth) Need to consider interactions between real and monetary-financial sides of economy CBFS' actions take place within a specific geopolitical context, in which monetary policies in high-income countries affect agency of developing economies May require democratic debate on balance between CBs' inflation goals and environmental objectives

Note: "CBs" stands for central banks, and "CBFS" for central banks and financial supervisors.
Source: Authors, adapted from Oman et al. (2022).

markets, and role of the state), making it clear that existing CBFS mandates correspond to specific worldviews that are subject to debate.

2 | VIEW 1: A RISK-BASED APPROACH TO CENTRAL BANKING AND FINANCIAL SUPERVISION WITH RESPECT TO ENVIRONMENTAL CHALLENGES

2.1 | Rationale

In the early 2010s, the idea emerged that climate change could be a source of financial risk (e.g., Carbon Tracker, 2013). This perception arose within the CBFS community (see Quorning, 2023) following a landmark speech

by Mark Carney, then Governor of the Bank of England, titled "Breaking the tragedy of the horizon" (Carney, 2015). The "tragedy" is the following: by focusing on the short-term, financial actors and regulators do not consider longer-term consequences of climate change in their decisions. This is likely to exacerbate climate change, generating systemic risks in the financial system.

These financial risks are usually classified as "physical" and "transition" sources of risk. "Physical" sources of risk can be acute—that is, climate-related weather events (e.g., fires and floods) becoming more frequent and severe—or chronic, stemming from long-term changes in climate patterns (e.g., sea-level rise). Both acute and chronic physical sources of risks can cause financial losses.

Preventing the emergence of these physical risks would require a rapid reduction in greenhouse gas (GHG) emissions—a reduction which could, however, be a source of transition risks. Indeed, economic and financial agents whose business models are not adapted to a low-carbon economy could suffer significant financial losses (Semieniuk et al., 2021). In particular, the transition could lead to the emergence of "stranded assets," defined by van der Ploeg and Rezai (2020) as assets whose profit expectations would be drastically reduced by decarbonization. This could be the case for investments in fossil fuel supply, as the low-carbon transition requires keeping a large share of fossil-fuel reserves in the ground. This asset stranding could lead to massive revaluation of asset portfolios and firms' defaulting on credit, ultimately posing a systemic threat (see Daumas, 2023) and leading to what Carney (2015) called "a climate Minsky moment."

Besides their impact on financial stability, climate change and other ecological issues can also hamper the ability of central banks to fulfill their primary mandate of price stability, as we could enter a "new age of energy inflation" (Schnabel, 2022). Isabel Schnabel, a member of the Executive Board of the European Central Bank (ECB), distinguishes between "climateflation," "fossilflation," and "greenflation." The first relates to physical climate shocks' impacts on inflation: for example, frequent and severe droughts could disrupt food supplies (McKibbin et al., 2017) and thereby raise food prices. The second, "fossilflation," could be caused by our economies' dependency on fossil fuels: an increase in their prices (e.g., through carbon taxation) to foster the transition would push prices up in the short run. Finally, "greenflation" relates to growing demand for low-carbon technologies during the transition, which is expected to raise demand for metals and minerals, pushing up prices. Overall, these inflationary pressures, combined with a possible decrease in output because of climate and other shocks and structural processes, could keep inflation high or generate inflation for years (Klein, 2023; Villeroy de Galhau, 2019).

Therefore, CBFS should ensure that price and financial stability, which they typically have the mandate to ensure (although mandates can vary across jurisdictions), remain resilient in the face of climate change. Many CBFS now share this view, which led to the establishment of the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) in December 2017. As of March 2023, the NGFS comprised 125 members and 19 observers. Moreover, this "risk-based" approach to climate change has recently been extended to broader environmental or "nature-related" risks, notably those related to biodiversity loss (NGFS, 2022; NGFS and INSPIRE, 2022).

Under this rationale, in the long run money is neutral: there is a disconnection between nominal variables and real variables, which means that central banks cannot affect long-term growth and that giving them the narrow mandate of price stability generates no costs in the long term (Bénassy-Quéré et al., 2019, p. 251). In addition, this rationale generally hinges on three related presuppositions: financial markets are efficient (see Aglietta & Espagne, 2016); financial assets have an objective value; and asset prices reflect so-called fundamentals (see Orléan, 2013). Finally, the underlying presupposition is that the role of the state in the economy is to fix market failures—that is, to improve the efficiency of resource allocation in comparison to the "market outcome" (Schnabel, 2020).

2.2 | Proposals

In line with Carney's (2015) stance that "that which is measured can be managed," the consensus among CBFS is that climate-related risks should be assessed and quantified. Most CBFS agree that the measurement of these risks cannot be based on past data but should instead rely on forward-looking, scenario-based analyses (Campiglio et al., 2018; NGFS, 2020b). Indeed, the traditional way to perform financial risk assessments uses historical events to derive probability distributions of severe events. However, this method cannot be applied to a world impacted by climate change, as it will be very different from the world we know. Therefore, adverse climate-related scenarios (notably those of the NGFS—e.g., NGFS, 2020b) and climate stress tests (building on historical stress tests developed by central banks; see, e.g., Borio et al., 2012) have been developed in recent years (e.g. Battiston et al., 2017). CBFS have been using them to

assess the financial system's resilience to specific climate-related physical and transition shocks (ACPR/Banque de France, 2020; Vermeulen et al., 2019). For example, the ECB conducted a stress test based on internal data using the NGFS scenarios (NGFS, 2020b) and assessing the effect of physical shocks and transition shocks (mainly consisting of various carbon price pathways) on corporates and banks. This exercise showed that the probability of default of banks was higher in case of a disorderly transition and even higher in the absence of a transition (de Guindos, 2021).

Measuring climate-related risks would make it possible to "integrate [them] into financial stability monitoring and micro-supervision" (NGFS, 2019, p. 3), and possibly in each pillar of the current macroprudential framework under Basel III (Smolenska & Van't Klooster, 2022). Pillar I, on minimum capital requirements, could for example include new capital requirements and systemic risks buffers to account for climate-related risks (Monnin, 2021). Although these tools have not yet been implemented for climate risks, some developing and emerging economies have already introduced climate-related financial regulations (Dikau & Volz, 2021; D'Orazio & Popoyan, 2019). Regarding Pillar II, on supervisory review, and Pillar III, on market discipline and disclosure, some countries now require banks to develop procedures to identify (e.g., Brazil, see Febraban, 2014) and disclose climate-related financial risks. For instance, in France, Article 173-VI of the Energy Transition Act of 17 August 2015 makes it mandatory for financial institutions to disclose their exposure to and management of climate-related risks.

Finally, regarding monetary policy, climate change could affect the design of monetary regimes, including the choice of "(i) the central bank's target, (ii) the horizon over which a central bank is expected to meet its target, and (iii) the degree of flexibility embedded in monetary strategy" (NGFS, 2020a, p. 9). The NGFS (2021) has explored different options to integrate climate-related risks into central banks' monetary operations. First, the pricing of central bank loans for counterparties could be adjusted depending on their exposure to climate-related financial risks. In addition, in their collateral framework, central banks could accept assets deposited by counterparties as a guarantee only when these assets are not deemed too exposed to climate risks. Finally, the NGFS (2021) suggested, in the context of quantitative easing in 2021, that central banks could exclude or penalize assets deemed too exposed to climate-related risks in their asset purchases.

