



Ecological transition in a monetary economy of production: a heterodox approach

Maurizio Solari¹  · Alexandre Le Bloc'h¹  · Sergio Rossi¹ 

Received: 28 August 2023 / Revised: 13 December 2023 / Accepted: 19 December 2023
© The Author(s) 2024

Abstract

The global warming challenge is probably the major issue of our epoch, calling for a concerted response involving as many entities as possible. The economic system being the main responsible of this troubling situation, it is logical to address it first. The actual monetary economy of production has the banking system as the main driver of its functioning which justifies putting our attention on it. Central banks play a prominent role in such a system. They thus dispose of a relevant room for maneuver, which constitutes one of the main topics addressed here. Before that, this article discusses environmental concerns in a monetary production economy, advocating for an ecological economics approach as our privileged analytical foundation and highlighting the seminal role of the banking system in the monetary essence of our economic system, thus calling for an effort to enrich current monetary policy practices which must depart from the myth of ‘market neutrality’. We therefore propose four axes of intervention with regard to the greening of central banks’ action, which aim at redirecting credit away from carbon-intensive activities and towards low-carbon economic sectors. As needed as it is, adjusting monetary policy would however not suffice, the actual climate crisis being enrooted within the economic growth mantra applied through a profit-seeking scheme. A questioning of the very basis of our economic system is thus required to make the economy sustainable and finally safeguarding the conditions of life on earth.

Keywords Climate change · Ecological economics · Greening monetary policy · Monetary economy of production · Post-growth

JEL classification E51 · E58 · O44 · Q57

For the special issue on “Macro-financial policy at the crossroad: addressing climate change, biodiversity loss, and environmental degradation” of the *Eurasian Economic Review*.

Extended author information available on the last page of the article

1 Introduction¹

Though it is not wrong to say that the climate crisis is a long-term phenomenon that will impact supply conditions (Schroeder, 2023), one should first emphasize that supply conditions are at the origin of it. Forgetting such causality would account for neglecting the very root of climate change, namely the functioning of our modern capitalist economies, and would lead us to address consequences instead of causes. This is the bias in which environmental economics is so far locked-in, as it relies on the same analytical ground that generated global warming in the first place. Faced with this deadlock, we argue that another perspective should be adopted if one aims at addressing the climate crisis at its origins. This paper therefore advocates for a shift to ecological economics, the sole approach that could steer human societies towards a real ecological transition and that is able to embrace the complexity of the interactions between economic activities conducted by humans and the environment in which all those activities take place.

Global warming is often described as anthropologically rooted, while a closer look at Fig. 1 shows that the concentration of carbon dioxide (CO₂), measured in parts per million (ppm), has exploded only since the eighteenth century, far after humanity appeared on earth. We argue, therefore, for the capitalist root of global warming (Moore, 2016), which has been intensified by globalization and the international diversification of manufacturing operations (IDMO). To reverse such a scheme, the proper functioning of the monetary economy of production we live in, too often ignored in mainstream macroeconomics, must be recalled and understood. The aim of this paper is therefore to offer such understanding, which then enables us to further investigate the role the banking system ought to play, especially regarding central banks. Building upon existing literature in the field, our research sheds light on the fundamental role of the banking system in economic production and the resulting global warming, thereby allowing us to propose monetary policy tools contributing to curbing carbon emissions by eventually quitting the so-called ‘neutrality principle’ so far still blindly respected by monetary authorities worldwide.

Unsurprisingly, the question of the role of monetary policy in the context of climate change is, so far, essentially studied through a ‘risk approach’ by international mainstream institutions like the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) or the Task Force on Climate-related Financial Disclosures (TCFD) launched by the United Nations. The core idea of such an approach is that the climate crisis embodies multiple risks to the global economy, hence presenting risks for both financial and price stability (Allen et al., 2020; Andersson et al., 2020; D’Orazio & Popoyan, 2022), thereby threatening central banks in the pursuit of their mandate (Dafermos et al., 2021; Dikau & Volz, 2021; NGFS, 2021). Many scholars, however, claim this approach is insufficient if not futile (Couppey-Soubeyran, 2020; Kedward et al., 2022), as it remains silent about

¹ The authors thank the two anonymous referees for their much constructive comments on a previous version of this paper, which have all been integrated into this revised version. The usual disclaimer applies.

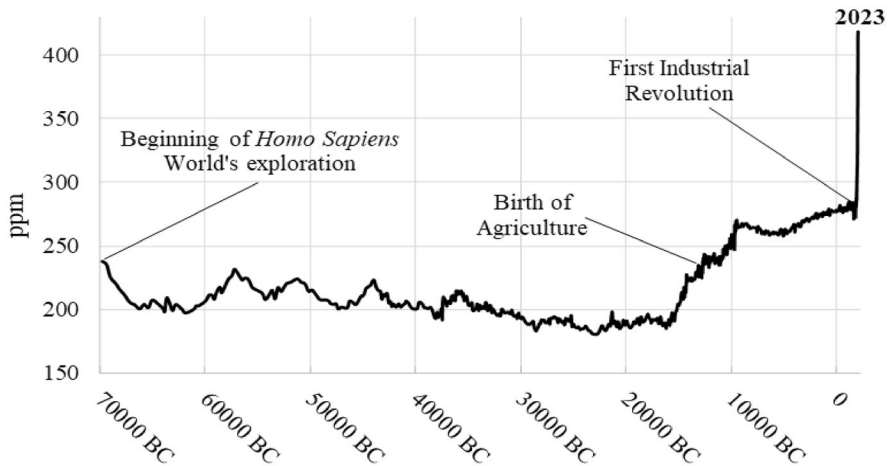


Fig. 1 Evolution of world CO₂ concentration in ppm. *Source:* authors' elaboration based on OurWorldInData (2023)

the causal relationship between carbon emissions (among many other environmental degradations) and the banking and financial sectors, thereby acting *ex-post* on the causes–consequences sequence of climate change. The impact of banking institutions' operations on climate change, embodied in the concept of 'double materiality' (see Täger, 2021; Boissinot et al., 2022) seems therefore generally far from being sufficiently taken into account by central bankers across the globe. It is true that protective (prudential) measures are needed to ensure central banks' resilience to emerging climate-related risks, if these monetary authorities want to preserve their credibility and ability to achieve their traditional mission of guaranteeing price stability. However, proactive measures are those of interest for properly addressing climate-change causes (Boneva et al., 2022) and would in turn allow central banks to reduce their exposure by contributing to the prevention of climate-related systemic risks (Dafermos, 2021). This is especially valid in our monetary economy of production, where multiple bank loans are granted *ex nihilo*, that is, without pre-existing bank deposit, to polluting firms (Graziani, 2003).

While somehow more ambitious policies with promotional purposes are to be found in emerging economies, there seems to be no direct climate policy intervention on financial markets in most high-income regions (Baer et al., 2021; D'Orazio & Popoyan, 2019). Such a 'promotional gap', partly explained by a weak public control on private financial markets and a strong attachment to monetary authorities' independence from the political sphere in Western economies, raises doubt on the ability of those Western financial systems, currently locked into the use of almost only informational measures aiming at 'fixing the market', to efficiently support the urgent low-carbon transition needed (Ameli et al., 2020). The later actions are taken to complete a real ecological transition, the greater the severity of the climate crisis is going to be; a crisis that would in turn cause dramatic monetary, economic and financial instability issues.

In this regard, the next section discusses environmental concerns framed in a monetary production economy through the lens of ecological economics, highlighting the seminal role of the banking system in the production process, which is differentiated into two phases—planning and realization—and therefore identifies the logical series of events at the origin of nature degradation induced by economic activity. The third section expands on this and presents four monetary policy measures aiming at aligning central banks' actions with climate objectives defined in the Paris Agreement. The fourth section deepens the analysis by questioning the solving capacity of monetary policy alone in the fight against climate change and opens the door for an alternative paradigm for human prosperity on earth. The last section concludes, summarizing our main arguments briefly.

2 Ecological concerns within a monetary economy of production

Economic activity involves essentially production and consumption. Although often superposed, production and economic production do not fully correspond. Production exceeds and involves economic production, since the former includes any human activity transforming matter and energy and giving rise to a utility-form. Beyond the peculiar characteristics of any particular type of production, two main steps are required. First, the product as well as the production process must be conceptualized and projected. This phase, strictly made by human beings, chronologically and logically precedes the second one, consisting of the realization of the projected product (Schmitt, 1984/2021).

Production becomes 'economic' when a monetary-numerical form of the product is generated (Keynes, 1936; Rossi, 2008) and firstly assigned to the producers, that is, workers, in the form of wages (Schmitt, 1984/2021; Solari, 2023). In so doing, money homogenizes a set of heterogeneous products, allowing for measuring them, though in a dimension-less fashion (Schmitt, 1984/2021). Such homogenization is essential, since it allows everyone to buy other things than what s/he participated to produce, thus making a society based on the division of labor viable. As for production, also economic production consists of two steps, and money's issue takes place between them. When a production project exists (first step), it needs money to be realized. Money is 'credit-driven and demand-determined' (Moore, 1988, p. 46) and in our economic system banks are the only agents able to grant credit out of nothing (Rossi, 2007). Schematically, the firm demands a credit to the bank to pay workers (Graziani, 2003; Solari, 2023), the latter then produce the goods and services (second step), which exist thus in two forms: the real-commodity form, and the numerical-monetary form (Schmitt, 1984/2021). In other words, our economies are *monetary economies of production* where money is endogenous and issued out of nothing by banks, that is, without the need of pre-existing savings (Graziani, 2003).

It is mostly the second step that engenders an impact on the planet. Any activity obeys the second law of thermodynamics, stating that the entropy increases (see Georgescu-Roegen, 1971). In the case of economic production, the entropic process is accelerated by its exosomatic character, consisting of the use of automated machines (Georgescu-Roegen, 1971; Lotka, 1945). Especially since the first

industrial revolution and as a result of the increasing mechanization, humanity has exponentially raised the consumption of energy and matter, further increased by the ‘economic growth mantra’ stating that any economic system should grow by a growing rate. The use of fossil fuels to run machines is releasing more and more matter into the atmosphere in the form of greenhouse gasses (GHG), impeding degraded energy to flow out the planet earth, warming it up as a consequence. Such an evil path is even worsened by the IDMO, which implies the consumption of matter and energy to transport (components of) commodities all around the world (Jackson & Victor, 2019).

As a matter of fact, any ecological-oriented policy should intervene before the second step, especially by integrating ecological criteria, as fundamental economic choices, into the selection process of the production-projects to realize eventually thanks to the credit line opened by the banking system; Fig. 2 offers a schematic representation of where those policy choices are to be made. Following an ecological economics perspective, nature should be considered as a holistic whole, incorporating humanity as an *organic* part, and economic activity as well (Spash & Ryan, 2012). Economic production should therefore be subsumed to ecological constraints, while today the opposite occurs. The impact of economic production, including transportation, is modifying the conditions of life on earth, thus threatening human’s as well as any other species’ survival.

The selection process takes place at two levels: within the firm and through the bank. Both actually mobilize only financial and commercial criteria, which are

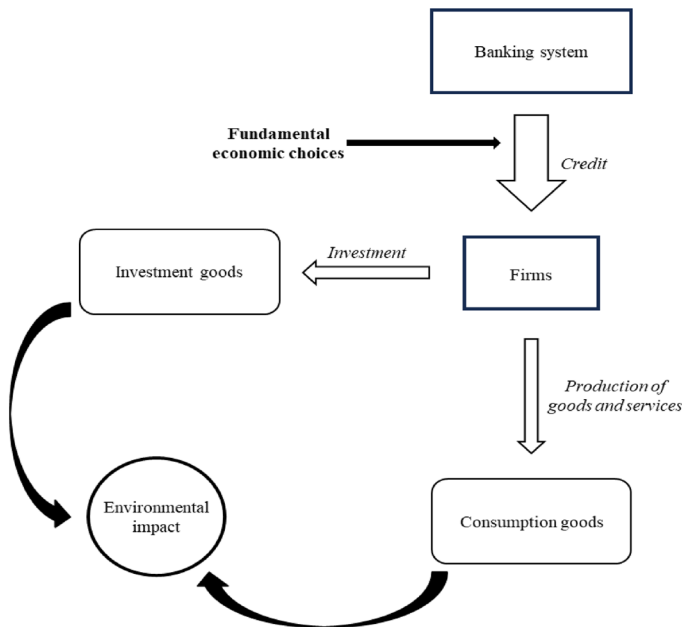


Fig. 2 Causes-consequences sequence of environmental damages in a monetary economy of production. *Source:* authors’ elaboration

finally related to each other. The financial ones essentially concern the solvability of the project or the firm. Banks particularly apply them when choosing whether to grant or not a credit to a firm. Several aspects are usually verified, such as timeliness of past payments, patrimonial health, already existent long-term engagement, and so on. The goal is to decrease as much as possible the risk of debt's non-repayment. On the firm's side, the commercial criteria are mobilized, referring to the *effective demand* principle, stating that firms produce according to their forecasts about the demand for the relevant product (Keynes, 1936). Firms thus hold only the projects having the higher expected profits. This could also integrate ecological concerns, whether the targeted customers are perceived as 'eco-sensitive'. Nevertheless, this is just sometimes the case and even when it is, firms too often implement 'green washing' actions rather than effective ones (see In & Schumacher, 2021).

The need for ecological criteria lies in the very fact that the value of nature is economically set to zero (Tietenberg & Lewis, 1984/2018; see Solari & Rossi, 2023 for further elaboration). Only goods and services produced through monetization acquire an economic value, consisting precisely in their monetary form. It follows that only commodities have an economic price determined by their production costs plus a possible mark-up (Schmitt, 1984/2021; Cencini, 2012). Nature has not been produced by anyone and it has no value in economic terms, while being highly valuable in many other respects. This holds for both the use of natural resources—lands, seas, fossil fuels, and so on—and the pollution as well as the waste engendered—greenhouse gasses, micro- and nano-plastic spread all over the world, oil slicks, nuclear disasters, and so on (see Moore, 2016). Concerning the use of natural resources, there is no macroeconomic cost. The payment for acquiring the property of, or simply the right to use, some natural item, just imply a transfer of an existing or future income to the owner of this item (Solari & Rossi, 2023). The production of goods and services, by contrast, implies the creation of a completely new income, first in the form of wages and afterwards in several derived forms, such as profit, interest income, and property income as well (Rossi, 2007). On the pollution and waste side, the costs appear *ex-post*, that is, after the economic production (and perhaps consumption) occurs. This allows for easily externalizing them, usually saddling the public sector with these costs. In both cases, there are weak incentives to act ecologically, or even negative ones since such a behavior increases the costs for firms, thus lowering their position within the financial and commercial ranking developed before.

Overall, the policies proposed and applied up to now have proven to be ineffective, as Fig. 3 shows with regards to the Kyoto Protocol and the Paris Climate Agreement, after which the fossil CO₂ emissions accelerated as the red stretches underscore in Fig. 3. These policies are shaped by the mainstream approach in economics, which neglects the position of the economy as embedded into nature and lacks the monetary essence of the economic system (see Solari & Rossi, 2023). In short, the attempt to include environmental issues into economic models has failed when we look at the results. We suggest, following the ecological economics approach, to insert the economy into a bigger frame. By introducing ecological criteria at the very beginning of the economic process, namely before it has an impact on the planet, we hopefully intervene *ex-ante*, thus impeding natural degradation, rather than trying to

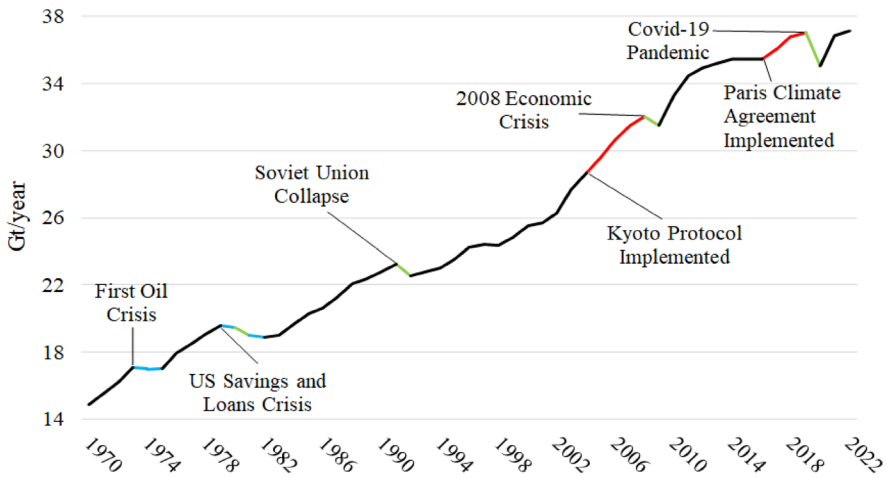


Fig. 3 World fossil CO₂ emissions in gigatonnes (Gt) per year. *Source:* authors' elaboration based on Friedlingstein et al. (2023)

mitigate it *ex-post*. In other words, our aim is to integrate double materiality, which suggests that institutions, including as much private companies as central banks, should not only consider the impact of climate change on their activities, but also the consequences of their operations on climate change (see Dafermos, 2021; Täger, 2021), from the very beginning of the production process. As already mentioned, such criteria should be applied both by firms and banks. The aim of this paper is to further investigate the role the banking system could and should play, especially with regard to central banks. Nevertheless, to do this we have to better analyze the structure and functioning of this system.