2.3 | Debates and potential limitations

We identify two main existing critiques of the risk-based approach described above.

The first one regards the feasibility of appropriately measuring climate-related risks, as a result of the radical uncertainty around the economic and financial consequences of climate change (including catastrophic climate change) and climate action, and societies' response to them (Bolton et al., 2020a; Chenet et al., 2021; Kemp et al., 2022).

In terms of physical risks, possible catastrophic and unpredictable outcomes could occur because of non-linear phenomena, tipping points (Lenton, 2021; Rockström et al., 2009; Steffen et al., 2018), model misspecification leading to underestimated risks (e.g., on sea-level rise, see Ciracì et al., 2023), and possible chain reactions within the biogeophysical world. For instance, Lovejoy and Nobre (2018) show that deforestation in the Amazon could rapidly turn part of this forest into a savannah, with significant consequences on the regional climate—which also highlights the interlinkages between climate- and nature-related risks. Chain reactions could also occur in the socioeconomic sphere—for example, with famines or diseases triggering mass migration or conflicts.

Transition risks are equally difficult to assess, as future of economic and climate policies, political developments, social preferences, and technologies are fundamentally uncertain. While specific modeling approaches—such as system dynamics, agent-based, or stock-flow consistent models that may better capture disequilibria (Svartzman et al., 2021)—can help understand these uncertainties, the risks (or threats) to which the financial system is exposed cannot be ascribed probability distributions (Zenghelis & Stern, 2016).

A second criticism is that the risk-based approach rests on the questionable belief that more transparency on climate risks will necessarily generate an "efficient market reaction to climate change risks" (Carney, 2015). Indeed, Baer et al. (2021) note that current policies implemented by CBFS rely on providing information to financial institutions rather than on incentives or coercion. It is assumed that financial actors simply lack the relevant information on climate change: the more or less implicit rationale is that, should they know about the risks (e.g., thanks to mandatory disclosures), the cost of capital would rise for climate-risky assets and investments would be redirected away from them, hence contributing to financial stability. This implicitly assumes informationally efficient financial markets, a hypothesis that is not empirically verified (Christophers, 2017; Stern & Stiglitz, 2021). In particular, Stern and Stiglitz (2021)

stress that the financial system suffers from critical market failures, including the fact that the socialization of losses may induce collective moral hazard and excessive risk-taking, for example investment in fossil fuels.

3 | VIEW 2: CENTRAL BANKS AND FINANCIAL SUPERVISORS AS PROACTIVE AGENTS OF CHANGE

3.1 | Rationale

The challenges discussed above have led some to argue that CBFS should take a more proactive stance on environmental risks for three reasons. First, they consider that such risks are, somehow paradoxically, not *financial risks* strictly speaking. Indeed, insofar as they cannot be precisely measured (as discussed above) and that many of their impacts fall beyond the time horizon that is usually considered by CBFS (see Hansen, 2022), it could be more appropriate to refer to them (for instance) as nature-related *threats* to long-term price and financial stability. Some have suggested using the concept of radical uncertainty (Chenet et al., 2021) to emphasize that the term "risk" is not appropriate.[4]

Second, the proponents of a proactive stance argue that CBFS are key players when it comes to redirecting financial flows and even transforming the architecture of the whole financial system in light of new challenges. This view is reinforced by the fact that since the 2007–2008 Global Finance Crisis, central banks' actions have gained possibly unprecedented significance from a macroeconomic perspective, to such an extent that they may have become "first responders of economic policy" (Tooze, 2020). For instance, they have set record low or even negative policy interest rates (before reversing this in response to a sharp rise in inflation) and significantly increased the size of their balance sheets through the purchase of public and private assets, thereby keeping the cost of capital low for many agents.

Third, the financial system is not only subject to environmental risks but also actively contributes to the emergence of such risks (or threats), through what some call the endogeneity of nature-related financial risks (e.g., Dafermos, 2022; Kedward et al., 2020), while others prefer to use the term of double materiality (Boissinot et al., 2022; European Commission, 2019; Oman & Svartzman, 2021; see Figure 1). This would justify that CBFS, in their capacity as guardians of the stability of the financial system, do not let it contribute to the externality generated by their lending, investment, and asset allocation decisions. Furthermore, central banks can reinforce the dependence of the economic and financial system on fossil fuels through their own operations. For instance, Dafermos et al. (2020) find that the bonds held in July 2020 by the ECB under the Corporate Sector Purchase Programme (CSPP) and the Pandemic Emergency Purchase Programme (PEPP) suffered from a "carbon bias," that is, these programs would contribute to making access to capital cheaper for these firms.

Under this rationale, money is endogenous and therefore not neutral. Changes in nominal variables can have a long-run impact on real variables, and monetary policy—encompassing policy interest rates, asset purchases, and collateral rules—can have effects that vary across sectors. Consequently, the efficient market hypothesis is assumed not to hold, and the financial system is seen as shaping the economy (Chenet et al., 2021). Finally, this rationale assumes that markets are shaped and created by the state, giving it a much broader and more fundamental role than in the risk-based approach (see Mazzucato & Rodrik, 2023).

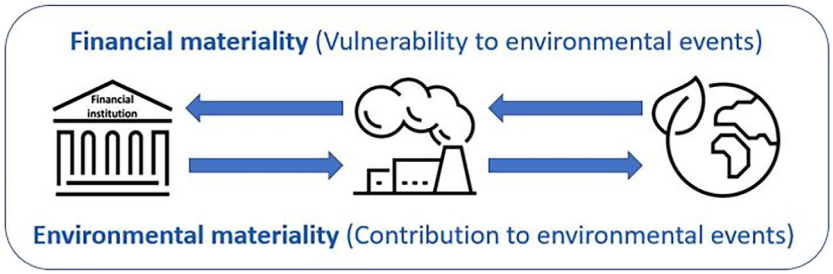

FIGURE 1 The double materiality—or endogeneity—of nature-related financial risks. *Source*: Adapted from Boissinot et al. (2022) and Oman and Svartzman (2021).

3.2 | Proposals

Many existing proposals can be categorized under this proactive approach, in which CBFS would aim to "directly shape bank lending" (Smolenska & Van't Klooster, 2022) and non-banking financial institutions' investments. On the prudential side, some have called for a change in the first pillar on banking regulation that would require that every euro invested into the sector would have to be backed by the same amount of capital (Finance Watch, 2021). Robins et al. (2021) suggest that all regulated financial institutions should be required to submit low-carbon transition plans, and the latter should condition access to central bank monetary operations. That is, financial institutions that contribute less to the transition would have less favorable refinancing conditions, and vice versa.