To finally settle any payment, leaving 'the seller with no further claim on the buyer' (Goodhart, 1975/1989, p. 26), a third agent is required above the payer and the payee (Rossi, 2008). It is so because 'nobody pays with her/his own debt' (Schmitt, 1975, p. 20, our translation), since this would allow anyone to pay with just a promise of payment, that is, an IOU (Graziani, 2003; Rossi, 2007). Any monetary system is thus shaped on three levels: at the bottom, there are non-bank agents, such as firms, households, non-government organizations, and so on; at the second level there are commercial banks, which are entitled to settle any transaction between non-bank agents; and at the third level there is the central bank, in charge for the settlement of interbank transactions (Schmitt, 1975). As explained above, the decision to grant credit for any economic activity is up to commercial banks. This does not mean that the central bank has no role to play. On the contrary, the central bank acts as a cornerstone of the relevant monetary system, usually at a national level (Rossi, 2008; Schmitt, 1975), thereby defining the framework within which commercial banks operate. To be sure, central banks fix the rules and they especially set the interest rate that banks have to pay to obtain liquidity, in the form of credit from the central bank. Such a central interest rate shapes the whole interest

rate structure within the economy. For instance, the commercial banks' interest rate on loans is defined as the central rate plus a mark-up (Graziani, 2003).

The intermediary role of the central bank is twofold. Whenever a transaction between two non-bank agents involves more than one bank, the monetary intermediation of the central bank is required, since an interbank transaction has to be settled. In the case the paying bank does not have enough liquidity to finance the relevant transaction, and does not find a bank disposed to lend this liquidity to it, the bank demands the central bank to act as a financial intermediary, by providing the needed liquidity, against collaterals (Rossi, 2007). These liquidity-providing operations are essential for any monetary system and they are applied daily at huge volumes. This gives a margin of maneuver to the central banks to impact on the selection process explained above. Central banks are indeed in a position to determine the conditions of any liquidity-providing operations, for instance which kind of collateral would be accepted and which would not, or the interest rate imposed on these operations. The position of central banks is far from being neutral and should be exploited to speed up a greening economy. Let us elaborate on this in the next section.

3 Some monetary policy proposals

Facing the reality of climate change, central banks are called for a much greater implication in the ecological transition, going way beyond what has been shyly announced in the last years by major central bankers (see for instance European Central Bank, 2021). Frequently constrained by excessively narrow interpretations of their mandates (see van't Klooster & de Boer, 2022), monetary authorities of advanced economies, maybe with the exception of the Chinese and Brazilian central banks (D'Orazio & Popoyan, 2022), have been limited to an insufficient risk exposure approach (Baer et al., 2021; Dafermos, 2021) in their enterprise of substantial climate actions. While signalling and demand effects can indeed be seen as important steps towards a generalized distancing from carbon-intensive financing, they remain blunt tools to prompt the required global reallocation of capital aligned with decarbonization, namely because of the fundamental uncertainty (Dafermos, 2021; Kedward et al., 2022) of environmental threats that renders the latter impossible to internalize into asset pricing (see Chenet et al., 2021). Instead, the double materiality lens (Boissinot et al., 2022) requires dismissing the sole market-based perspective and placing greater emphasis on environmental outcomes as justification for (monetary) policy intervention.

Consequently, we argue that, whatever direction the greening of monetary policy is to be going towards, it is first needed to step away from the principle of monetary policy neutrality (Dikau & Volz, 2021; van't Klooster & de Boer, 2022). This principle, which has long governed central bankers' actions, aims at excluding any sectoral intervention due to the fact that it would bring distortions in financial markets and would run counter their primary mandate of price stability. Statements made by the Governor of the Banque de France, François Villeroy de Galhau, and Chairman of the Swiss National Bank, Thomas Jordan, are quite clear in this connection (see Villeroy de Galhau, 2015; Jordan, 2017). However, decisions taken by monetary

authorities are never neutral (Rossi, 2022), as they translate into a variety of consequences on the economic system as a whole and always affect income distribution and capital allocation (Rochon & Vallet, 2022). In formulating their monetary policy operations, they unavoidably encounter political considerations, and the consistent application of ‘market neutrality’, which is itself a political choice, extracts these issues from a distinctly political deliberation process (van’t Klooster & Fontan, 2020). Following the so-called ‘neutrality principle’ when carrying out asset purchase programs is nothing but neutral, as it promotes and exacerbates the *status quo* in capital allocation by replicating existing market failures and thereby implicitly subsidizing carbon emitters (Kedward et al., 2022; Schnabel, 2021). In fact, studies have shown that quantitative easing (QE) as conducted by the European Central Bank (ECB) has been biased towards some sectors, which appeared to be the most harmful for the environment (see Matikainen et al., 2017; Jourdan & Kalinowski, 2019; Dafermos et al., 2020). As we will discuss later on below, such neutral-supposed asset purchase programs hence embody distortions themselves, as they clearly result in better funding conditions for pollutant activities (Couppey-Soubeyran, 2020). It is also argued that the existing macroprudential framework, which barely integrates ecological concerns, further enhances such high ‘carbon bias’ (D’Orazio, 2021).

More generally speaking, departing from the idea that economic policy decisions ought to be neutral requires first to acknowledge that economics is not a hard science. As it remains in the field of social sciences, it cannot be free of any doctrinal view (Devoluy, 2019). Similarly, every market embraces a certain political vision of society, which is unavoidably reflected when economic policies are tailored to perfectly mimic market structures (van’t Klooster & Fontan, 2020). Admitting the reality that economic policies always come with a certain vision of the world would enable policy makers to design policies that can actually achieve some democratically defined political objectives, without appearing as a traitor to an economic discipline that is political by nature. Considering this pre-request fulfilled, in this section we propose four ‘light green’ monetary policy options (see also Couppey-Soubeyran, 2020) that would change the conditions at which banks could grant credit to firms, thereby addressing the root of climate change in a monetary economy of production.

3.1 Interest rates differentiation

The first monetary policy option would be to adjust the central bank’s rate of interest in its refinancing operations with respect to the volume of green lending that is to be provided thanks to the central bank’s intermediation. In Europe, this can be done via the green targeted long-term refinancing operations (green TLTRO) proposal by van’t Klooster & van Tilburg (2020), which aims at increasing pressure on banks to green their portfolio. Current ECB’s TLTROs are indeed targeted in the way that they seek to enhance lending to the real economy, but there is no consideration of the environmental impact of these loans, an issue that could be mitigated by adding preferential interest rates for new loans complying with pre-defined ecological objectives (van’t Klooster & van Tilburg, 2020). Such an instrument can further be

employed to protect specific non-harmful economic activities in the current period of raising interest rates (Monnet & van't Klooster, 2023).

In a similar vein, the central bank could set its rate of interest for any refinancing operations according to the overall greenness degree of the borrowing bank taken as a whole. This proposal has been put forward by Kempf (2020), who suggests adding a 'climate premium' on top of the policy rate of interest set by the central bank for macroeconomic stabilization purposes. Such a premium could be positive or negative and would be determined as a function of each bank's average degree of climate-related risk associated with the loans that this bank grants to its customers. As a higher premium would be imposed on banks with bad 'climate grades' (Kempf, 2020), such a framework would strongly incentivize banks to give a closer look at whom they provide credits to. Indeed, a bank would remain in control of its overall climate grade and would rather improve it by adjusting its credit practices, as being poorly noted would bear a clear reputational cost and more importantly would threaten its solvability and profitability. Though this proposal, as do the other measures discussed below, comes with substantial challenges with respect to the implementation of a green taxonomy and the verification of its compliance (see Monnin, 2018; D'Orazio & Popoyan, 2019; Sawyer, 2022), it would have the merit to be applied to all banks needing to borrow from the central bank, with no discrimination (Kempf, 2020). Besides, to the extent that all interest rate setting fundamentally involves administered pricing rather than market-based pricing, the application of distinct interest rates relative to a bank's portfolio is not inherently more or less market-based than employing a uniform one (van't Klooster & van Tilburg, 2020).

3.2 Greening the collateral framework

Such an adjustment of the rate of interest could also be extended to assets issued by private sector companies and used as collateral in repurchase agreements made with the central bank. This second monetary policy option could be put into practice by reviewing the list of eligible assets accepted as counterparts of lending operations in order to introduce climate-related disclosure requirements and make sure these assets are aligned with ecological targets (see Couppey-Soubeyran, 2020). When bonds issued by carbon-intensive entities are included into the roster of eligible assets, while those issued by low-carbon entities are excluded, the overall collateral framework would induce more advantageous funding conditions for the former (Monnin, 2018), namely translating into increasing bond issuance by those polluting companies (Dafermos, 2021; Pelizzon et al., 2020). Under this circumstance, the central bank ought to take actions in order to alleviate such potential biases.