On the monetary policy side, several proposals also exist for "green" quantitative easing (e.g., Dafermos et al., 2018), for example, by excluding carbon-intensive assets from central banks' corporate assets purchase programs. Couppey-Soubeyran (2020) reviews other options aimed at "greening" existing instruments of central banks, such as main refinancing operations (e.g., by providing "greener" banks with better refinancing conditions) and targeted long-term refinancing operations (e.g., by providing banks with preferential loans "earmarked" for the funding of "green" projects; see van't Klooster & van Tilburg, 2020). Going even further, central banks could facilitate climate-friendly investments by buying, on the secondary market, green bonds issued by governments or public banks (see, e.g., De Grauwe, 2019; Bhattacharya et al., 2021, p. 32).

Some proactive monetary and financial policies are already being introduced in some countries (Dikau & Volz, 2021; D'Orazio & Popoyan, 2019). For example, the Bank of Japan and the Bank of Lebanon offer favorable refinancing terms to banks that lend to sustainable projects; the People's Bank of China (PBoC) differentiates interest rates on banks' deposits at the central bank based on the environmental performance of banks, and it accepts green bonds as banks' collateral with lower credit rating requirements (Baer et al., 2021). This last measure may have already contributed to lowering the yields of green-labeled bonds compared with similar non-green bonds (Macaire & Naef, 2021). The ECB also recently started to implement green monetary policy mechanisms, for instance by progressively limiting the share of assets issued by entities with a high carbon footprint that can be pledged as collateral (ECB, 2022). Moreover, other actions such as green targeted lending operations may be considered in the future (Schnabel, 2023).

3.3 | Debates and potential limitations

This proactive stance could face two main limitations related to potential trade-offs among objectives and to overall effectiveness, as discussed below.

First, trade-offs can emerge between CBFS' primary mandates of price and financial stability (with a short-term horizon) and the goal of enabling the ecological transition over the medium term (Dafermos, 2022). For instance, most central banks started to raise interest rates in 2022, and this could affect the ability to finance the low-carbon transition. Indeed, insofar as most low-carbon technologies and renewable energy projects tend to be riskier and require more upfront costs (compared with fossil fuel-based power plants, which typically require lower upfront costs and more operational costs throughout their lifetime), such projects become much less competitive when interest rates raise. For instance, a study (IEA, 2020) suggests that the leveraged cost of electricity (LCOE) of a gas-fired power plant would change marginally when discount rates double, whereas that of offshore wind can rise by close to 50%.

What is the central bank supposed to do, then, in such a situation? Some have suggested ad hoc solutions. For instance, in order to avoid the trade-off above, central banks could apply the concept of dual interest rates (Lonergan & Greene, 2020) to ecological issues, by offering preferential discount rates on targeted long-term refinancing operations to counterparties that invest relatively more in "green" assets (Jourdan & van Tilburg, 2022). However, such actions would need to be carefully assessed, notably because they could erode the credibility of central banks if they engage in actions that should primarily fall under the government's responsibility. Moreover, other trade-offs can also emerge. For instance, Oustry et al. (2020) find that even if it wanted to, the ECB could not align its collateral framework with the objectives of the Paris Agreement, because of a lack of existing green assets.

Second, and more fundamentally, CBFS' actions, no matter how proactive they are, will not be sufficient to trigger the structural economic change needed to address our ecological issues. In fact, some arguments behind a proactive central bank seem to rely implicitly on the belief that, because of the financial firepower they have displayed since the 2008 Global Financial Crisis, central banks could now put this power to use for the ecological transition. This is highly

dubious: in contrast to other areas where they can contribute to hedging the financial system against specific risks (e.g., by engaging in asset purchases or swapping currencies in times of market panic selling), central banks cannot deliver the long-term policies that are needed to address ecological issues. Monetary and prudential policies are less effective than fiscal policies (Krogstrup & Oman, 2019) and unconventional green policy is likely to deliver very little impact (Ferrari & Nispi Landi, 2023).

The above does not suggest that CBFS do not have any role to play in the ecological transition, but rather that their role should be addressed in light of the interactions of CBFS with other policy institutions in the context of the ecological transition (Bolton et al., 2020a), as discussed in the next section.

4 | VIEW #3: THE EVOLUTIONARY ROLE OF CENTRAL BANKS, FINANCIAL SUPERVISORS, AND THE STATE IN THE FACE OF UNPRECEDENTED ECOLOGICAL THREATS

4.1 | Rationale

The approaches discussed in the previous sections pose a dilemma for CBFS. Delivering on their mandates of price and financial stability may require a focus on the risk-based (view #1) and the proactive (view #2) approaches. At the same time, CBFS cannot and probably should not substitute for a lack of action from other institutions (e.g., weak or inadequate fiscal policy, industrial policy, or urban planning), as these actions are outside CBFS' remit. Thus, independently of how much central banks and the financial system seek to manage climate- and nature-related financial risks, they will continue to be exposed to them.

Overcoming this dilemma that CBFS face highlights policy coordination. Rather than determining what CBFS should do, the idea is to decide how CBFS actions fit within different transition scenarios. An example is Baer et al. (2021), who advocate close coordination among monetary, prudential, and fiscal policies, with each policy area staying within its current institutional boundaries. They argue that this avoids two pitfalls: (i) monetary and financial authorities' determining society's ability to deliver an ecological transition; and (ii) CBFS' paying too much attention to environmental issues, such that this jeopardizes their ability to deliver on their primary policy objectives.

Crucially, this approach to the role of CBFS is *contextualized* and *evolutionary*. Its rationale is that, like all institutions, CBFS co-evolve with their environment. That is, CBFS simultaneously shape and reflect determined institutional paradigms. For instance, as highlighted by Goodhart (2010), the role of central banks has historically alternated among price stability, financial stability, and support for state financing. More broadly, this view also stresses the state's historically critical role in coordinating private and public entities (Monnet, 2018).

It has been suggested that post-GFC policies ushered in a new age of central banking (see, e.g., Goodhart, 2010), a shift that precludes a return to the pre-GFC framework (Monnet, 2021). To account for evolutions and new challenges—notably environmental ones—some argue for a need to abandon the dominance of monetary over fiscal policies, and to develop a coherent framework to address the decarbonization challenge. For instance, Gabor (2020) calls for a "coordination without subordination" approach to fiscal-monetary cooperation,[5] and Kedward et al. (2022, p. 1) call for reviving "post-war credit policy regimes" through which CBFS would steer credit while challenging the power of "market-based finance."

According to van Tilburg and Simić (2021), a new role for central banks in mitigating climate change is consistent with their historical objectives. Indeed, central banks have historically ensured the availability of enough currency to serve society's needs (notably to finance wars, recover from natural disasters, and, more recently, indirectly fund support measures during the COVID-19 lockdowns), as well as to protect the stability of the currency and the financial and economic system. This includes progressively becoming lenders of last resort from the 18th century, and in many countries after World War II, supporting economic development (see, e.g., Monnet, 2018).

Under this rationale, money is a social institution, which gives it considerable power that operates through collective beliefs about value (Orléan, 2013). The underlying conception of finance in this rationale rejects the existence of an objective *ex ante* valuation of asset prices, and hence the efficient market hypothesis. In this conception, asset prices do not reflect so-called fundamentals but are instead a *sui generis* creation of the financial community in its pursuit of liquidity. This makes finance inherently unstable (Aglietta, 2018). Finally, the state is seen as a critical mechanism for large-scale coordination across the entire economy (Monnet, 2018).