Another alternative could consist in the setting of requirements of concentration limits for high-polluting assets or minimum shares of low polluting assets for counterparties to access certain refinancing facilities from the central bank (Boneva et al., 2022). In this regard, the study of Oustry et al. (2020) suggests that there is already a sufficient pool of assets compatible with a low-carbon transition that can be put as collateral as an alternative to currently 'brown' assets used by commercial banks. It therefore supports that the greening of the collateral framework, under a monetary

policy approach, is indeed possible without threatening financial stability. Besides, within the list of eligible assets, a central bank could additionally adjust the pricing of the collateral framework by applying an additional haircut related to the carbon intensity of the issuer. This would reduce incentives of commercial banks to hold bonds issued by highly polluting firms, as the liquidity they could obtain by providing these bonds to the central bank would be littler than what could be borrowed against the provision of greener bonds, thus with a smaller (if any) haircut. It is however important that such punitive collateral haircuts for carbon-intensive assets must be applied irrespective of the ultimate utilization of cash proceeds, to prevent green washing using so-called ‘green repos’ (see Kedward et al., 2022).

3.3 Green asset purchase programs

A third monetary policy option that could easily be implemented within the current institutional framework refers to the so-called ‘green QE’. In fact, central banks have largely adopted QE as a modern monetary policy tool since the 2008 global economic and financial crisis, purchasing massive volumes of public and corporate bonds to introduce liquidity into financial markets, however without targeting any particular sector or any specific bond-issuing entity more than another. Yet, where that liquidity is introduced matters (van’t Klooster & Fontan, 2020). As it has been shown by many scholars, the neutrality principle consisting in ensuring that the central bank’s purchases of corporate bonds reflect the existing eligible bond market structure is far from being appropriate to catalyze the transition towards a low-carbon economy, owing to the fact that it is biased towards carbon-intensive companies (see Matikainen et al., 2017; Dafermos et al., 2020; Schoenmaker, 2021).

The pretended neutrality principle should hence be put to an end for at least two reasons. First, it lowers the cost of borrowing for those carbon-intensive firms, as they are the ones weighting the most in the pool of eligible assets, therefore providing advantageous funding conditions to entities operating in pollutant activities. By such behavior, central banks actively inhibit the transition to a low-carbon economy (Dafermos et al., 2020). Second, the ‘neutrality principle’ puts the entire financial system at risk, as additional debt issuance from GHG-emitting sectors increases, thereby weakening the resilience of the financial system to climate-related risks (see Monnin, 2018). At the end of the day, corporate sector purchase programs involve distributive choices (Monnet & van’t Klooster, 2023) and embody greater threat of financial fragility in addition to running counter to the engagement of major economies to generate less carbon emissions as they allow polluting companies emitting purchased assets to increase investment and employment (Giambona et al., 2020; Luck & Zimmerman, 2020), hence their ecological impact. Many scholars therefore propose scenarios in which such a bias would be alleviated, one of them being the mere exclusion from the central bank’s financial portfolio of all assets issued by carbon-intensive sectors, among which those issued by fossil fuel companies (Dafermos et al., 2020; Sawyer, 2022).

In order to foster a further boost to the overall green bond market, monetary authorities might also contemplate implementing a lasting QE initiative dedicated

solely to holding bonds sourced from this specific market (Dafermos et al., 2018). By massively engaging in such continuous asset purchase programs, central banks have emerged as prominent market players in last decade's financialized capitalism, possessing the most substantial balance sheets among all historical and existing financial institutions (Black, 2021). Their weight and persistent interventions have de facto provided them with the capacity of shaping financial markets (Baer et al., 2021; Dafermos, 2021; Thiemann et al., 2023), a capacity that can no longer be overlooked. This obviously poses the question of the (re)politicization of their actions. To optimize the positive impact of monetary policy, it is crucial that the management of central banks' portfolios is structured to appropriately reflect ecological and social priorities (van't Klooster & Fontan, 2020). These considerations equally hold in the current period of quantitative tightening (QT), where high-carbon bonds should be first discarded, and the corresponding partial reinvestment tilted towards low-carbon bonds issuers (Claeys, 2023). In the case of maturing securities, central banks could also decide to reinvest the principal payments exclusively on green bonds (Monnet & van't Klooster, 2023).

3.4 Adjusting reserve requirements

If it is verified that higher capital requirements are empirically associated with lower credit growth, hence with a lower risk of financial instability (Budnik & Kleibel, 2018; Cerruti et al., 2017), it makes sense to think about policy tools to increase reserves requirements for specific loans granted for pollutant activities (D'Orazio & Popoyan, 2019). Indeed, among the conventional monetary policy tools at the disposal of central banks is the level of reserves that commercial banks must keep with them. When left under-remunerated, these reserves represent a cost that commercial banks seek to minimize by minimizing their volume. A consequent approach, already adopted by the People's Bank of China, could be for central banks to set differentiated reserves requirement rates contingent on the extent of green lending undertaken by their counterparties (Choi et al., 2020).

So far, the reserve requirement tool usually concerns the volume of bank deposits, that is, the liability side of banks' balance sheet. An alternative proposal by Palley (2004) aims at influencing the amount of loans issued by banks, but this time with regard to the asset side of their balance sheet. In a framework with such an asset-based reserve requirement (ABRR), banks as well as other financial intermediaries 'would be obliged to hold reserves against different types of assets, with the reserve requirement being adjustable at the discretion of the monetary authority' (Palley, 2004, p. 45). One of the great advantages of the concept of ABRR is that the additional policy tools it provides allow monetary authorities to focus on a larger variety of economic targets, going beyond the limit imposed by the Tinbergen rule (see Tinbergen, 1952). The idea of extending the ABRR framework in even finer decisions about credit was already suggested in Palley's original article but referring to the overheated housing market (see Palley, 2004). When talking about mitigating climate change, it would therefore be possible to consider introducing 'green ABRRs' aiming at making tailored decisions about pricing credit and asset returns

according to the polluting nature of the credit granted. Imposing higher ABRRs for bank credits provided to carbon-intensive sectors would disincentivize the ‘bad’ alongside incentivizing the ‘good’ (Olk et al., 2022), and therefore help fine-tuning the allocation of bank credit (van’t Klooster, 2022) towards activities deemed socially and environmentally sustainable. Additionally, ABRRs guarantee greater financial stability, hence greater macroeconomic stability, as they could be designed to prevent banks from providing non-GDP-related credits (see Myftari & Rossi, 2007). In short, such a proposal could lead to an additional monetary policy instrument, therefore allowing the central bank to reach, besides its traditional objective of price stability, other macroeconomic objectives, namely, financial stability and more importantly in the scope of the present paper, climate sustainability.

There is overall already a large room of maneuver for central banks to make their functioning aligned with the objective of the Paris Agreement, as long as the harmful neutrality principle does no longer prevail in central banks’ actions. It is interesting to note that the engagement in greening the banking sector largely differs across countries, with high-income economies seeming to lag way behind low-income and emerging economies (see D’Orazio & Popoyan, 2019; Baer et al., 2021; Dafermos, 2021). Although unconventional instruments such as green credit policies are often associated with a deflationary context, we maintain that taking allocative measures in support of the ecological transition is not only feasible but also necessary in the current period of upward pressures on the price level (Monnet & van’t Klooster, 2023). The main features of proactive measures presented above are summarized in Table 1, which depicts how each monetary policy instrument would be used according to the current risk-exposure approach versus the proactive or promotional approach we advocate for. These monetary policy tools are only four out of many others, some of them however highly subject to controversy among economists and therefore requiring a scientific discussion that goes beyond the scope of this paper (see Couppey-Soubeyran, 2020). Nevertheless, it would be naïve to believe that greening monetary policy could itself address climate change. The next section addresses this point.

4 Monetary policy as a necessary but insufficient tool

Relying on monetary policy instruments to effectively prompt the ecological transition faces scrutiny on two fronts. First, skepticism arises concerning the effectiveness of the sole monetary policy redirecting credit away from environmentally detrimental activities and towards low-carbon economic sectors devoid of profitable opportunities. Second, even if successful in steering credit away from pollutant activities, the overarching challenge lies in the broader environmental impact associated with any type of economic activity, thereby requiring a more holistic approach, as does ecological economics. Let us address these two limitations in turn.

Table 1 Examples of climate monetary policy instruments under a risk-exposure versus a promotional approach

	Risk-oriented approach	Proactive approach
Direct instruments		
Quantitative easing (QE) or tightening (QT)	Exclusion of assets exhibiting high climate-related risks; reflect the eligible bond market structure in central bank's purchases and holdings (mirroring the market)	Abandon the neutrality principle in asset purchase programs; exclusion of assets issued by carbon-intensive sectors from the central bank's portfolio; consider a QE initiative exclusively for green bonds; reinvest principal payments on assets compatible with climate-related criteria only
Indirect instruments		
Central bank's rate of interest	Adapt interest rates conditional on a counterparty's disclosure of climate-related risk information	Special central bank's rate of interest for refinancing operations targeting green lending; addition of a 'climate premium' on the central bank's interest rate based on the borrowing bank's climate risk; higher premiums for banks with worse climate grades
Collateral framework for assets	Introduce climate-related risks disclosure requirements for eligible assets in repurchase agreements; adjust haircuts with respect to climate risks	Exclusion (negative screening) or introduction (positive screening) of assets based on their alignment with ecological targets; establish concentration limits for high-polluting assets or minimum shares of low-polluting assets; introduction of punitive haircuts for carbon-intensive assets
Reserve requirement and asset-based reserve requirement (ABRR)	Adjusting reserves requirements on riskweighted loans of the bank; higher ABRRs for loans to sectors with high climate-risks exposure	Differentiate reserves requirement rates based on the volume of green lending undertaken by their counterparties; expand the ABRR framework for tailored decisions on pricing credit and asset returns based on the environmental impact of the credit granted; higher ABRRs for loans granted for pollutant activities

Source: authors' elaboration based on Dafermos (2021), NGFS (2021) and Kedward et al. (2022)

4.1 Questioning the monetary policy transmission mechanism

For monetary policy interventions to eventually translate into effects, one should make sure that the transmission mechanism from monetary policy to macroeconomic magnitudes functions adequately. Here, the aforementioned proactive measures central banks could take to foster the achievement of ecological targets require that firms' investment plans are rather sensitive to changes in the cost of funding. In fact, in our monetary economy of production where loans precede deposits (see Moore, 1988; Lavoie, 2011; Cencini & Rossi, 2015), commercial banks allow the occurrence of macroeconomic investment by responding favorably to the demand for credit by firms, which derives from the extent to which these firms are planning on investing. The transmission mechanism suggested in the above green monetary policy interventions is that, by tilting or narrowing their asset purchase programs and collateral framework to low-carbon assets only, central banks would create incentives to pull commercial banks' lending activity towards sectors with milder ecological footprint, resulting therefore in lower cost of borrowing for corporations in such sectors, hence emphasizing green investments. Yet, as it is for any macroeconomic magnitude, monetary policy transmission mechanisms are not certain (Rossi, 2008). Empirical research so far offers mixed evidence with respect to the sensitivity of investment to variation in interest rates (Rochon & Vallet, 2022); more specifically, companies' investment plans seem rather insensitive to a decrease in interest rates, and only somewhat more responsive when interest rates increase (Sharpe & Suarez, 2015). It could thus be feared that fine-tuning monetary policy in order to favor sustainable activities would not suffice to see an investment surge in the latter as needed.

On the other hand, one could nevertheless expect that, for instance, setting a substantial punitive 'climate premium' on refinancing operations for banks with large carbon-intensive lending activities or extremely high haircuts on brown assets could translate into severe tightening effects on capital allocation to pollutant sectors of the economy. The discriminant character of such interest rates or haircuts—applied only on brown credits or brown assets—could participate to increase its effectiveness. The picture is indeed different. Rather than operating through the interest rate or the haircut for accelerating or slowing down the investment, we propose to use these instruments to redirect the actual willingness to invest from brown to green activities. But for these measures to be able to effectively steer credit towards economic activities compatible with environmental protection, increasing the volume of green lending and investments while lowering pollutant ones, there shall be no room for half-way uses of monetary policy instruments; the control of investment would require the strict control of credit, both its volume and its direction (Marshall & Rochon, 2022; Robinson, 1943). This calls for the application of not only one green monetary policy instrument but rather a collection of them in order to make a positive contribution in a world where complementary policy tools, namely green fiscal and macroprudential tools (see D'Orazio, 2021), do already exist.

Credit is thus ultimately determined by the demand for it by firms for the financing of their production, but the factors of this demand are not limited solely to borrowing conditions. Though most post-Keynesians suggest a role for the central bank

in credit allocation, particularly via its function as a lender of last resort for both the banking sector and the government (Hein, 2017), banks still may refuse to grant the demanded loans, in light of poor profit expectations or negative anticipations regarding the future trajectory of the business cycle (Rochon & Rossi, 2017). They can alternatively be willing to satisfy firms' demand for credit, however at such costly borrowing conditions that fewer credit lines will eventually be asked and granted (Lavoie, 2011). Consequently, it could be argued that central banks cannot compel banks to engage in lending to sustainable activities and that, instead, credit dynamics are influenced solely by demand originating from profit opportunities in the real economy, with central banks only responding by accommodating such demand. This is in line with the accommodist (horizontalist) approach, which posits that the volume and the direction of credit supplied adapt endogenously to shifts in firms' requirements for working capital, the entire process of credit granting being governed by the price of credit, which is, via the intermediation of commercial banks, determined by the central bank's monetary policy choice (Fontana, 2003). In this sense, even though the price of credit can largely influence its demand, one should not neglect the weight of effective demand, thus the general state of economic activity, in firms' decisions with respect to what they intend to produce and the related debt they should consequently enter into.

4.2 Questioning the sustainability of economic growth

The main goal should thus be to redirect economic activity, and economic growth as a consequence, towards a more sustainable path. As Asensio (2017, p. 129, *our italics*) has cogently pointed out '[r]ethinking economic growth means to consider what are the main factors influencing the firms' expectation with respect to the *return on investment* and with respect to the *demand for goods and services*', that is, effective demand. The interest rate is supposed to impact on the 'return on investment' side, by increasing the cost of accessing the capital needed to invest. Nevertheless, interest rates do not impact only on investment decisions. The economic agents' decisions of consumption are influenced by the set of interest rates, for instance through the wealth effect (see Rossi, 2020). This affects the firms' demand forecasts and the level of production eventually. Effective demand is multifaceted and integrates several other variables, such as disposable income, trust in the future, conjunctural situation, and so on. The consumers' sensitiveness about ecological issues also enters into the picture. From a post-Keynesian perspective, the long-term is fashioned by the succession of short-term contexts (Asensio, 2017). Among the latter, we find several elements, such as the state of the technology, the expectations about the future, and also the institutional frame, including the central interest rate. Reshaping the interest rate structure is thus a necessary but insufficient condition to make both demand and effective demand more sustainable.

The ecological economics versus environmental economics debate consists largely of this. While environmental economists focus on integrating the economy's impact on nature within economic models, ecological economists claim for a change of perspective. Generally speaking, environmental economists' models

still have as central assumption the egoistic essence of men. Such models follow the utility (for consumers) or profit (for firms) maximization pattern. The goal is therefore to modify agent's preferences by introducing some incentives. The monetary policy instruments we have proposed in the previous section go in this direction, even though they are applied at the very core of the production process. Nevertheless, a far deeper change is required, both in theory and practice (Vatn, 2005). Recent decades have been marked by the so-called economic globalization, for instance through the IDMO process, inducing a further increase in material and energy consumption, largely due to transportation (Jackson & Victor, 2019). Two main reasons have made it possible: the lower cost of labor in the Global South and the low cost of transportation. In other words, globalization has followed a profit-seeking and capital-accumulation path, rather than a widespread well-being purpose. This raises the issue of global inequalities, since the Global South needs matter and energy consumption to develop itself economically, for instance because today's economies, especially small ones, are typically highly dependent on foreign trade (Jespersen, 2006), namely for food security (Bren d'Amour & Anderson, 2020). The actual alarming situation has been largely engendered by the Global North and the 'costs' should therefore fall especially on developed countries (Bedir & Yilmaz, 2016).

The degraded conditions of life and the scarcity of resources give rise to social tensions, possibly causing major conflicts and wars, both inter- and intra-species (Lotka, 1945). Ecological economists point out the strong link between the growing economic activities and the degradation of nature. The introduction of ecological (as well as social) criteria into the selection process of production projects is therefore essential and urgent. The monetary policies suggested in this paper are a step in this direction. By making the access to credit costlier, pollutant activities will require higher returns to be profitable and therefore eligible for a banking credit, thus reducing them in volume. This will hopefully add up to an increasing sensitivity of consumers and economic agents largely speaking, which will prefer green than brown products. On the contrary, green productions will be incentivized. Firstly, by the interest rate premium mechanism, and secondly because of the higher rentability compared to that of brown ones.