4.2 | Proposals

The practical translation of this rationale is far from obvious. The central question is how, in practice, the actions and functions of central banks and other agents should coevolve to enable a low-carbon or broader ecological transition. Specifically, what type of coordination is needed among fiscal, monetary, and financial policies with respect to addressing environmental issues such as climate change mitigation and adaptation (Krogstrup & Oman, 2019)? The notion that interactions between fiscal, monetary and prudential policy need to be examined is recurrent, especially among post-Keynesian economists (e.g., Lavoie, 2016; Rochon & Vallet, 2020). It also extends to neoclassical economists, including the argument of Bernanke (2003) that, under some circumstances, cooperation between central banks and the fiscal authorities is consistent with central bank independence. Similarly, ECB board member Fabio Panetta has stressed the importance of successful fiscal-monetary coordination in the euro area (Panetta, 2021).

Ongoing evolutions in policy frameworks, combined with the increasingly pressing urgency of tackling ecological threats, could lead fiscal policy to become dominant within the macroeconomic policy framework. This could also lead central banks to change, rather than becoming subordinated "all other things being equal." Exploring such possible evolutions, Gabor (2020) calls for central banks to support governments by keeping borrowing costs low. This reflects the likelihood that central banks may well have to trade off different objectives, notably government support for the low-carbon transition and price stability. In the same spirit, Couppey-Soubeyran and Delandre (2021) include direct monetary financing of the government by central banks as a paradigm shift that may be acceptable and necessary, although it would be incompatible with many central banks' current mandates and/or paradigms.

A second type of proposal relates to the assessment of the way CBFS actions account for environmental justice dimensions. Some have argued that central banks in high-income economies need to put climate justice at the core of their actions, for instance by buying sovereign bonds from low-income countries that could otherwise suffer from climate change-related sovereign debt crises (Dafermos, 2021). Similarly, others have called for creating an international lender of last resort function that would provide the means of payments for international transactions (Aglietta & Espagne, 2022).

4.3 | Debates and potential limitations

Debates around central bank independence are implicit in several of these proposals. Importantly, Braun and Downey (2020) argue that the principle of central bank independence as it is commonly understood must be challenged if societies are to effectively address climate change (see also Deyris et al., 2022; Scialom, 2022). Eich (2022), drawing on Tucker (2018), points out that even proponents of the main features of existing institutional arrangements warn that attempts by central banks to eschew debates on democratic legitimacy by invoking their technocratic neutrality have backfired. Relatedly, Aglietta (2018) notes that central bank independence refers to these institutions' means rather than objectives, and that the latter cannot be separated from broader policies, which citizens entrust to representatives with the overarching goal of achieving social welfare. Goodhart and Lastra (2023) indicate that, in light of the environmental challenges discussed above but also other ones (geopolitics, COVID-19, and so on), "the prior degree of separation between monetary and fiscal policy can no longer be maintained," thereby calling for reconsidering the very mandate of central banks and the nature of its interactions with fiscal policy.

Others hold that the relevant challenge is not to replay "an old debate about whether central banks should be independent, but rather to define this independence in new terms" (Monnet, 2021). Instead, focusing on the euro area, Monnet (2021) calls for the creation of a European Credit Council that would operate under the authority of the European Parliament. It would become a stakeholder with which the ECB would be required to interact. The inspiration for this proposal is the credit councils set up in many countries (notably France) in the post-World War II "Golden Age" period, from around 1945 to 1975. Such a council would be responsible for discussing the coordination of European policies on financial issues, including discussions with central banks on financing the low-carbon transition.

Monnet (2023) argues that this proposal addresses the democratic dimension of central banking, which requires that central banks pay attention to their insurance role and the ways in which their actions are part of credit policy. The proposed European Credit Council would thus be a "deliberative body aimed at strengthening Parliamentary power on monetary and credit policies, the democratic legitimacy of central bank policy in the Euro Area as well as its coordination with other European policies." A more limited but related proposal is that of Hockett and Omarova (2018) for the creation of a National Investment Authority in the United States, "operationally situated" between the Federal Reserve

and the Treasury. This authority would pool municipal bonds into a nationwide market to finance state and federal public investments in new infrastructure, including low-carbon infrastructure.

A potential limitation of these proposals is that they keep economic expertise in the driver's seat with respect to decision-making regarding the impact of the economy on the environment and vice-versa. The legitimacy of this stance is not obvious given the crucial role of other types of expertise, notably legal, in shaping the economy, policies, and capital allocation (e.g., Pistor, 2019). Some argue that central banks' powers must be partly reined in or at least seriously questioned (e.g., Dietsch et al., 2018), and their potential role in credit guidance (following the proposals of Monnet, 2021, 2023) should occur within a "web of institutions, including public development banks, which take such decisions based on the formulation of political will" (Bolton et al., 2020a; Thiemann, 2023).[6] More broadly, some argue that ecological threats pose a normative challenge to societies: public policies and policy frameworks must anticipate retrospective ethical judgment of present choices, an endeavor that cannot be left to central banks or indeed economic expertise alone (Dupuy, 2022).

Another potentially major constraint faced by these proposals relates to the rapidly growing literature that suggests that remaining within planetary boundaries will involve a limit to GDP growth, at least in high-income economies (Haberl et al., 2020; Keyßer & Lenzen, 2021). Reflections on how central banking could be affected by binding ecological limits and the constraints they impose on the economy is at a very early stage in the academic and central banking literature (Cahen-Fourot, 2022; Goulard, 2021; Kedward et al., 2020; Svartzman et al., 2020; Gardes-Landolfini et al., 2023). Such constraints would raise profound questions for central banks. For instance, in a world without growth or with persistent economic contraction, how would incomes, inflation, employment, and asset valuations (not to mention distributional outcomes) be affected?[7] Would central banks face new trade-offs, or would existing ones (e.g., between price and financial stability) be exacerbated in such a radically new environment?

In addition, some proposals of monetary reforms appear implicitly to assume that transforming the monetary system can enable transformations in the "real" economy. However, they typically do not assess how monetary systems themselves reflect broader socioeconomic relations (Orléan, 2013) and how biophysical flows are organized to support specific regimes of accumulation (Svartzman et al., 2019). In other words, in tackling the challenge of assessing the future of central banking in the age of ecological threats, a necessary starting point is to think about the complex and evolving interactions between the "real" and "monetary-financial" sides of the economy (Oman & Svartzman, 2021). Or in the words of Baer et al. (2021), "it takes two to dance"[8]: thinking about the future of central banking and money requires thinking about broader socioeconomic transformations (including in the international arena), and vice versa.