That being said, even green productions have an impact on the planet, therefore making a 1-to-1 substitution not feasible in the long run. The fairy tale of absolute 'decoupling' between output growth and GHG emissions, if we adopt a consumption-based perspective and properly include imported pollution, has been sufficiently dismissed empirically (D'Alessandro et al., 2020; Hickel & Kallis, 2020; Parrique et al., 2019). An overall reduction of the economic production seems unavoidable—consider again Fig. 3, notably the blue and green stretches, showing that the concentration of CO₂ in the atmosphere has decreased only during the major economic downturns since 1970—which will imply an increase of unemployment of great magnitude. Moreover, this would add up to technological unemployment (Cesaratto et al., 2003). One way to lighten such a problem is to increase effective demand and economic growth as a consequence. However, such a solution goes in the opposite direction than the one required to fight global warming. Moreover, the link between perpetual economic growth and people's well-being has already been

rejected (Devoluy, 2019; Stiglitz et al., 2010). A second possible way is to decrease the working time considered as ‘full-time’, thus redistributing work among a larger number of people, while reducing the overall time worked by the whole society. Such a second possibility—that we cannot elaborate further because of space constraints—appears as a logical consequence of the monetary policies proposed in this paper, to make the latter ecologically effective without engendering major social turmoil. In other words, the policies we propose do not fulfill the deep change we need, but they could operate as a first, essential step in the right direction.

The main source of the actual global warming being the exosomatic intensity of economic activity, it would be naïve to believe in technological development as a solution, since the latter is often subsumed to economic criteria, such as profit-seeking. Moreover, even research, development and utilization of new technologies, as with any other economic activity, imply the consumption of natural matter and energy (Spash & Ryan, 2012; Scott, 2017; Jackson & Victor, 2019), as the entropy law suggests. The hope of a technological improvement that will save the world is a risky bet, considering the urgency of the problem and the cost it entails in terms of further natural degradation. It would be better to recognize the limits of the economy—which is only an (organic) part of nature—and enrich the economic decision process by integrating criteria coming from other disciplines.

5 Conclusion

The very cause of global warming, and nature degradation largely speaking, lies in economic activities, especially in the actual globalization regime. We thus argue for the introduction of ecological (as well as social) criteria within the decision process concerning the economic activities to implement or not. However, this calls for a deep comprehension of the economic system to select effective criteria and to apply them efficiently. The monetary economy of production shaping our world has to be considered as such. The choices on what, how, and how much to produce are taken by firms and indirectly validated by banks, the latter providing the credit lines needed to start the production process. The consumer power, by contrast, has to be resized. If it is true that firms decide about their production on the basis of effective demand, it is also true that consumer choices are biased by several influences and by marketing efforts, which are designed to increase consumption, even if this implies an increased impact on nature. It is therefore fair to introduce—perhaps by legal interventions and related sanctions—some ecological criteria into the first phase of production, namely the conceptualization of the product and the way of production. This phase, indeed, precedes the most polluting one, that is, real production and transportation.

Between the two phases, there are firms’ and banks’ decisions about production and credit-granting respectively. It is therefore on these economic agents that the above criteria should be imposed. The selection of these criteria goes beyond the purposes of this paper, mainly because it should involve a large multidisciplinary effort. However, we propose some policy tools that could be used by central banks, that is, the institutions in charge for the well-functioning of the payments system,

as well as the financial system, generally speaking, to stimulate the integration of such criteria. First, if central banks adjust their policy rates of interest for refinancing operations with regard to the activities thus monetized, they would induce banks to prioritize sustainable activities when opening credit lines to firms. By adding a climate premium on top of their interest rate, central banks would fine-tune the credit policy of commercial banks. The same would occur by enlarging the number of green assets and reducing that of brown ones in the list of eligible assets accepted as collateral within these refinancing operations. In addition, the demand by commercial banks for these green assets would increase their financial worth, attracting further investors. Such a result could be attained also applying a green QE, and this policy should be firstly applied, at fixed term, to allow banks to accumulate green assets in their balance sheets, thereby facilitating the adjustment of the eligible assets list explained above. The fourth policy proposed in this paper is probably the most interesting. It allows for improving both ecological sensitivity and financial resilience. Nowadays, the reserve requirements imposed on commercial banks are liability-based, that is, calibrated on the amount of deposits managed by banks. This is nonsense. Since loans make deposits (see Rossi, 2007), it would be by far more efficient to fix the reserves on loans, hopefully introducing a higher reserve requirement for brown credits. This would be economically justified by future climate disasters' consequences, which will jeopardize the economic system. In short, we argue for the implementation of these policies altogether to maximize their impact.

If we refer to Lordon's (2010) expression, neoliberal capitalism has fallen into the delirium of the unlimited, with respect both to the quantitative capture (the unlimited growth of GDP) and to the qualitative one (unlimited mobilization of the workforce). As Fig. 3 shows, only decreasing the economic activity overall will reduce the impact on nature. However, only major economic crises have engendered such a path so far, with the related social distresses related to them. The connection between ecological economics and post-Keynesian economics should be further developed. Current economic literature does not sufficiently emphasize, in our view, the importance of taking a monetary perspective to address ecological issues. This is crucial both to deeply understand the role of the economy as source of global warming, and to propose effective solutions, ecologically, socially, and economically altogether. This paper attempts to do this in two main ways. First, by reinforcing the comprehension of our monetary economies of production, the essence of which is too often misunderstood. The usual claim for abandoning the growth mantra cannot overlook the social and economic problems it will engender. Only by deeply knowing the functioning of the monetary economy of production one would be able to select and apply effective solutions. Along these lines lies the second contribution of this paper, which is to depict some policies that are technically quite easily applicable, considering the urgency of the problem, and fit the monetary essence of our economic system. Our aim is to reshape monetary policy to make it more sustainable, thus inducing commercial banks to act ecologically. Central banks are the cornerstone of national monetary systems, nevertheless they limit themselves to the guarantee of price stability—and, to a lesser extent, financial stability—in the name of the neutrality principle. The latter is however a hollow concept, since it implies to maintain the *status quo* in capital allocation so far almost exclusively governed by

the economic growth mantra, which is precisely the cause of the actual global warming. We advocate for a (re)politicization of monetary policy, which is as urgent as it could be the first step towards a spread set up of these ecological criteria to select green productions by discarding brown ones. By replacing the current risk-oriented approach with the proactive approach we argue for, monetary policy could become the engine of the deep and structural breakthrough we need to face the global warming issue.

Author contributions All authors contributed to the study conception and design. The first draft of the manuscript was written by MS and ALB and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding Open access funding provided by University of Fribourg. The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Abiry, R., Ferdinandusse, M., Ludwig, A., & Nerlich, C. (2022). Climate change mitigation: How effective is green quantitative easing? *ZEW – Centre for European Economic Research Discussion Paper*, 22–027.
- Allen, T., Dees, S., Boissinot, J., Caicedo Graciano, C.M., Chouard, V., Clerc, L., de Gaye, A., Devulder, A., Diot, S., Lisack, N., Pegoraro, F., Rabaté, M., Svartzman, R., & Vernet, L. (2020). Climate-related scenarios for financial stability assessment: An application to France. *Banque de France Working Paper*, 774.
- Ameli, N., Drummond, P., Bisaro, A., Grubb, M., & Chenet, H. (2020). Climate finance and disclosure for institutional investors: Why transparency is not enough. *Climatic Change*, 160(4), 565–589. <https://doi.org/10.1007/s10584-019-02542-2>
- Andersson, M., Baccianti, C., & Morgan, J., (2020). Climate change and the macro economy. *ECB Occasional Paper Series*, 243. <https://doi.org/10.2866/83282>
- Asensio, A. (2017). Rethinking the environment. In L.-P. Rochon & S. Rossi (Eds.), *A Modern Guide to Rethinking Economics* (pp. 129–150). Edward Elgar.
- Baer, M., Campiglio, E., & Deyris, J. (2021). It takes two to dance: Institutional dynamics and climate-related financial policies. *Ecological Economics*, 190(107210), 1–11. <https://doi.org/10.1016/j.ecolecon.2021.107210>

- Bedir, S., & Yilmaz, V. M. (2016). CO2 emissions and human development in OECD countries: Granger causality analysis with a panel data approach. *Eurasian Economic Review*, 6, 97–110. <https://doi.org/10.1007/s40822-015-0037-2>
- Black, J. (2021). Central banks face new balancing act with their huge asset piles. *Bloomberg*. Retrieved November 17, 2023, from <https://www.bloomberg.com/news/articles/2021-05-26/central-banks-face-new-balancing-act-with-their-huge-asset-piles#xj4y7vzkg>
- Boissinot, J., Goulard, S., 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 Paper*, 5. Retrieved November 15, 2023, from <https://eprints.lse.ac.uk/115539/>
- Boneva, L., Ferrucci, G., & Mongelli, F. P. (2022). Climate change and central banks: What role for monetary policy? *Climate Policy*, 22(6), 770–787. <https://doi.org/10.1080/14693062.2022.2070119>
- Bren d'Amour, C., & Anderson, W. (2020). International trade and the stability of food supplies in the Global South. *Environmental Research Letters*, 15(074005), 1–10. <https://doi.org/10.1088/1748-9326/ab832f>
- Budnik, K., & Kleibel, J. (2018). Macroprudential regulation in the European Union in 1995–2014: Introducing a new data set on policy actions of a macroprudential nature. *European Central Bank Working Paper*, 2123.
- Cencini, A. (2012). Towards a macroeconomic approach to macroeconomics. In C. Gnos & S. Rossi (Eds.), *Modern monetary macroeconomics. A new paradigm for economic policy* (pp. 39–68). Cheltenham: Edward Elgar Publishing.
- Cencini, A., & Rossi, S. (2015). *Economic and financial crises: A new macroeconomic analysis*. Palgrave Macmillan.
- Cerruti, E., Claessens, S., & Laeven, L. (2017). The use and effectiveness of macroprudential policies: New evidence. *Journal of Financial Stability*, 28, 203–224.
- Cesaratto, S., Serrano, F., & Stirati, A. (2003). Technical change, effective demand and employment. *Review of Political Economy*, 15(1), 33–52. <https://doi.org/10.1080/09538250308444>
- Chenet, H., Ryan-Collins, J., & van Lerven, F. (2021). Climate-related financial policy in a world of radical uncertainty: Towards a precautionary approach. *Ecological Economics*, 183, 106957. <https://doi.org/10.1016/j.ecolecon.2021.106957>
- Choi, J., Escalante, D., & Lund Larsen, M. (2020). *Green banking in China – Emerging trends*. Climate Policy Initiative. Retrieved November 21, 2023, from <https://www.climatepolicyinitiative.org/publication/green-banking-in-china-emerging-trends/>
- Claeys, G. (2023). *Finding the right balance (sheet): Quantitative tightening in the euro area*. Monetary Dialogue Papers. Retrieved November 21, 2023, from <https://www.bruegel.org/sites/default/files/2023-03/Claeys%20QT%202023%20Final.pdf>
- Coupey-Soubeyran, J. (2020). The role of monetary policy in the ecological transition: An overview of various greening options. *Veblen Institute for Economic Reforms*. Retrieved August 22, 2023, from https://www.veblen-institute.org/IMG/pdf/the_role_of_monetary_policy_in_the_ecological_transition_an_overview_of_various_greening_options.pdf
- D'Alessandro, S., Cieplinski, A., Distefano, T., & Dittmer, K. (2020). Feasible alternatives to green growth. *Nature Sustainability*, 3(4), 329–335. <https://doi.org/10.1038/s41893-020-0484-y>
- D'Orazio, P. (2021). Towards a post-pandemic policy framework to manage climate-related financial risks and resilience. *Climate Policy*, 21(10), 1368–1382. <https://doi.org/10.1080/14693062.2021.1975623>
- D'Orazio, P., & Popoyan, L. (2019). Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies? *Ecological Economics*, 160(C), 25–37. <https://doi.org/10.1016/j.ecolecon.2019.01.029>
- D'Orazio, P., & Popoyan, L. (2022). Realising central banks' climate ambitions through financial stability mandates. *Intereconomics*, 57(2), 103–111. <https://doi.org/10.1007/s10272-022-1039-4>
- Dafermos, Y., Nikolaidi, M., & Galanis, G. (2018). Can green quantitative easing (QE) reduce global warming? *Foundation for European Progressive Studies*. Retrieved August 25, 2023, from <https://research.gold.ac.uk/id/eprint/25412/>
- 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*. Retrieved August 25, 2023, from <https://neweconomics.org/uploads/files/Decarbonising-is-easy.pdf>

- Dafermos, Y., Kriwoluzky, A., Vargas, M., Volz, U., & Wittich, J. (2021). The price of hesitation: How the climate crisis threatens price stability and what the ECB must do about it. *German Institute for Economic Research: Politikberatung kompakt*, 173.
- Dafermos, Y. (2021). Climate change, central banking and financial supervision: Beyond the risk exposure approach. *SOAS Department of Economics Working Paper*, 243.
- Devoluy, M. (2019). *L'économie: Une science "impossible" – Déconstruire pour avancer*. Éditions Véroné.
- Dikau, S., & Volz, U. (2021). Central bank mandates, sustainability objectives and the promotion of green finance. *Ecological Economics*, 184, 107022. <https://doi.org/10.1016/j.ecolecon.2021.107022>
- European Central Bank (2021). *The ECB's monetary policy strategy statement*. European Central Bank. Retrieved November 20, 2023, from https://www.ecb.europa.eu/home/search/review/html/ecb.strategyreview_monpol_strategy_statement.en.html
- Fontana, G. (2003). Post Keynesian approaches to endogenous money: A time framework explanation. *Review of Political Economy*, 15(3), 291–314. <https://doi.org/10.1080/09538250308431>
- Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Bakker, D. C. E., Hauck, J., Landschützer, P., Le Quéré, C., Luijckx, I. T., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Anthoni, P., ... Zheng, B. (2003). Global Carbon Budget 2023. *Earth System Science Data*, 15, 5301–5369. <https://doi.org/10.5194/essd-15-5301-2023>. Retrieved December 12, 2023.
- Georgescu-Roegen, N. (1971). *The Entropy law and the economic process*. Harvard University Press.
- Giambona, E., Matta, R., Peydró, J.L., & Wang, Y. (2020, October 25). Quantitative easing, investment and safe assets: the corporate-bond lending channel. Retrieved November 15, 2023, from <https://doi.org/10.2139/ssrn.3593760>
- Goodhart, C.A.E. (1975/1989). *Money, Information and Uncertainty*. Macmillan.
- Graziani, A. (2003). *The monetary theory of production*. Cambridge: Cambridge University Press.
- Hein, E. (2017). Post-Keynesian macroeconomics since the mid 1990s: Main developments. *European Journal of Economics and Economic Policies: Intervention*, 14(2), 131–172.
- Hickel, J., & Kallis, G. (2020). Is green growth possible? *New Political Economy*, 25(4), 469–486. <https://doi.org/10.1080/13563467.2019.1598964>
- In, S. Y., & Schumacher, K. (2021). Carbonwashing: ESG data greenwashing in a post-Paris world. In T. Heller & A. Seiger (Eds.), *Settling climate accounts: Navigating the road to net zero* (pp. 39–58). Springer International Publishing. https://doi.org/10.1007/978-3-030-83650-4_3 Available online at (accessed 30 November 2023).
- Jackson, T., & Peter, A.V. (2019). Unraveling the claims for (and against) green growth. *Science*, 366(6468), 950–951. <https://doi.org/10.1126/science.aay0749>
- Jespersen, J. (2006). Exchange rate arrangements and EU enlargement. In L.-P. Rochon & S. Rossi (Eds.), *Monetary and exchange rate systems* (pp. 232–254). Edward Elgar Publishing.
- Jordan, T. (2017). *Comments on the SNB's monetary and investment policy*. Speech by Thomas Jordan. Retrieved November 17, 2023, from https://www.snb.ch/en/publications/communication/speeches/2017/ref_20170428_tjn
- Jourdan, S., & Kalinowski, W. (2019). Aligning monetary policy with the EU's climate targets. *Veblen Institute for Economic Reforms and Positive Money Working Paper*. Retrieved August 27, 2023, from https://www.veblen-institute.org/IMG/pdf/aligning_monetary_policy_with_eu_s_climate_targets.pdf
- 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 Institute for Innovation and Public Purpose Working Paper Series*, 2022–11. Advance online publication. <https://doi.org/10.2139/ssrn.4198146>
- Kempf, H. (2020). Verdier la politique monétaire. *Revue D'économie Politique*, 130(3), 311–343. <https://doi.org/10.3917/redp.303.0311>
- Keynes, J. M. (1936). *The general theory of employment, interest and money*. Macmillan.
- Lavoie, M. (2011). Money, credit and central banks in post-Keynesian economics. In E. Hein & E. Stockhammer (Eds.), *A modern guide to keynesian macroeconomics and economic policies* (pp. 34–60). Edward Elgar Publishing.
- Lordon, F. (2010). *Capitalisme, désir et servitude – Marx et Spinoza*. La Fabrique éditions.
- Lotka, A. J. (1945). The law of evolution as a maximal principle. *Human Biology*, 17(3), 167–194.