Moreover, the ways in which CBFS act against environmental threats need to be addressed in a specific geopolitical context. For instance, DiLeo et al. (2023) argue that the ECB was able to adopt much more proactive climate-related policies (as discussed above) than the U.S. Federal Reserve because of a more polarized and partisan debate on climate change and a stronger influence of the fossil fuel industry in the United States. The authors further argue that given the international connectedness of central banking, it is to be expected that pressures toward more convergence will occur. This would take place through a partial scaling back of some of the commitments made by the ECB, along with some incipient actions and increased cooperation from the U.S. Federal Reserve.

However, central banks do not only face different contexts in different countries, they also contribute to shaping the global geoeconomic order. For instance, building on Chang's (2002) concept of "kicking away the ladder,"[9] Vernengo (2016) argues that central banks in high-income countries are partly responsible for the inability of central banks in developing economies to promote economic development (although the latter's mandate often seeks it; see Dikau & Volz, 2021): according to him, high-income countries first proactively used central banking policy to promote industrialization processes and conquer new markets (most notably in the 18th and 19th centuries), before they started focusing on price and financial stability while requesting from developing economies to do the same. In doing so, they would have kicked away the (central banking) ladder, that is, they would not have enabled developing economies to implement the policies needed to address their industrial (and environmental) challenges, in the same manner they themselves were able to do.

As a result of the above, the international monetary system is characterized by a hierarchy of currencies, dominated by currencies from high-income countries. It is increasingly acknowledged that this hierarchical structure makes it difficult for developing economies to attract the long-term funding they need to finance the low-carbon transition (Svartzman & Althouse, 2020). Indeed, capital flows toward developing economies often depend on exogenous factors, such as the interest rate set by the U.S. Federal Reserve, and these flows are often disconnected from domestic economic conditions (Kaltenbrunner & Painceira, 2018). For instance, the sharp increases in policy interest rates in most high-income countries since 2022 are generating strong pressures on exchange rates in most developing economies

(as investors ask for a higher risk premium to hold their debts), and could trigger a debt crisis in addition to slowing down the pace of necessary investments in the ecological transition (Prasad et al., 2022). Addressing such questions would therefore require developing an "international political economy of central banking" in the context of the ecological transition. This has not, to our knowledge, been addressed by existing proposals, although some recent work aims to address the topic of cross-border climate-related risks in the context of a geoeconomically fragmented world (Espagne et al., 2023).

5 | CONCLUSION

This article seeks to provide a comprehensive overview of the growing literature on the role of CBFS in the era of ecological threats. We identify three main normative approaches in policy debates (or three "tales"), recognizing the nuances and partial overlap among them (see Table 1 above): the risk-based approach; the proactive approach; and the evolutionary approach. For each, we summarize the rationale, main proposals, and debates and potential limitations associated with the approach.

A key message is that this is a nascent field that is characterized by implicit presuppositions about money, finance, and the role of the state in the economy and the international arena. In this context, the question of CBFS' role in the age of ecological threats is likely to remain deeply contested. Indeed, the "Overton window" of positions is changing rapidly, with the once-marginal idea that climate change (and even nature loss more broadly) falls within the mandate of CBFS having become mainstream over the span of just a few years. New proposals garner both support and fierce opposition across the ideological spectrum, highlighting the crucial role of worldviews in underpinning economic doctrines and theories and the central bank mandates that they justify.

Equally important, the arguments at stake and the sharp differences in the corresponding worldviews suggest that the interactions and interdependencies among the financial system, the economy and natural systems remain poorly understood in economic theory. This is all the more so when taking into account geopolitical considerations (e.g., the fact that the policies and actions of central banks in high-income countries have economic and environmental consequences for developing economies). As evidence on the planetary emergency mounts, open and transparent deliberation on the role of CBFS in the age of ecological threats has never been more urgent.

AUTHOR CONTRIBUTIONS

William Oman: Conceptualization (equal); writing – original draft (equal); writing – review and editing (equal). **Mathilde Salin:** Conceptualization (equal); writing – original draft (equal); writing – review and editing (equal). **Romain Svartzman:** Conceptualization (equal); writing – original draft (equal); writing – review and editing (equal).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ORCID

William Oman https://orcid.org/0009-0003-7779-884X
Mathilde Salin https://orcid.org/0000-0002-0505-3174
Romain Svartzman https://orcid.org/0000-0001-6792-5954

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ENDNOTES

[1] For instance, a widely used textbook argues that "Defining and implementing monetary policy is the function of the central bank, an often independent branch of government that is responsible for setting interest rates, maintaining

the value of the currency, and ensuring that the banking system does not fall short of liquidity, even in the case of a crisis" (Bénassy-Quéré et al., 2019, p. 8).

[2] Importantly, all three worldviews discussed in this paper correspond to an ontology, naturalism, that originated relatively recently in the West and differs in major ways from the three other existing ontologies: totemism, animism, and analogism (Descola, 2013). This naturalist ontology excludes philosophical worldviews that constitute a different "ethical horizon." This ontological bias has profound yet little-discussed ramifications for economic theories and the policies and institutions they support. The analysis of these ramifications is beyond the scope of this article, however.

[3] See the discussion on "problem-confusions" in economics in Weber (1949).

[4] The concept of "risk" refers to something that has a calculable probability, whereas uncertainty refers to the possibility of outcomes that do not lend themselves to probability measurement (Knight, 2009 [Knight, 1921]; Keynes, 1936).

[5] Some economists, however, argue that we may be in an era of fiscal dominance (White, 2021).

[6] More specifically, Thiemann (2023) argues that there may need to be a democratic debate on the balance between central banks' inflation objectives and the low-carbon transition, which in turn could lead to the conclusion that to achieve the latter we may be forced to abandon the former. Thiemann argues that a case can even be made that central banks' regular interventions to save financialized capitalism aggravate the situation from a climate perspective.

[7] Economic contraction could be a byproduct of so-called "sufficiency" policies and norms. As noted by Hache (2022), sufficiency aims to optimally link infrastructures and equipment to citizens' real needs, in a societal vision seeking to satisfy better consumption behavior adapted to the climate emergency.

[8] A difference between Baer et al. (2021) and the findings of this paper is that in the former, it is assumed that a "first-best" scenario in which government policies would introduce ambitious policies would enable central banks and supervisors to simply focus on the price and financial stability implications of such policies. In contrast, the evolutionary perspective discussed here shows that central banks' and supervisors' actions are part of the ambitious policies needed, in the same way as they have always significantly contributed to major structural changes in the past.

[9] This concept refers to the fact that developed countries have used specific policies such as high trade tariffs to become rich before exerting pressures on developing economies so that they do not adopt similar policies, thereby kicking away the ladder they have used to climb to the top.

REFERENCES

ACPR/Banque de France. (2020). Scenarios and main assumptions of the ACPR pilot climate exercise.

Aglietta, M. (2018). *Money: 5,000 years of debt and power*. Verso Books.

Aglietta, M., & Espagne, E. (2022). Environmental change and the international lender of last resort. In S. A. Kappes, L.-P. Rochon, & G. Vallet (Eds.), *Central banking, monetary policy and the environment*. Edward Elgar.

Aglietta, M. & Espagne, E. (2016). Climate and finance systemic risks, more than an analogy? The climate fragility hypothesis, CEPII Working Paper 2016-10.

Baer, M., Campiglio, E., & Deyris, J. (2021). It takes two to dance: Institutional dynamics and climate-related financial policies. Grantham Research Institute on Climate Change and the Environment, Working Paper No. 356.

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., & Visentin, G. (2017). A climate stress-test of the financial system. *Nature Climate Change*, *7*(4), 283–288.

Bénassy-Quéré, A., Cœuré, B., Jacquet, P., & Pisani-Ferry, J. (2019). *Economic policy: Theory and practice*. Oxford University Press.

Bernanke, B. (2003). Some thoughts on monetary policy in Japan. Speech on May 31, 2003. Federal Reserve Board.

Bhattacharya, A., Ivanya, M., Oman, W., & Stern, N. (2021). Climate action to unlock the inclusive growth story of the 21st century. IMF Working Paper 21/147.

Boissinot, J., Goulard, S., Le Calvar, L., Salin, M., Svartzman, R., & Weber, P. F. (2022). Aligning financial and monetary policies with the concept of double materiality: Rationales, proposals and challenges. The Inspire Sustainable Central Banking Toolbox Policy Briefing Papers (5). Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, London, UK.

Bolton, P., Després, M., Pereira da Silva, L. A., Samama, F., & Svartzman, R. (2020a). "Green swans": Central banks in the age of climate-related risks. *Banque de France Bulletin*, *229*(8).

Bolton, P., Després, M., Pereira da Silva, L., Samama, F., & Svartzman, R. (2020b). Penser la stabilité financiè'e à l'ère des risques écologiques globaux – Vers de nouveaux arbitrages entre efficience et résilience des systèmes complexes. *Revue d'Economie Financière*, *138*, 41–54. https://doi.org/10.3917/ecofi.138.0041

Borio, C., Drehmann, M., & Tsatsaronis, K. (2012). Stress-testing macro stress testing: Does it live up to expectations? BIS Working Paper No. 369.

Braun, B., & Downey, L. (2020). *Against amnesia: Re-imagining central banking. Discussion note 2020/01*. Council on Economic Policies.

Cahen-Fourot, L. (2022). Central banking for a social-ecological transformation. In S. A. Kappes, L.-P. Rochon, & G. Vallet (Eds.), *The future of central banking* (pp. 195–218). Edward Elgar.
Campiglio, E., Dafermos, Y., Monnin, P., Ryan-Collins, J., Schotten, G., & Tanaka, M. (2018). Climate change challenges for central banks and financial regulators. *Nature Climate Change*, *8*(6), 462–468.
Carbon Tracker. (2013). Wasted capital and stranded assets. Press release.
Carney, M. (2015). *Breaking the tragedy of the horizon – Climate change and financial stability*. Lloyd's of London.
Chang, H. J. (2002). *Kicking away the ladder: Development strategy in historical perspective*. Anthem Press.
Chenet, H., Ryan-Collins, J., & van Lerven, F. (2021). Finance, climate-change and radical uncertainty: Towards a precautionary approach to financial policy. *Ecological Economics*, *183*, 106957.
Christophers, B. (2017). Climate change and financial instability: Risk disclosure and the problematics of neoliberal governance. *Annals of the American Association of Geographers*, *107*(5), 1108–1127.
Ciracì, E., Rignot, E., Scheuchl, B., Tolpekin, V., Wollersheim, M., An, L., Milillo, P., Bueso-Bello, J. L., Rizzoli, P., & Dini, L. (2023). Melt rates in the kilometer-size grounding zone of Petermann glacier, Greenland, before and during a retreat. *Proceedings of the National Academy of Sciences*, *120*(20), e2220924120.
Cochrane, J. (2020). *"Challenges for central banks," comments at the ECB conference on monetary policy: Bridging science and practice*. Hoover Institution, Stanford University.
Couppey-Soubeyran, J. (2020). *The role of monetary policy in the ecological transition: An overview of various greening options*. Veblen Institute for Economic Reforms.
Couppey-Soubeyran, J., & Delandre, P. (2021). *La transition monétaire. Pour une monnaie au service du bien commun*. Veblen Institute for Economic Reforms.
Dafermos, Y. (2021). *How should central banks respond to the climate crisis? Blog*. SOAS University of London.
Dafermos, Y. (2022). Climate change, central banking and financial supervision: Beyond the risk exposure approach. In S. A. Kappes, L.-P. Rochon, & G. Vallet (Eds.), *The future of central banking* (pp. 175–194). Edward Elgar.
Dafermos, Y., Gabor, D., Nikolaidi, M., Pawloff, A., & van Lerven, F. (2020). *Decarbonising is easy. Beyond market neutrality in the ECB's corporate QE*. New Economics Foundation.
Dafermos, Y., Nikolaidi, M., & Galanis, G. (2018). Climate change, financial stability and monetary policy. *Ecological Economics*, *152*, 219–234.
Daumas, L. (2023). Financial stability, stranded assets and the low-carbon transition – A critical review of the theoretical and applied literatures. *Journal of Economic Surveys*, 1–116. https://doi.org/10.1111/joes.12551
de Grauwe, P. (2019). Green money without inflation. *Vierteljahrshefte zur Wirtschaftsforschung*, *88*, 51–54.
de Guindos, L. (2021). *Shining a light on climate risks: The ECB's economy-wide climate stress test*. The ECB Blog.
Descola, P. (2013). *Beyond nature and culture*. The University of Chicago Press.
Deyris, J., Le Quang, G., & Scialom, L. (2022). *Shaky foundations – Central bank independence in the 21st century. EconomiX Working Paper 2022-16*. Université Paris Nanterre.
Dietsch, P., Claveau, F., & Fontan, C. (2018). *Do central banks serve the people?* Wiley.
Dikau, S., & Volz, U. (2021). Central bank mandates, sustainability objectives and the promotion of green finance. *Ecological Economics*, *184*, 107022.
DiLeo, M., Rudebsusch, G. D., & Van't Klooster, J. (2023). *Why the fed and ECB parted ways on climate change: The politics of divergence in the global central banking community. Hutchins Center Working Paper #88*. The Brookings Institution.
D'Orazio, P., & Popoyan, L. (2019). Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies? *Ecological Economics*, *160*, 25–37.
Dupuy, J.-P. (2022). *How to think about catastrophe: Toward a theory of enlightened Doomsaying*. Michigan State University Press.
ECB. (2022). ECB takes further steps to incorporate climate change into its monetary policy operations. Press release, 4 July 2022.
Eich, S. (2022). *The currency of politics: The political theory of money from Aristotle to Keynes*. Princeton University Press.
Espagne, E., Oman, W., Mercure, J.-F., Svartzman, R., Volz, U., Pollitt, H., Semieniuk, G., & Campiglio, E. (2023). Cross-border risks of a global economy in mid-transition. IMF Working Paper No. 2023/184.
European Commission. (2019). *Guidelines on reporting climate-related information*. European Commission Directorate-General for Financial Stability, Financial Services and Capital Markets Union.
Febraban. (2014). *The Brazilian financial system and the green economy: Alignment with sustainable development*. Brazilian Federation of Banks (FEBRABAN) and United Nations Environment Programme (UNEP).
Ferrari, A., & Nispi Landi, V. (2023). Whatever it takes to save the planet? Central banks and unconventional green policy. *Macroeconomic Dynamics*, 1–26. https://doi.org/10.1017/S1365100523000032
Finance Watch. (2021). A silver bullet against green swans. Incorporating climate-related financial risk into bank and insurance prudential rules.
Gabor, D. (2020). *Revolution without revolutionaries: Interrogating the return of monetary financing. Transformative responses to the crisis*. Heinrich-Böll-Foundation.
Gardes-Landolfini, C., Grippa, P., Oman, W., & Yu, S. (2023). Energy Transition and Geoeconomic Fragmentation: Implications for Climate Scenario Design. IMF Staff Climate Note No. 2023/003, International Monetary Fund, Washington, DC.
Goodhart, C. (2010). The changing role of central banks. BIS Working Paper No. 326.