- Luck, S., & Zimmermann, T. (2020). Employment effects of unconventional monetary policy: Evidence from QE. *Journal of Financial Economics*, 135, 678–703. <https://doi.org/10.1016/j.jfineco.2019.07.004>
- Marshall, W. C., & Rochon, L. P. (2022). Understanding full investment and the potential role of public banks. *Review of Political Economy*, 34(2), 340–355. <https://doi.org/10.1080/09538259.2021.2013633>
- Matikainen, S., Campiglio, E., & Zenghelis, D. (2017). The climate impact of quantitative easing. *Grantham Research Institute on Climate Change and the Environment Policy Paper*. Retrieved August 27, 2023, from https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2017/05/ClimateImpactQuantEasing_Matikainen-et-al.pdf
- Monnet, E., & van't Klooster, J. (2023, July). Using green credit policy to bring down inflation: What central bankers can learn from history. *The Inspire Sustainable Central Banking Toolbox Policy Briefing Paper*, 13. Retrieved November 15, 2023, from <https://www.inspiregreenfinance.org/publications/using-green-credit-policy-to-bring-down-inflation-what-central-bankers-can-learn-from-history/>
- Monnin, P. (2018). Central banks and the transition to a low-carbon economy. *Council on Economic Policies Discussion Note*, 2018/1. Retrieved August 27, 2023, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3350913
- Moore, B. J. (1988). *Horizontalists and Verticalists: The Macroeconomics of Credit Money*. Cambridge University Press.
- Moore, J. W. (2016). The rise of cheap nature. In J. W. Moore (Ed.), *Anthropocene or capitalocene? Nature, history, and the crisis of capitalism* (pp. 78–115). PM Press.
- Myftari, E., & Rossi, S. (2007). Asset prices and monetary policy: Should central banks adopt asset-based reserve requirements? Paper for the *Eleventh Berlin Conference of the Research Network Macroeconomic Policies*, Berlin, Germany, 26–27 October.
- Network of Central Banks and Supervisors for Greening the Financial System (2021). *Adapting central bank operations to a hotter world: Reviewing some options*. NGFS Technical document. Retrieved, November 15, 2023, from https://www.ngfs.net/sites/default/files/media/2021/06/17/ngfs_monetary_policy_operations_final.pdf
- Olk, C., Schneider, C., & Hickel, J. (2022). *How to pay for saving the world: Modern Monetary Theory for a degrowth transition*. SSRN. Retrieved August 27, 2023, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4172005
- OurWorldInData (2023). CO₂ and greenhouse gas emissions. Retrieved August 26, 2023, from <https://ourworldindata.org/co2-and-greenhouse-gas-emissions>
- Oustry, A., Erkan, B., Svartzman, R., & Weber, P.-F. (2020). Climate-related risks and central banks' collateral policy: A methodological experiment. *Revue Économique*, 73(2), 173–218.
- Palley, T. (2004). Asset-based reserve requirements: Reasserting domestic monetary control in an era of financial innovation and instability. *Review of Political Economy*, 16(1), 43–58. <https://doi.org/10.1080/0953825032000145454>
- Parrique, T., Barth, J., Briens, F., Kerschner, C., Kraus-Polk, A., Kuokkanen, A., & Spangenberg, J.H. (2019). Decoupling debunked: Evidence and arguments against green growth as a sole strategy for sustainability. *European Environmental Bureau*.
- Pelizzon, L., Riedel, M., Simon, Z., & Subrahmanyam, M.G. (2020). Collateral eligibility of corporate debt in the Eurosystem. *SAFE Working Paper*, 275. <https://doi.org/10.2139/ssrn.3586409>
- Robinson, J. (1943). *The problem of full employment*. Study outline 18. London: The Workers' Educational Association & Workers' Educational Trade Union Committee.
- Rochon, L.-P., & Rossi, S. (2017). Horizontalism and structuralism: A suggested reinterpretation. In L.-P. Rochon & S. Rossi (Eds.), *Advances in endogenous money analysis* (pp. 379–397). Edward Elgar Publishing.
- Rochon, L.-P., & Vallet, G. (2022). The institutions of the people, by the people and for the people? Addressing central banks' power and social responsibility in a democracy. *PSL Quarterly Review*, 75(301), 83–102. <https://doi.org/10.13133/2037-3643/17727>
- Rossi, S. (2007). *Money and Payments in Theory and Practice*. London & New York: Routledge.
- Rossi, S. (2008). *Macroeconomie monétaire: Théories et politiques*. Brussels, Paris & Zürich: Bruylant, LGDJ and Schulthess.
- Rossi, S. (2020). Central banks' contribution to financial instability. *Bulletin of Political Economy*, 14(2), 203–217.

- Rossi, S. (2022). The political benefits of ‘unconventional’ monetary policies in times of crisis. *Review of Political Economy*. <https://doi.org/10.1080/09538259.2022.2114290>. Advance online publication.
- Sawyer, M. (2022). Monetary policy, environmental sustainability and the climate emergency. In L.-P. Rochon, S. Kappes, & G. Vallet (Eds.), *Central banking, monetary policy and the environment* (pp. 54–71). Edward Elgar Publishing.
- Schmitt, B. (1984/2021). *Unemployment and Capital Malformations*, translated by X. Bradley & A. Cencini. Routledge.
- Schmitt, B. (1975). *Théorie unitaire de la monnaie, nationale et internationale*. Castella.
- Schnabel, I. (2021). *From green neglect to green dominance?* Speech given at the “greening monetary policy – Central banking and climate change”, Cleveland. Retrieved November 15, 2023, from https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210303_1_annex~3c03f9a09c.en.pdf
- Schoenmaker, D. (2021). Greening monetary policy. *Climate Policy*. <https://doi.org/10.1080/14693062.2020.1868392>. Advance online publication.
- Schroeder, S. K. (2023). Greening monetary policy: CBDCs and community development banks. *Journal of Economic Issues*, 57(2), 654–660. <https://doi.org/10.1080/00213624.2023.2202571>
- Scott, R. H. (2017). Rethinking the environment. In L.-P. Rochon & S. Rossi (Eds.), *A modern guide to rethinking economics* (pp. 319–336). Edward Elgar.
- Sharpe, S., & Suarez, G. (2015). *Why isn't investment more sensitive to interest rates: Evidence from surveys*. Advance online publication. <https://doi.org/10.2139/ssrn.2667352>
- Solari, M. (2023). Money creation – nature of. In L.-P. Rochon & S. Rossi (Eds.), *Elgar Encyclopedia of Post-Keynesian economics* (pp. 293–295). Edward Elgar.
- Solari, M., & Rossi, S. (2023). Should we care about the environment in a market economy? In H. Bougrine, L.-P. Rochon, & M. Seccareccia (Eds.), *Intermediate microeconomics: Theory, policy and competing perspectives*. Edward Elgar. Forthcoming.
- Spash, C. L., & Ryan, A. (2012). Economic schools of thought on the environment: Investigating unity and division. *Cambridge Journal of Economics*, 36(5), 1091–1121. <https://doi.org/10.1093/cje/bes023>
- Stiglitz, J., Sen, A., & Fitoussi, J.-P. (2010). *Mismeasuring our Lives: Why GDP Doesn't Add Up*. The New Press.
- Täger, M. (2021). ‘Double materiality’: What is it and why does it matter? *Grantham Research Institute on Climate Change and the Environment*. Retrieved November 15, 2023, from <https://www.lse.ac.uk/granthaminstitute/news/double-materiality-what-is-it-and-why-does-it-matter/>
- Thiemann, M., Büttner, T., & Kessler, O. (2023). Beyond market neutrality? Central banks and the problem of climate change. *Finance and Society*, 9(1), 14–34. <https://doi.org/10.2218/finsoc.8090>
- Tietenberg, T., & Lewis, L. (1984/2018). *Environmental and Natural Resource Economics* (11th ed.) Routledge
- van't Klooster, J., & van Tilburg, R. (2020). *Targeting a sustainable recovery with Green TLTROs*. Positive Money Europe & Sustainable Finance Lab. Retrieved November 20, 2023, from <http://www.positivemoney.eu/wp-content/uploads/2020/09/Green-TLTROs.pdf>
- van't Klooster, J. (2022). The case of a European credit council: Historical and constitutional fine-tuning. *Accounting, Economics, and Law: A Convivium*. <https://doi.org/10.1515/acl-2022-0074>. Advance online publication.
- van't Klooster, J., & de Boer, N. (2022). What to do with the ECB’s secondary mandate. *Journal of Common Market Studies*, 61(3), 730–746. <https://doi.org/10.1111/jcms.13406>
- van't Klooster, J., & Fontan, C., (2020). The myth of market neutrality: A comparative study of the European Central Bank’s and the Swiss National Bank’s corporate security purchases. *New Political Economy*, 25(6), 865–879. <https://doi.org/10.1080/13563467.2019.1657077>.
- Vatn, A. (2005). Rationality, institutions and environmental policy. *Ecological Economics*, 55(2), 203–217. <https://doi.org/10.1016/j.ecolecon.2004.12.001>
- Villeroy de Galhau, F. (2015). *Climate change: The financial sector and pathways to 2 °C*. Speech by François Villeroy de Galhau. Retrieved August 25, 2023, from <https://www.banque-france.fr/en/intervention/climate-change-financial-sector-and-pathways-2deg>

Authors and Affiliations

Maurizio Solari¹  · Alexandre Le Bloc'h¹  · Sergio Rossi¹ 

✉ Sergio Rossi
sergio.rossi@unifr.ch

Maurizio Solari
maurizio.solari@unifr.ch

Alexandre Le Bloc'h
alexandre.lebloch@unifr.ch

¹ Department of Economics, University of Fribourg (Switzerland), Boulevard de Pérolles 90 (mailbox 22), CH–1700 Fribourg, Switzerland