Goodhart, C., & Lastra, R. (2023). The changing and growing roles of independent central banks now do require a reconsideration of their mandate. *Accounting, Economics, and Law: A Convivium*. https://doi.org/10.1515/ael-2022-0097

Goulard, S. (2021). Speech-green swan conference, at the Green Swan 2021 global virtual conference, 3 June 2021.

Haberl, H., Wiedenhofer, D., Virág, D., Kalt, G., Plank, B., Brockway, P., Fishman, T., Hausknost, D., Krausmann, F., Leon-Gruchalski, B., Mayer, A., Pichler, M., Schaffartzik, A., Sousa, T., Streeck, J., & Creutzig, F. (2020). A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: Synthesizing the insights. *Environmental Research Letters*, *15*, 065003.

Hache, E. (2022). La sobriété, vecteur de puissance? *Revue Internationale et Stratégique*, *128*, 77–86.

Hansen, L. P. (2022). Central banking challenges posed by uncertain climate change and natural disasters. *Journal of Monetary Economics*, *125*, 1–15. https://doi.org/10.1016/j.jmoneco.2021.09.010

Hockett, R., & Omarova, S. (2018). White paper: A national investment authority. Cornell Legal Studies Research Paper No. 18-10.

IEA. (2020). *Projected costs of generating electricity 2020*. International Energy Agency.

Jourdan, S., & van Tilburg, R. (2022). The ECB can help fix the energy price crisis: play the long game. Brave New Europe, 28 January 2022. https://braveneweurope.com/stanislas-jourdan-rens-van-tilburg-the-ecb-can-help-fix-the-energy-price-crisis-play-the-long-game

Kaltenbrunner, A., & Painceira, J. P. (2018). Subordinated financial integration and financialisation in emerging capitalist economies: The Brazilian experience. *New Political Economy*, *23*(3), 290–313.

Kedward, K., Gabor, D., & Ryan-Collins, J. (2022). Aligning finance with the green transition: From a risk-based to an allocative green credit policy regime. UCL IIPP Working Paper 2022/11.

Kedward, K., Ryan-Collins, J., & Chenet, H. (2020). Managing nature-related financial risks: A precautionary policy approach for central banks and financial supervisors. *UCL Institute for Innovation and Public Purpose Working Paper 2020-09*. https://www.ucl.ac.uk/bartlett/public-purpose/publications/2020/aug/managing-nature-related-financial-risks

Kemp, L., Xu, C., Depledge, J., Ebi, K. L., Gibbins, G., Kohler, T. A., Rockström, J., Scheffer, M., Schellnhuber, H. J., Steffen, W., & Lenton, T. M. (2022). Climate Endgame: Exploring catastrophic climate change scenarios. Proceedings of the National Academy of Sciences, 119 (34). https://doi.org/10.1073/pnas.2108146119

Keynes, J. M. (1936). *The general theory of employment, interest and money, 2013 edition*. Cambridge University Press.

Keyßer, L. T., & Lenzen, M. (2021). 1.5 °C degrowth scenarios suggest the need for new mitigation pathways. *Nature Communications*, *12*, 2676.

Klein, M. C. (2023). *How a warming planet—And a graying population—Could keep inflation high for years*. VoxEU.

Knight, F. H. (1921). *Risk, uncertainty and profit*. University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship.

Krogstrup, S., & Oman, W. (2019). Macroeconomic and financial policies for climate change mitigation: A review of the literature. IMF Working Paper No. 19/185, International Monetary Fund, Washington, DC.

Lavoie, M. (2016). Convergence towards the normal rate of capacity utilization in neo-Kaleckian models: The role of non-capacity creating autonomous expenditures. *Metroeconomica*, *67*(1), 172–201.

Lenton, T. M. (2021). Tipping points in the climate system. *Weather*, *76*, 325–326. https://doi.org/10.1002/wea.4058

Lonergan, E., & Greene, M. (2020). *Dual interest rates give central banks limitless fire power*. VoxEU.

Lovejoy, E., & Nobre, C. (2018). Amazon tipping point. *Science Advances*, *4*(2), eaat2340. https://doi.org/10.1126/sciadv.aat2340

Macaire, C., & Naef, A. (2021). Greening monetary policy: Evidence from the People's Bank of China. Banque de France Working Paper No. 812.

Mazzucato, M., & Rodrik, D. (2023). Industrial policy with conditionalities: A taxonomy and sample cases. UCL Institute for Innovation and Public Purpose Working Paper No. 2023/07.

McKibbin, W. J., Morris, A., Panton, A., & Wilcoxen, P. (2017). Climate change and monetary policy: Dealing with disruption. CAMA Working Paper No. 77/2017.

Monnet, E. (2018). *Controlling credit: Central banking and the planned economy in postwar France, 1948–1973*. Cambridge University Press.

Monnet, E. (2021). *New central banking calls for a European credit council*. VoxEU, Centre for Economic Policy Research.

Monnet, E. (2023). The democratic challenge of central Bank credit policies. *Accounting, Economics, and Law: A Convivium*. https://www.degruyter.com/document/doi/10.1515/ael-2022-0113/html?lang=en

Monnin, P. (2021). Systemic risk buffers—The missing piece in the prudential response to climate risks. *Council on Economic Policies*. https://www.cepweb.org/systemic-risk-buffers-the-missing-piece-in-the-prudential-response-to-climate-risks/

NGFS. (2019). First comprehensive report—A call for action. Climate change as a source of financial risk. Network of Central Banks and Supervisors for Greening the Financial System.

NGFS. (2020a). Climate change and monetary policy. Initial takeaways. *Network of Central Banks and Supervisors for Greening the Financial System*.

NGFS. (2020b). Guide to climate scenario analysis for central banks and supervisors. *Network of Central Banks and Supervisors for Greening the Financial System*.

NGFS. (2021). Adapting central bank operations to a hotter world, reviewing some options. Network of Central Banks and Supervisors for Greening the Financial System.

NGFS. (2022). Statement on nature-related financial risks. *Network of Central Banks and Supervisors for Greening the Financial System*.

NGFS and INSPIRE. (2022). Central banking and supervision in the biosphere: An agenda for action on biodiversity loss, financial risk and system stability. Final report of the NGFS-INSPIRE study group on biodiversity and financial stability. *NGFS Occasional Paper*.

Oman, W., & Svartzman, R. (2021). What justifies sustainable finance measures? Financial-economic interactions and possible implications for policymakers. *CESifo Forum*, *22*(3), 3–11.

Oman, W., Salin, M., & Svartzman, R. (2022). Contending views on the role of central banks in the age of climate change: A review of the literature. In S. A. Kappes, L.-P. Rochon, & G. Vallet (Eds.), *The future of central banking* (pp. 151–174). Edward Elgar.

Orléan, A. (2013). *The empire of value*. The MIT Press.

Oustry, A., Bunyamin, A., Svartzman, R., & Weber, P. F. (2020). Climate-related risks and central banks' collateral policy: A methodological experiment. Banque de France Working Paper No. 790.

Panetta, F. (2021). Monetary-fiscal interactions on the way out of the crisis. Keynote speech at the Conference of the Governors of Mediterranean Central Banks on "Central banks at the frontline of the COVID-19 crisis: Weathering the storm, spurring the recovery".

Pigou, A. (1920). *The economics of welfare*. Macmillan.

Pistor, K. (2019). *The code of capital: How the law creates wealth and inequality*. Princeton University Press.

Prasad, A., Loukoianova, E., Feng, A. X., & Oman, W. (2022). Mobilizing private climate financing in emerging market and developing economies. IMF Staff Climate Note 2022/007.

Quorning, S. (2023). The 'climate shift' in central banks: How field arbitrageurs paved the way for climate stress testing. *Review of International Political Economy*, *23*(6), 671–688. https://doi.org/10.1080/09692290.2023.2171470

Robins, N., Dikau, S., & Volz, U. (2021). *Net-zero central banking: A new phase in greening the financial system*. Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science and SOAS Center for Sustainable Finance.

Rochon, L.-P., & Vallet, G. (2020). Monetary policy and structural change: An introduction. *Bulletin of Political Economy*, *14*(2), 149–152.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., … Foley, J. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society*, *14*(2), 32.

Schnabel, I. (2020). *When markets fail—The need for collective action in tackling climate change*. Speech at the European Sustainable Finance Summit.

Schnabel, I. (2022). A new age of energy inflation: climateflation, fossilflation and greenflation. Speech at a panel on "Monetary Policy and Climate Change" at The ECB and its Watchers XXII Conference, Frankfurt am Main.

Schnabel, I. (2023). *Monetary policy tightening and the green transition*. Speech at the International Symposium on Central Bank Independence.

Scialom, L. (2022). Les banques centrales au défi de la transition écologique. *Revue Économique*, *73*(2), 219–242.

Semieniuk, G., Campiglio, E., Mercure, J.-F., Volz, U., & Edwards, N. R. (2021). Low-carbon transition risks for finance. *WIREs Climate Change*, *12*, e678. https://doi.org/10.1002/wcc.678

Smolenska, A., & Van't Klooster, J. (2022). A risky bet: Climate change and the EU's microprudential framework for banks. *Journal of Financial Regulation*, *8*(1), 51–74.

Steffen, W., Rockström, J., Richardson, K., Lenton, T. M., Folke, C., Liverman, D., Summerhayes, C. P., Barnosky, A. D., Cornell, S. E., Crucifix, M., Donges, J. F., Fetzer, I., Lade, S. J., Scheffer, M., Winkelmann, R., & Schellnhuber, H. J. (2018). Trajectories of the earth system in the anthropocene. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(33), 8252–8259.

Stern, N., & Stiglitz, J. (2021). The social cost of carbon, risk, distribution, market failures: An alternative approach. NBER Working Paper No. 28472.

Svartzman, R., & Althouse, J. (2020). Greening the international monetary system? Not without addressing the political ecology of global imbalances. *Review of International Political Economy*, *29*, 844–869. https://doi.org/10.1080/09692290.2020.1854326

Svartzman, R., Ament, J., Barmes, D., Erickson, J. D., Farley, J., Guay-Boutet, C., & Kosoy, N. (2020). Money, interest rates and accumulation on a finite planet—Revisiting the 'monetary growth imperative' through institutionalist approaches. In R. Costanza, J. Erickson, J. Farley, & I. Kubiszewski (Eds.), *Sustainable wellbeing futures: A research and action agenda for ecological economics* (pp. 266–283). Edward Elgar.

Svartzman, R., Bolton, R., Despres, M., Pereira Da Silva, L., & Samama, F. (2021). Central banks, financial stability and policy coordination in the age of climate uncertainty: A three-layered analytical and operational framework. *Climate Policy*, *21*(4), 563–580. https://doi.org/10.1080/14693062.2020.1862743

Svartzman, R., Dron, D., & Espagne, E. (2019). From ecological macroeconomics to a theory of endogenous money for a finite planet. *Ecological Economics*, *162*, 108–120. https://doi.org/10.1016/j.ecolecon.2019.04.018

Thiemann, M. (2023). Is asking questions free of charge? Questioning the value of independent central banks through the lens of a European credit council. *Accounting, Economics, and Law: A Convivium*.

Tirole, J. (2019). Institutional and economic challenges for central banking. European Central Bank, Monetary policy: The challenges ahead (Colloquium in honour of Benoît Cœuré, held on 17–18 December 2019), pp. 34–40.

Tooze, A. (2020). The death of the central Bank myth. *Foreign Policy*. https://foreignpolicy.com/2020/05/13/european-central-bank-myth-monetary-policy-german-court-ruling/

Tucker, P. (2018). *Unelected power: The quest for legitimacy in central banking and the regulatory state*. Princeton University Press.

van der Ploeg, F., & Rezai, A. (2020). Stranded assets in the transition to a carbon-free economy. *Annual Review of Resource Economics*, *12*, 281–298. https://doi.org/10.1146/annurev-resource-110519-040938

van Tilburg, R., & Simić, A. (2021). *Every avenue available: Lessons from monetary history for tackling climate change*. Sustainable Finance Lab.

van't Klooster, J., & van Tilburg, R. (2020). *Targeting a sustainable recovery with green TLTROs*. Positive Money and Sustainable Finance Lab.

Vermeulen, R., Schets, E., Lohuis, M., Kölbl, B., Jansen, D.-J., & Heeringa, W. (2019). *An energy transition risk stress test for the financial system of The Netherlands. DNB occasional studies 1607*. Netherlands Central Bank, Research Department.

Vernengo, M. (2016). Kicking away the ladder, too: Inside central banks. *Journal of Economic Issues*, *50*(2), 452–460.

Villeroy de Galhau, F. (2019). Climate change: Central banks are taking action. *Banque de France Financial Stability Review*, *23*, 7–16.

Weber, M. (1949). *Methodology of social sciences*. Free Press.

White, W. R. (2021). It's worse than 'reverse': The full case against ultra low and negative interest rates. INET Working Paper No. 151-26.

Zenghelis, D., & Stern, N. (2016). *The importance of looking forward to manage risks: Submission to the task force on climate-related financial disclosures*. ESRC Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment.

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